OPERATIONS AND MAINTENANCE PLAN

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Table of Contents:

Document Control Sheet ... i
1. Introduction ... 1
1.1 Purpose and Scope ... 1
1.2 Integrated O&M Strategic Goals ... 1
1.3 Description of OOI Network ... 2
1.3.1 Functional components of the OOI ... 2
1.4 Concept of Operations ... 3
2. Referenced Documents ... 5
3. OOI Organizational Structure & Governance ... 6
3.1 Ocean Leadership ... 7
3.1.1 Responsibilities ... 7
3.1.2 Policies ... 8
3.1.3 Procedures ... 9
3.2 Observatory Advisory Team (OAT) ... 9
3.2.1 Proposed Membership ... 9
3.2.2 Responsibilities ... 9
3.2.3 Policies ... 9
3.2.4 Procedures ... 10
3.3 Observatory Operations Team (OOT) ... 10
3.3.1 Proposed Membership ... 10
3.3.2 Responsibilities ... 10
3.3.3 Policies ... 11
3.3.4 Procedures ... 11
3.4 Program Advisory Committee (PAC) ... 11
3.4.1 Responsibilities ... 11
3.5 University-National Oceanographic Laboratory System (UNOLS) ... 11
3.5.1 Responsibilities ... 11
4 OOI Operations and Maintenance Integration ... 12
4.1 Identification and Development of Integrated O&M Activities ... 12
4.1.1 O&M Transitional Working Groups ... 13
4.2 IO Specific O&M Activities ... 15
4.2.1 Cyberinfrastructure (CI) ... 15
4.2.2 Coastal / Global Scale Nodes (CGSN) ... 15
4.2.3 Regional Scale Nodes ... 16
4.2.4 Primary Node Sites ... 17
4.2.5 Education and Public Engagement (EPE) ... 18
5 OOI Transition to Operations Strategy ... 19
5.1 Year 1 – Early Pre-Operations ... 20
5.1.1 Cyberinfrastructure ... 21
5.1.2 Coastal / Global Scale Nodes ... 21
5.1.3 Regional Scale Nodes ... 22
5.2 Year 2 – Mid Pre-Operations ... 22
5.2.1 Cyberinfrastructure ... 23
5.2.2 Coastal / Global Scale Nodes ... 23
5.2.3 Regional Scale Nodes ... 23
5.2.4 Education and Public Engagement ... 24
5.3 Year 3 – Late Pre-Operations ... 24
5.3.1 Cyberinfrastructure ... 24
5.3.2 Coastal / Global Scale Nodes ... 25
5.3.3 Regional Scale Nodes ... 25
5.3.4 Education and Public Engagement ... 26
5.4 Year 4 – Early Operations ... 26
5.4.1 Cyberinfrastructure ... 26
5.4.2 Coastal / Global Scale Nodes ... 26
5.4.3 Regional Scale Nodes ... 27

5.4.4 Education and Public Engagement 27
5.5 Year 5 – Interim Operations 27
5.5.1 Cyberinfrastructure 28
5.5.2 Coastal / Global Scale Nodes 28
5.5.3 Regional Scale Nodes 28
5.5.4 Education and Public Engagement 29
6 OOI Full Operations and Maintenance 30
6.1 Operations 30
6.1.1 Overall Operations Concepts (Sustaining Operational Capability) 30
6.1.2 Operational Concepts Applied to Ocean Deployments 30
6.1.3 Policies & Procedures 33
6.1.3.1 Cyberinfrastructure 33
6.1.3.2 Coastal / Global Scale Nodes 35
6.1.3.3 Regional Scale Nodes 37
6.2 OOI Maintenance 40
6.2.1 Cyberinfrastructure Maintenance 41
6.2.2 Coastal / Global Scale Nodes Maintenance 47
6.2.3 Regional Scale Nodes Maintenance 50
▪ Transmission Facilities 50
• Support Facilities 53
▪ RSN Level 1 Process 57
▪ RSN Level 2 Process Flows 57
▪ RSN Level 3 Process Flows 58
▪ RSN Level 4 Process Flows 59
6.3 Operational Data Policy 59
6.3.1 Cyberinfrastructure 59
6.3.2 Coastal / Global Scale Nodes 59
6.4 Calibration Plan 62
6.4.1 Coastal / Global Scale Nodes 63
6.4.2 Regional Scale Nodes 63
6.5 IO Specific Sparing & Service Life Replacement Strategies 64
6.5.1 Cyberinfrastructure 64
6.5.2 Coastal / Global Scale Nodes 64
6.5.3 Regional Scale Nodes 65
6.6 OOI User Support and Helpdesk 67
6.6.1 Cyberinfrastructure 67
6.6.2 Coastal / Global Scale Nodes 67
6.6.3 Regional Scale Nodes 68
7 OOI Proposal Management (Draft) 70
7.1 Definitions: 73
8 O&M Program Metrics 74
9 OOI Operations Budget 75
9.1 High Level Assumptions 75
9.2 Budget Overview 76
9.3 Transitions from Construction to O&M that have budgetary impact 76
10 Staffing Outline for O&M 78
10.1 Consortium for Ocean Leadership Staffing Plan 78
10.2 CI O&M Staffing Plan 80
10.3 CGSN O&M Staffing Plan 82
10.4 Regional Scale Nodes O&M Staffing Plan 84
11 Security 87
11.1 Cyberinfrastructure 87
11.2 Coastal / Global Scale Nodes 87
11.3 Regional Scale Nodes 87
11.3.1 Physical Security 87
11.3.2 Data Security 88

11.3.3 Operational Security ... 88
12 Environmental Health & Safety ... 90
13 Quality Assurance & Quality Control ... 91
13.1 PMO ... 91
13.2 Cyberinfrastructure ... 91
13.3 Coastal / Global Scale Nodes ... 91
13.4 Regional Scale Nodes ... 91
13.4.1 Quality Plan ... 91
14 The Educational Component of Operations and Maintenance ... 93
Appendix A: Operations and Maintenance Requirements ... 94
Appendix B: Concept for Future Pioneer Array Deployment ... 95
Appendix C: OOI Program Assumptions ... 96
Appendix D: Data Management Plan ... 107
Appendix F: OOI Organizational Charts ... 108
Appendix F: OOI Organizational Charts ... 109
Appendix G: Acronyms ... 115

1. Introduction

1.1 Purpose and Scope

The purpose of the Ocean Observatories Initiative (OOI) Operations and Maintenance (O&M) Plan is to establish a structure in which the Consortium for Ocean Leadership (OL) and the OOI Implementing Organizations (IOs) can document the responsibilities and processes for governance, daily operations, maintenance, administration, reporting, and the creation of policies and procedures. It is the intent of this document to identify how the various activities, both common and unique, are coordinated among OL and all the IOs of the Ocean Observatories Initiative. The initial OOI O&M requirements upon which this plan is developed are listed in Appendix A and will be expanded upon as the system is implemented and policies are identified.

The O&M Plan documents and describes the management of the operational aspects of the OOI infrastructure. The Plan also documents how policies and processes, that govern the Marine and Cyber Infrastructure IOs, are implemented.

This Plan supports a hierarchical governance approach that places policies, procedures and decisions with the responsible entity at an appropriate level. Unless otherwise stated, policies and procedures are generally approved at one level above the responsible entity.

This document describes the O&M management organization and the management of documents, processes and procedures that guide O&M. Operations and Maintenance of the OOI will continue for twenty-five years or more after the OOI systems and subsystems are deployed. O&M will require changes to policy, processes and procedures throughout the system lifecycle. These changes will be reviewed, approved and documented by the appropriate responsible entities, as identified in this plan. . Supporting documents that are referred to within this plan are listed in Section 2.

1.2 Integrated O&M Strategic Goals

The OOI has established a set of strategic goals to guide Operations and Maintenance. These goals lead to the development of policies and processes to meet program performance milestones and incorporate improvements in both operations and financial management through the lifetime of the program. The goals of an integrated O&M plan are to:

- Maximize availability of high quality data from all components of the OOI.

- Adapt O&M approaches as the OOI infrastructure evolves in response to scientific or budgetary requirements.

- Govern and execute operations that ensure inclusion of the broader scientific community.

- Minimize O&M costs.

- Modify operational or maintenance processes based on the operational state of the network.

- Expedite decision making and conflict resolution.

1.3 Description of OOI Network

The OOI consists of multiple integrated systems that provide sustained, high-quality measurements of many air-sea, ocean, and seafloor parameters across a range of spatial scales. The integrated observatory systems will permit scientists to apply these data to a wide range of scientifically and socially critical topics in areas as diverse as climate change, ocean acidification, ecosystem health, carbon cycling, and seafloor volcanism that supports novel life forms, while also providing essential time series observations of multiple ocean processes and providing the capability to detect specific short-lived events (e.g. earthquakes, storms, plankton blooms). This observatory system consists of fixed and mobile platforms at multiple locations, with each platform designed to support a broad array of instruments, all connected and controlled via a sophisticated communications and computation framework.

The planning, design, development and implementation of the OOI is founded on the need for sustained observations of multiple parameters and processes in the ocean and through the seafloor via an infrastructure that can be extended and expanded in response to the evolution of social and scientific priorities over the next twenty to thirty years. The operations and maintenance of the OOI therefore must support the *two principal scientific and research mandates* that are the basis for its construction:

1) Sustained delivery of high-quality data for two to three decades;
2) Expandability of the infrastructure to support new capabilities.

The OOI management objective is to fulfill these two mandates with the most *cost-effective* approach for operations and maintenance across the observatory network. This document defines the integrated approach that the OOI Operations and Maintenance (O&M) team will use to meet this management objective.

1.3.1 Functional components of the OOI

The OOI is an integrated system of systems with capabilities for: measurement of ocean and seafloor properties and processes; integration and storage of the resulting data; displaying and providing access to the data, in a variety of forms, to the user community.

Although managed and coordinated at the system level by the Program Management Office (PMO) at Ocean Leadership (OL), the OOI has specific components that are the responsibilities of the following OOI Implementing Organizations (IOs) through the phases of construction, transition into operations, and post commissioning into full operation and maintenance.

Cyber Infrastructure (CI) – The University of California at San Diego (UCSD) provides the communications, storage and computational capabilities framework for real-time and near real-time access to all the data from the distributed sensing assets of the OOI, along with the capabilities to manage and interact with the all of the various distributed components of the system (instruments, computational and storage elements).

Coastal/Global Scale Nodes (CGSN) – The Woods Hole Oceanographic Institution (WHOI), with partners Oregon State University (OSU) and Scripps Institution of Oceanography (SIO) provide advanced sensing platforms (moored and mobile) at four high-latitude sites (Global) and at coastal sites off the Pacific Northwest (Coastal Endurance Array) and in the mid-Atlantic Bight (Coastal Pioneer Array). All platforms will carry physical, biological, and chemical sensors, and will characterize ocean properties and processes from the air-sea interface to the seafloor. All data will be integrated into the system and readily accessible through the CI framework.

Regional Scale Nodes (RSN) – The University of Washington (UW) provides the cabled infrastructure to support the installation of physical, biological, chemical and geological instruments on the seafloor and through the water column at key locations on the Juan de Fuca tectonic plate. This instrument suite will characterize properties and processes from the upper water column to below the seafloor and will be distributed across fixed and mobile platforms. The unique high-power, high-bandwidth capability and expandability of the RSN network will be coupled with the continental shelf moored systems off the coast of Oregon (CGSN). All data will be integrated into the system and readily accessible through the CI framework.

Education and Public Engagement (EPE) - Rutgers, The State University of New Jersey (RSUNJ), with partners University of Maine (UM) and Raytheon Mission Operations and Services, will lead the development of educational capabilities for the OOI and leverage the system's Cyber Infrastructure capabilities by constructing a series of software and web-based social networking tools to engage a wide range of users including faculty, graduate and undergraduate students, informal science educators and the general public

Details of the construction design and construction schedule are available in the OOI Final Network Design (Document No.1101-00000) and OOI Project Execution Plan (Document No. 1001-00000).

1.4 Concept of Operations

The mission of the Ocean Observatories Initiative is to provide long-term, affordable, and reliable access to global-scale, maritime observable phenomena. While specific features of, or operational requirements for, the observatory may change over time, its fundamental mission is to provide high quality data from a robust suite of instruments to support analyses of global trends.

Ocean Observatory data will be collected from a multitude of widely distributed platforms, instruments and sensors to provide a myriad of synoptic datasets. As a result, an investigator can synthesize a nearly infinite combination of relationships to derive correlations among smaller sub-sets of observations. While individual users may only focus on a limited set of observable parameters, the value of the OOI is the unprecedented ability to construct a substantial database of observations and provide real-time access to the entire instrument suite.

To achieve this mission, the OOI must provide a reliable infrastructure to support continuous observations and associated management of acquired data. Further, the OOI must do so at a cost that is affordable for users (i.e. customers) and owners (or sponsors).

Over the OOI life cycle, operational costs will exceed the development and installation costs. Affordability and availability flow from a maintainable infrastructure. To meet these requirements the OOI has established a design philosophy that considers O&M costs as an important criterion to achieving affordability and availability goals. While the technical capabilities of the OOI are of paramount importance to the scientific community, the operational characteristics will largely determine the long-term success of the scientific mission.

The overall operations and maintenance (O&M) phase of the OOI is directed by the National Science Foundation (NSF) and Ocean Leadership who provide necessary governance and program management (see section 3). Within Ocean Leadership, the Observatory Advisory Team (OAT) will provide high-level oversight and policy guidance of OOI-wide operations, advising the OOI O&M Manager (OMM). A second group, the Observatory Operations Team (OOT), chaired by the OMM, with participation by all IOs, will ensure uniform daily operations across the OOI through the implementation and coordination of appropriate policies and procedures.

Although there are four Implementing Organizations directly operating and maintaining the OOI infrastructure, and have specific requirements to achieve long-term data flow, there are parallel operational activities that flow across all components of the program.

Proper coordination of these Cross-IO functions is particularly vital to insuring efficiency of operation and minimizing material expenditures. The Cross-IO functions are addressed within one of four categories which include:

- Common Operations
- Field Operations
- Data Product Management
- Refurbishment and Calibration

To guide the transition from construction to operations and maintenance, four Working Groups (WGs) have been formed to identify and define policies, documents, processes, procedures and associated schedules and costing of the parallel operation activities above. It is expected that the cross-IO and functionality centric O&M WGs will transition into advisory groups for the Observatory Advisory Team (OAT) and Observatory Operations Team (OOT) as O&M processes and procedures become more mature and stable during the post-construction, steady state phase of the OOI lifecycle.

2. Referenced Documents

The following documents are incorporated by reference and reside in the OOI Document Repository:

Table 2-1: Referenced Documents

Document No.	Document Title
3101-00004	CGSN Commissioning Plan
3101-00063	CGSN Cruise Planning
3101-00056	CGSN Deployment/Recovery Operations Procedure
3101-00009	CGSN Environmental Health and Safety Plan
3101-00033	CGSN Integration and Verification Plan
3101-00067	CGSN Property Management Plan
3101-00008	CGSN Quality Assurance Plan
3101-00057	CGSN Ship Scheduling Procedure
3101-00055	CGSN Shipping Procedure
3206-00007	CGSN Site Characterization: Argentine Basin Array
3205-00007	CGSN Site Characterization: Endurance Array
3202-00007	CGSN Site Characterization: Irminger Sea Array
3204-00007	CGSN Site Characterization: Pioneer Array
3201-00007	CGSN Site Characterization: Southern Ocean Array
3203-00007	CGSN Site Characterization: Station Papa Array
1012-00000	CI Cybersecurity Plan
1004-00000	OOI Commissioning Plan
1000-00000	OOI Configuration Management Plan
1006-00000	OOI Environmental Health and Safety Plan
1101-00000	OOI Final Network Design
1001-00000	OOI Project Execution Plan
1011-00000	OOI Property Management Plan
1003-00000	OOI Quality Assurance Plan
1100-00000	OOI Systems Engineering Management Plan
1102-00000	OOI Data Management Plan
4314-00001	OOI-RSN Secondary Infrastructure Spares Plan
4308-00005	OOI-RSN Sensor Maintenance, Risk, and Replacement
4318-00001	Remotely Operated Vehicle (ROV) Strategy White Paper
4016-00001	RSN Commissioning Plan
4011-00001	RSN Environmental Health and Safety Plan
4316-00001	RSN Fouling of Instruments and Infrastructure
4315-00001	RSN Installation Planning Scenarios – Hydrate Ridge
4015-00001	RSN Property Management Plan
4010-00001	RSN Quality Assurance and Quality Control Plan
TOM	Telecommunications Operations Map (TeleManagement Forum process guide book)

3. OOI Organizational Structure & Governance

The O&M governance framework insures that the entire network is operated and controlled as a single entity with consistent program policies and common processes (Figure 3-1). With oversight by NSF, Ocean Leadership serves as the systems integrator for the OOI Network, facilitating communication and common practices across the IO teams that operate the system. Ocean Leadership will lead the Observatory Advisory Team (OAT) to provide high-level management review and policy direction for the OOI. In addition, a second group, the Observatory Operations Team (OOT), will provide the communication and coordination necessary to sustain uniform operations across the OOI through the implementation of appropriate policies and procedures.

Figure 3-1: Operations Framework

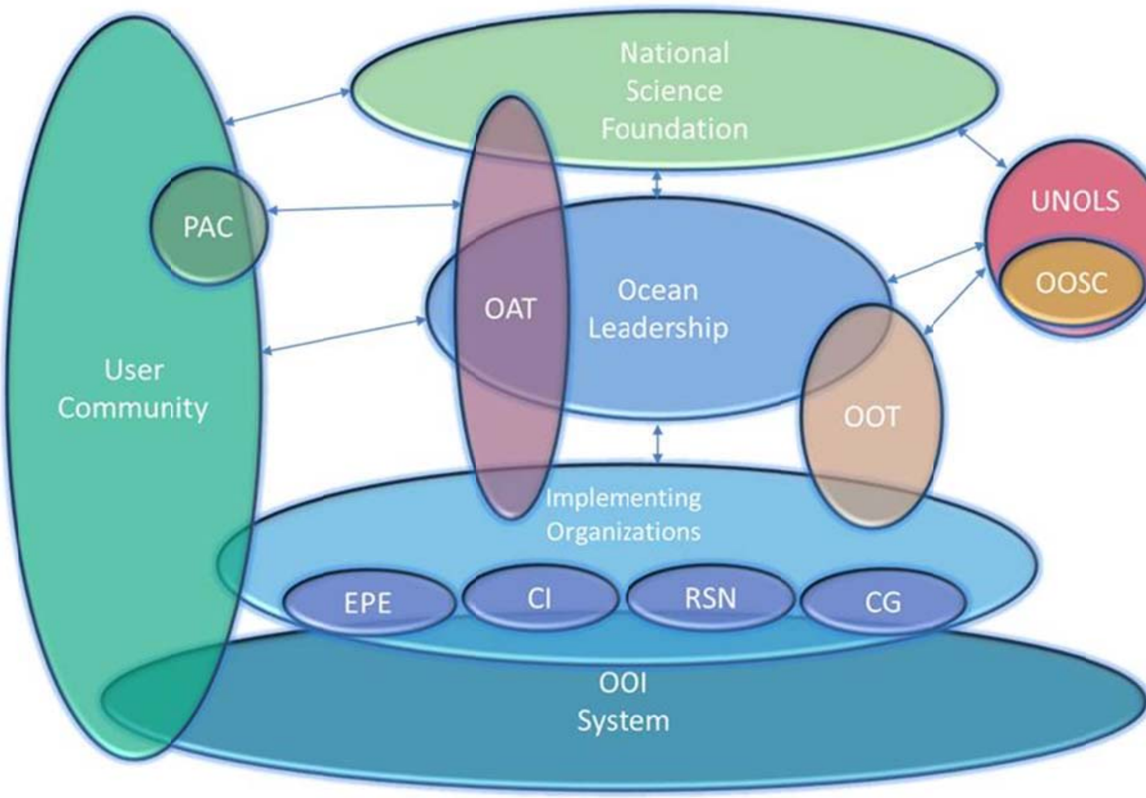

Figure 3-1 Schematic representation of the governance framework for OOI Operations and Maintenance. The OOT (Observatory Operations Team) and the OAT (Observatory Advisory Team), as described in the section below, provide technical and management guidance within the Operational phase of the OOI. Active communication channels will exist among external scientists, advisory groups, the Program Office at Ocean Leadership, and the NSF.

3.1 Ocean Leadership

As the systems integrator for the OOI, Ocean Leadership's project team will have overall responsibility for ensuring that the OOI operates to fulfill the system requirements as expected by the National Science Foundation and for the science community. To meet this commitment, OL will manage the O&M Program with an efficient structure which: implements configuration control of the OOI; monitors and controls the availability and quality of OOI data products; and institutes policies as necessary to formalize accountability, insure compliance with agreements and regulations, and standardizes processes.

3.1.1 Responsibilities

A full-time OOI Operations and Maintenance Manager (OMM) at OL will be responsible for efficiently coordinating O&M activities through the O&M Managers at each IO. The OMM will also participate in the Observatory Advisory Team (OAT) meetings and will lead the Observatory Operations Team (OOT). Ocean Leadership and the OMM will have primary responsibility for a number of activities that insure efficient coordination among the IOs regarding Operations and Maintenance.

<u>Uniform Operations:</u> The OL and the IO O&M Managers are responsible for establishing standardized OOI operations throughout the IOs. As part of this responsibility, OL will continuously review system metrics on performance, availability and reliability, data quality and availability, as well as procedures and documentation to identify real or potential trouble areas and incorporate lessons learned and best practices into the OOI processes and documentation.

<u>Troubleshooting:</u> The CI IO will have primary responsibility for network troubleshooting. The RSN and CGSN will have monitoring and network troubleshooting capability. CI IO will manage the Helpdesk function that will log and report on the status of all reported system problems. The OOT will meet weekly, or as required to review issues of network operations and corrective or mitigating activities that are being performed by the IOs.

<u>Operational Configuration:</u> The OL and the OMM are responsible for insuring the approved baseline operational configuration is maintained. It is also responsible for maintaining a real-time web display of the operational status of each instrument, network, and computational component of the system.

<u>Configuration Management:</u> Ocean Leadership (or other NSF-designated management organization) will oversee the management of the OOI configuration from the time that a final baseline configuration is established, until the system is decommissioned.. Ocean Leadership will chair Change Control Boards (CCBs) and review and approve changes to the OOI configuration in accordance with the OOI Configuration Management Plan (CMP). Ocean Leadership will be responsible for conducting periodic configuration audits of the OOI to ensure that current versions of configuration drawings are being used and that the drawings represent an accurate portrayal of the OOI. The OL Systems Engineer is responsible for ensuring that the deployed assets are synchronized with the network drawings and requirements.

<u>Control documents:</u> The OL Systems Engineer (SE) is responsible for maintaining the control documents in a readily accessible and secure location and for tracking and approving changes to these documents.

<u>Approved Instrument List and Data Sheets:</u> The OL SE is responsible for the OOI Configuration and for maintaining approved instrument lists by facility, including an appropriate data sheet for each instrument.

<u>Conflict Resolution:</u> The OL OMM is responsible for resolving conflicts with sites, ports and assignments, and power and network bandwidth allocation during events. In most cases, OL will have pre-planned likely scenarios, working through the OOT forum, but it may be asked to intervene in real-time situations.

<u>Ownership:</u> Ocean Leadership will assume ownership of all equipment /materials and supplies and services following official acceptance, as described in the OOI Commissioning Plan. Similarly, OL will assume ownership of the OOI Network on behalf of the NSF following system acceptance. A legal white paper, commissioned by the Joint Oceanographic Institutions (JOI), recommended this approach to the

JOI Board of Governors (prior to formation of the Consortium for Ocean Leadership) on October 26, 2006. The Board of Trustees of the Consortium for Ocean Leadership unanimously approved this approach on May 28, 2009.

Asset Inventory: OOI will be constructed using NSF (Federal) funds and other institutional contributions. It is imperative that OL maintain an accurate and current inventory of all OOI property and equipment purchased with government funds for use on the OOI. Ocean Leadership has the primary responsibility for instituting a property and equipment management system that meets 45 Code of Federal Regulations (CFR) requirements, NSF Astronomy and Astrophysics Research Grants (AAG), Chapter I, Section D Property and Management Standards, and various Office of Management and Budget (OMB) Circular (A-21, A-87, A-110 and A-122) property management requirements. The IO sub awards require implementation of property management systems in compliance with the above referenced regulations. The IOs have submitted Property Management Plans to OL to demonstrate their ability to comply with Property Management requirements. The OL Property Management Plan describes how Ocean Leadership will audit each IO's implementation of their Property Management Plans and ensure that OOI property is managed in accordance with federal regulations.

Insurance: As the OOI facility owner, OL will be responsible for obtaining adequate insurance coverage for the OOI assets and for any maintenance or legal agreements that might require payments to be made. Ocean Leadership is currently working with insurance underwriters to evaluate the risks and costs associated with insuring the post-deployment OOI systems and equipment.

Legal Agreements: As the facility owner, Ocean Leadership will be named on, and incur responsibilities under, permits, cable crossing agreements, and other legal documents under regulatory statutes. OL will be responsible for reviewing, approving, and signing all such agreements and will assume liability for any obligations of the agreements, even though the responsibility for negotiating and executing these agreements may be delegated to the IOs.

Partnerships / Agreements / Understandings: Ocean Leadership will be responsible for establishing and maintaining collaborative relationships and partnerships with international, intergovernmental, commercial, and academic entities on behalf of NSF and the OOI entities. These relationships and partnerships may take the form of Memoranda of Agreement or Memoranda of Understanding with these parties.

International Cable Protection Committee (ICPC): Ocean Leadership will be responsible for maintaining membership in good standing with the ICPC, which advocates for owners of submarine cable assets.

Annual Review Meeting with PAC (Program Advisory Committee), NSF, and User Community: Ocean Leadership will be responsible for coordinating an annual operational review meeting for the OOI that engages the user community.

3.1.2 Policies

Ocean Leadership's Ocean Observing Program Office proposes and maintains OOI operation policies and procedures in coordination with the NSF.

Ocean Leadership will institute policies as necessary to formalize accountability, insure compliance with agreements and regulations, and to standardize processes across OOI. A formal Policy review and approval process will be implemented through the OAT and approved policies maintained in the OOI Document Control System. The following are examples of policy categories that will fall under the purview of the Ocean Leadership.

- Asset Management
- User Community Outreach
- Configuration Management
- Insurance Types and Levels

3.1.3 Procedures

Procedures identify the process by which a policy is implemented. Generally, procedures are developed by the group that must implement the policy and be approved by the policyholder. For IO level procedures this would mean review by the OOT forum. For OOI level procedures, OL will seek approval from NSF and the Board of Trustees through the OAT forum.

3.2 Observatory Advisory Team (OAT)

3.2.1 Proposed Membership

The Observatory Advisory Team (OAT) will be chaired by the Ocean Leadership Principal Investigator. Membership will consist of representatives from the National Science Foundation, two Non-OOI representatives, the OL O&M Manager and the Principal Investigators (PIs) of the IOs. The chairperson will establishing regular meetings and agenda items that will determine what additional representatives should attend in an *ex-officio* role.

3.2.2 Responsibilities

<u>Oversight and Guidance:</u> The OAT is responsible for providing high-level management review and direction for the OOI. It sets priorities for meeting established science objectives, and resolves issues brought to it by the OOT. It is also provides the OOI Policy review and approval forum.

<u>Metrics Setting:</u> The OAT is responsible for determining what metrics need to be established and collected for the OOI Network. It will collate and review these metrics on a regular basis and use them as an impetus for process improvement. The selection of metrics, and their use in assessing network performance, will be reviewed periodically.

<u>Upgrade Planning:</u> The OAT is responsible for establishing what level of resource usage will trigger the planning and funding for upgrades. It will monitor and review this usage level on a regular basis.

<u>Expansion Planning:</u> The OAT is responsible for determining when the footprint of the OOI needs to be expanded to continue innovative science. It will monitor science results and publications, plan, and prioritize expansion plans.

3.2.3 Policies

Samples of the kinds of policies that will fall under the purview of the OAT are listed below.

Data Policy (see Appendix E)
Conflict of Interest Policy
End of Life Policy (OOI Network)
Classes of Users (Rights, Privileges, and Obligations; QA/QC) OOT
Policy for Changes in Instrument Settings OOT
Policy on Resource Management (Instrument Removal and Automatic Instrument Removal)
Maintenance Policy OOT
Policy on Charging for non-NSF users
Communication Policy – both internal and external
Metrics Policy
Review Policy
Policy on System Upgrades (Add more power and bandwidth, new type of buoy, etc.)
Policy on System Expansion (Add more nodes)
Policy on Acceptable Use of the System

3.2.4 Procedures

Procedures identify the process by which policies are implemented. Generally, procedures are developed by the group that must implement the policy and be approved by the policy holder. Types of procedures are:

Request to Change User Class
Statistical sampling procedures OOT
Inspection procedures OOT
System test procedures OOT

3.3 Observatory Operations Team (OOT)

3.3.1 Proposed Membership

The OOT is chaired by the OMM and consists of the O&M managers from each IO. Membership would also include Project or Operations Managers and Science Representatives from each IO and System Engineering Representation from OL. The OMM will be responsible for establishing regular meetings.

3.3.2 Responsibilities

<u>Communication of OOI Operations and Maintenance Status</u>: The OMM will be responsible to maintain frequent communications with IO O&M Managers to discuss unscheduled events and system availability issues, supporting a rapid troubleshooting process, and maintaining accurate OOI capabilities status for users.

<u>Commissioning Review and Approval:</u> The OOT is responsible for ensuring that the OOI facility has a common commissioning process for hardware, software, and instruments.

<u>Initial:</u> The OOT is responsible for reviewing the Operational Readiness Test plan and results for all new hardware and instruments.

<u>Following Maintenance:</u> The OOT is responsible for reviewing test results on hardware and instruments following maintenance to determine readiness for re-activation.

<u>Decommissioning Review and Approval:</u> The OOT is responsible for ensuring that the OOI facility has a common decommissioning process for hardware and instruments.

<u>Annual Work Plan (AWP) and Budget:</u> The OOT is responsible for reviewing the annual operations work plan and budget for the upcoming year. The work plan informs and communicates the OOI Network plans to the broader scientific community.

<u>Liaison with UNOLS:</u> The OOT will aggregate and forecast the UNOLS ship and Remotely Operated Vehicles (ROV) requirements for the OOI and determine how best to coordinate and communicate with UNOLS.

<u>User Training:</u> The OOT will coordinate with communications and outreach staff at the PMO and IOs to facilitate the preparation of user training classes, materials and information manuals for all classes of users and for scientists wishing to develop an instrument for deployment in the OOI. These should include cost estimates of the full process from required pre-deployment tests to commissioning.

<u>Assessment of Feasibility of Science Proposals for NSF:</u> The OOT is responsible for determining what information NSF, and a feasibility committee, may need to evaluate the technical readiness of science proposals and for implementing a means of meeting those needs.

<u>Operational Uniformity: The</u> OOT will endeavor to sustain uniform operations across the OOI through the development of appropriate policies and procedures. The OAT reviews and approves policies and

procedures promulgated by the OOT, and the OOT is responsible for maintaining and adhering to those approved policies and procedures.

3.3.3 Policies

The following are samples of the kinds of policies that will fall under the purview of the OOT. As the system matures some of the policies on the list may be moved to another operation group that the OAT deems as more appropriate to hold the policy.

Configuration Management Plan
Document Control Policy
Re-activating after Maintenance Policy
Approved Instrument Policy, including Data Sheet for U.S. Navy when applicable
Decommissioning Policy
Security Policy

3.3.4 Procedures

Procedures identify processes by which policies are implemented. Generally, procedures are developed by the group that must implement the policy and approved by the policy holder.

Conflict Resolution Procedure
Process for Adjusting the Annual Work Plan
Network Upgrade Procedures
Network Expansion Procedures
Procedure to Add Instruments (including Navy procedures where applicable)
Procedure to Remove Instruments, including Navy procedures where applicable
Instrument Activation Procedure to become an Approved Instrument (e.g., Dry Test, wet tests, security information to Navy)
Procedure to Change an Instrument Setting
Procedure for Resource Sharing

3.4 Program Advisory Committee (PAC)

The PAC works directly with the Program Director for Ocean Observing Activities at COL and formally reports to the Executive Committee of the Board of Trustees of Ocean Leadership on a regular basis.

3.4.1 Responsibilities

The PAC is the primary consultative group for the Program Director for Ocean Observing Activities at OL. It provides leadership on scientific and educational issues relating to and involving the OOI facility. It also provides strategic planning on science programs catalyzed by the OOI.

3.5 University-National Oceanographic Laboratory System (UNOLS)

3.5.1 Responsibilities

An objective of UNOLS is to coordinate and review the access to and utilization of facilities for academic oceanographic research. UNOLS makes appropriate recommendations of priorities for replacing, modifying or improving the numbers and mix of facilities for the community of users. Emphasis is placed on ships and other seagoing facilities.

Marine IOs within OOI and the OOT will have ongoing communication with UNOLS to insure availability of UNOLS vessels and other resources to support OOI cruise plans and schedules.

4 OOI Operations and Maintenance Integration

4.1 Identification and Development of Integrated O&M Activities

Throughout each operational year, the OOI O&M policies and procedures shall be reviewed, updated, and utilized in the budget creation and program management processes to insure that the primary mandates of the program are being met in the most cost-effective manner. Such reviews will incorporate the lessons learned from each previous operational period.

At the O&M NSF review of Year 1, it was proposed that four O&M Working Groups (Figure 3.1) be formed to enhance cross IO collaborative process development. These groups include 1) Common Operations 2) Field Operations 3) Data Product Management and 4) Refurbishment and Calibration. The O&M WG ongoing mission is to focus and catalyze the process of developing the O&M plans and processes, with integration across the IOs, and to bring a detailed understanding of these plans and processes to bear on the development of the BOEs, AWPs, and budgets. The support for these groups will be provided starting in Year 2, and the groups will continue through the transition to O&M into the early years of O&M to support the evolving maturation of O&M plans and processes. At the highest level, these groups support the goal of delivering the highest quality science products, safely, at the lowest possible operating cost. In doing so these Working Groups will work to:

- Develop procedures collaboratively with subject matter experts
- Establish common procedures across IOs
- Create sustainable O&M processes for the field operations of the Marine IOs
- Create a culture of continuous process improvement, and
- Support the provision of clear objectives and governance for O&M.

Figure 4-1: O&M Working Groups

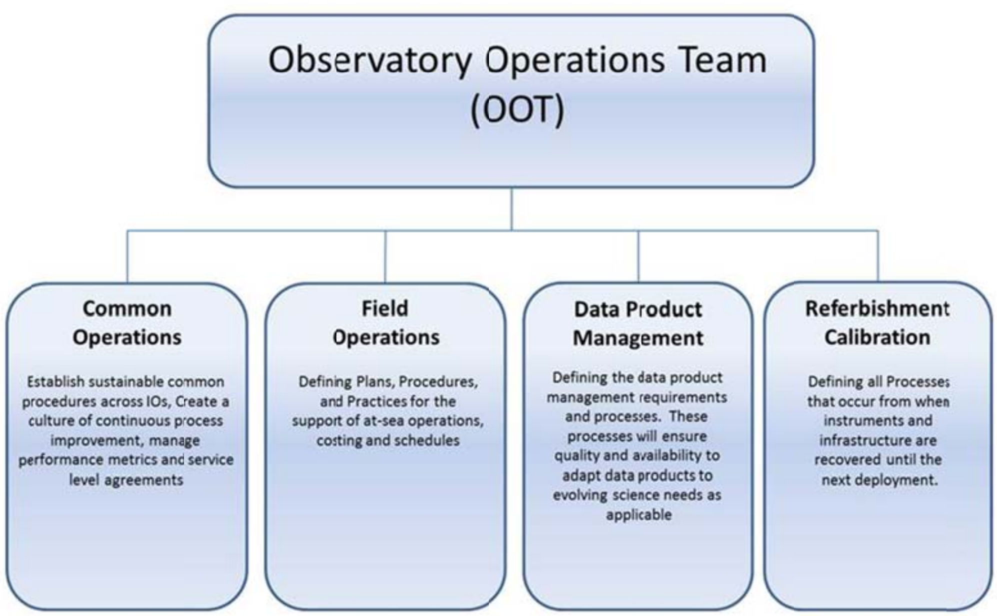

Figure 4-1 shows the four Working Groups and their specific charges.

These groups became active in Year 2, with 2 FTE (Full Time Equivalent) in RSN and 3 FTE in CGSN (one each at WHOI, SIO, and OSU). In Year 2 work will focus initially on establishing governance and working group leadership structure, identifying long term working group members, who will then identify critical processes to be addressed in each Working Group. Deliverables for Year 2 include: establishment of the Working Groups, development of governance structure, identification and categorization of processes by functional area, definition and prioritization of Working Group deliverables, and initiation of quarterly Working Group meetings, the first to be held in January 2011.

4.1.1 O&M Transitional Working Groups

The Common Operations Applications Working Group

This group is responsible for delivering common operational policies, processes and procedures that support the operation of the OOI Observatory as a single system. Part of this responsibility is to define the MREFC build to O&M "operations handoffs" (transition to operations), including acceptance & commissioning and identifying transition gaps and resolutions.
Deliverables from this group include recommendations for process, data and tool requirements in the following areas:

- <u>Operational Financial Processes</u>
  Develop transparent financial operational management and reporting procedures and policies, including O&M procurement, vendor management (support contracts), Life cycle procurement processes; Asset & property tracking.

- <u>User Support</u>
  Develop integrated user management and reporting procedures and policies for internal and external OOI users; including OOI system issue identification, assignment, tracking, resolution, and user satisfaction metrics; New services requests (e.g. analysis and consultation for adding PI new sensors); technical support requests for existing users.

- <u>Operational System Management</u>

  a. Develop integrated system operations and reporting procedures for the OOI system, including: system health management; access/permissions definitions; performance metrics.
  b. Operational control of OOI assets, including: profiler operations; glider mission planning; adaptive sampling at instrument/sensor level; notification and tracking of maintenance activities, including planned and unplanned maintenance, service history and alerts.

- <u>Programmatic Annual Processes</u>
  Develop an annual programmatic process and timeline to effectively coordinate cross IO activities supporting OOI work planning and funding, including the Integrated O&M Plan, annual and out years schedule and budget, and coming project year AWP.

The Field Operations Working Group

This group will develop common field procedures across the IOs. Its deliverables address Process, Data, and Tool Requirements for:

- Cruise Planning
- Cruise Staffing
- Permitting
- Field Facilities
- Field Equipment
- Field Transportation
- Field Sampling

The Data Product Management Working Group

This is the working group responsible for identifying/defining the data and data product management requirements and processes of the OOI in the operational phase of the project. These processes will ensure data quality and product availability, as per the OOI documents, and the ability to adapt the OOI data products to evolving science needs as applicable. Responsibilities include:

- Stewardship of Data Management Plan (DMP)
- Maintenance of Data Product List (DPL)
- Maintenance of Data Product Algorithms
- Maintenance and improvement of data product QA/QC and calibration/validation procedures
- Maintenance of OOI sampling strategy plan
- Seek and implement community input/needs into above tasks, e.g. annually or as necessary

The Refurbishment Manufacturing Working Group

This group will develop common refurbishment procedures for marine assets. For this group, deliverables include process, data, and tool requirements for:

- Refurbishment Manufacturing (restart)
- Instrument Calibration Procedures
- Sustaining Engineering
- Material Planning and Procurement
- Material QA (Supplier Corrective Action as needed)
- Inventory Management
- Equipment Life Cycle Management
- Facilities Maintenance
- Assembly, Inspection and Test of Equipment, Tooling and Fixturing (test harnesses, jigs, etc.)

Each Working Group will have representation from CI, CGSN, RSN and EPE IOs. The Working Groups will report out quarterly, addressing priorities determined by the OOT. In recognition of the transition to O&M, the Working Groups will focus on maturation of the O&M plan. They will work to create common templates, tools, and language and to address metrics, risk management, and ongoing O&M plan updates.

The primary intent of the Working Groups is to expedite the early development of underlying O&M processes and plans. Additionally, over the long term these teams will create and foster a culture of continuous process improvement. The OOI O&M management plans to enable continuous process improvement by feeding back lessons learned and encouraging OOI-wide adoption of best-practices. This will be accomplished through the use of common templates, tools, and language, by ensuring that procedures become controlled documents, and by enforcing common repository and version control. Key process metrics will be established to monitor and evaluate process performance, and will be reviewed periodically for improvement opportunities.

These Working Groups will participate in the annual updates of this Integrated O&M Plan.

4.2 IO Specific O&M Activities

There are differences in the specific responsibilities assigned to each IO derived from the differences in in their assigned components of the OOI. This section describes some of these IO specific activities.

4.2.1 Cyberinfrastructure (CI)

The Cyberinfratstructure Implementing Organization provides the communications, storage and computational capabilities for real-time and near real-time access to all the data from the distributed sensing assets of the OOI. . It maintains the Information Technology (IT) assets that connect sensors with data repositories. It also maintains the capabilities to manage and interact with the all of the various distributed components of the system, to obtain data and sensor status

Observatory Execution Facilities (OEF) are brick and mortar facilities, provided by telecommunications vendors, where OOI rents floor space on a square footage basis. Cyberinfrastructure equipment is installed at each OEF location, provided power and telecommunications connections, locked in a secure cage, and left to run in an unmanned “lights off” mode. This equipment provides the interface between CI and the Marine Observatories by hosting Cyberinfrastructure Point of Presence (CyberPoP) software.

Facility requirements including space, power, heating, air conditioning, computer resources, available communications, transportation, and other standards are factors in assessing the site facilities. Facility space requirements include initial staging and integration space, operational and maintenance equipment and spares storage as well as maintenance, operation, and administrative work areas. Pre-installation site survey results recommend system requirements for the baseline Cyberinfrastructure System as well as recommendations for potential site enhancements, if necessary.

4.2.2 Coastal / Global Scale Nodes (CGSN)

The Coastal / Global Scale Nodes (CGSN) component will operate and maintain two coastal arrays and a global array. The work includes equipment calibrations, refurbishment and replacement, as well as the monitoring of status, and delivery of data in near real time and in delayed mode to CI.

Each CGSN array is supported by two sets of hardware. The first is built and deployed under the Major Research Equipment and Facilities Construction (MREFC) funding. The second, labeled “Operational property”, is built under O&M funding. The requirement for two hardware sets is driven by the need, during the first turnaround (recovery and redeployment) at each site, to have a complete set of fresh hardware to install. This allows the site to be re-established independent of any loss or failure in the first deployed set of equipment. It also allows the first set of hardware to be returned home for post-deployment procedures (data downloading, instrument post-calibration, failure analysis, refurbishment, updating). On each subsequent deployment, each set of hardware, will alternately be placed in the water, or removed from the water for refurbishment. There are other advantages to acquiring both sets of equipment together, such as reduction in manufacturing and shipping costs as well as the availability of the second set for test and burn-in well in advance of shipping dates.

The Coastal Arrays operated and maintained by CGSN include the Endurance Array and the Pioneer Array.

The Endurance Array, located off Oregon and Washington, consists of two lines of coastal mooring arrays that will be deployed for the duration of the OOI. One line of moorings is located off Newport, OR and the other off Grays Harbor, WA. Each Endurance mooring line has two moorings at each of three sites, at water depths of 25m, 80m, and 500-600m. The 80m and 600m sites of the Newport line each have one of the two moorings physically connected to the RSN cable. The other Newport line moorings and those of the Grays Harbor line are not connected to the RSN cable. The Endurance moorings not connected to the cable will be serviced each spring and fall, with a University-National Oceanographic Laboratory System (UNOLS) vessel used to deploy new moorings and recover the previously deployed moorings. The moorings connected to the RSN cable will be serviced in collaboration with RSN operations once per year, with a second service visit each year not requiring access to the cable connection. The Endurance Array's six gliders will be serviced every 2-3 months from a chartered small vessel. Endurance Array data flows through the RSN cable with latency of <1 second, via satellite and RF telemetry, and via internet for delayed-mode data recovered from instruments after recovery.

The second coastal array, the Pioneer Array, is planned for an approximately 5-year long deployment off the mid-Atlantic Bight. The intent of the Pioneer Array concept is to have an array that can be relocated to other costal sites at the request of the NSF in response to community input. The CGSN component is responsible for the operations and maintenance of the Pioneer Array at the initial mid-Atlantic Bight location, including calibrations, refurbishment and replacement, monitoring of status and function, and delivery of data in near real time and in delayed mode to CI. It is also responsible for documenting the steps required to relocate the Pioneer Array to another coastal location. The Pioneer Array includes 10 moorings (three surface moorings, five moored profilers with surface expressions, and three surface piercing profilers). Bottom platforms called multi-function nodes are placed at the foot of each surface mooring and attached by cable; two of these multifunction nodes will have docking stations for AUVs. Three AUVs will be deployed in and around the Pioneer Array, and six gliders will sample in a region including the moored array. Spring and fall cruises on UNOLS vessels will service the moorings, deploying new hardware and recovering previously deployed hardware. Four to five times per year additional cruises on smaller, non-UNOLS vessels will recover and redeploy gliders and AUVs. Data will flow from the Pioneer Array in near-real time via satellite telemetry and delayed mode data will be provided to CI via internet when instruments are recovered.

The global array includes four nodes: Ocean Station PAPA in the Gulf of Alaska, Irminger Sea off Greenland, Argentine Basin, and 55 South, at 55°S, 90°W, west of southern Chile. Each global node will have four moorings and three gliders. The global nodes will be serviced once per year at the optimum time of year when the combination of wind, waves, and occurrence of gales are most favorable. The two northern hemisphere sites will be visited with UNOLS vessels in the northern summer and the two southern hemisphere sites will be visited with UNOLS vessels in the southern summer. The four moorings at each node include a surface mooring, a profiling mooring equipped to sample the whole water column, and two subsurface moorings called flanking moorings. At PAPA the surface mooring is to be provided by NOAA PMEL (National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory), and that mooring will be serviced independently of the OOI resources at PAPA. The gliders at each global node will collect data from instruments on the subsurface flanking moorings. The gliders will transmit those data together with their own data via satellite. The profiler mooring will have a surface expression for data telemetry via satellite, and the surface mooring will also send data via satellite telemetry. The higher volume of internally recorded data will flow into the OOI network subsequent to instrument recovery.

In addition to the core infrastructure, additional instruments from external investigators will be supported per policies and procedures outlined in this document. CGSN will provide technical assistance and space at WHOI, OSU, and SIO in support of the O&M of such additions.

From an operational standpoint, CGSN O&M activities are mapped to personnel responsible for their conduct. With respect to the Integrated Observatory, the CGSN has two roles: one as a Marine Operator supplier of data (science and status) and one as a data user receiving lower level data for application of data QA/QC standardized processes in support of advancing the data level to more complete status.

4.2.3 Regional Scale Nodes

Located in the Northeast Pacific, the RSN component of the OOI will address plate-tectonic and mesoscale oceanographic processes using an integrated regional-scale infrastructure that represents a unique portion of the overall OOI system where coastal, regional, and global components are operating in close proximity. This will allow multiple process studies to be both spatially and temporally coherent at the scales of many of the processes involved. The Coastal program's Endurance Arrays will be on the margin-side of the RSN cable network. The Newport Endurance Line Extension will be directly attached to the RSN. Juxtaposing Station Papa and the coast arrays with the cabled RSN will enable examination of a broad spectrum of transient, triggered, and long-term changes that will have identifiable effects and consequences ranging over scales of meters to hundreds of kilometers and seconds to decades.

The RSN will be able to provide the ocean sciences community with virtually unlimited bandwidth and considerable electrical power that will enable real-time, remote collection of decadal-scale time-series measurements encompassing an entire tectonic plate, a major coastal upwelling system, a highly variable divergence zone between two North Pacific gyres, one of the most productive fishing areas in the world's oceans, boundary currents on the east and west coasts, and hundreds of kilometers of volcanically and seismically active plate boundaries that focus fluid convection through the crust, which support novel microbial ecosystems on and within the seafloor. The RSN will be installed in the Northeast Pacific Ocean on the southern two-thirds of the Juan de Fuca Plate, with the complementary 800 km cabled North-East Pacific Time-Series Undersea Networked Experiment (NEPTUNE) Canada system covering the northern third.

The backbone infrastructure of the RSN will comprise ~900 km of Electro-Optical (EO) cable, providing high power (10 kW/node) and high data rates (10 Gbps/node) and a time base accurate to within 10 microseconds to Primary Nodes located at two sites chosen for their proximity to diverse tectonic features and water column settings as described below.

Primary Nodes will support multiport expansion nodes, which will extend power and communications capacity to future experiments. The infrastructure will also support multiport science nodes, that step down the voltage and communications to variable lower levels (e.g., 375 V and 1 Gbps) for ease in conversion to instrument-specific input specifications. Benthic junction boxes will further provide various common input/output levels for oceanographic instruments and platforms. In concert, this secondary infrastructure provides expansion capabilities of 100km from the Primary Node locations that will support multiple user experiments or campaigns during the multi-decade life span of the OOI.

The design for the RSN water-column moorings includes four instrumented platforms (benthic package, deep profiler, 200m platform, shallow profiler) to provide measurements through the entire water column. The design comprises an Electro-Optical-Mechanical (EOM) cable anchored to the seafloor, rising to a buoyant platform 200m below the surface. Instruments on the 200m platform provide continuous measurements at this fixed location. A deep profiler samples ocean conditions from the seafloor to the platform depth by traversing the EOM cable. A benthic package will be deployed at the mooring base on the seafloor. Finally, a winched shallow profiler will record conditions between 200m to just below the sea surface. This highly capable mooring concept will rely upon engineering for robustness, lifecycle planning, and effective maintenance.
Education and Public Engagement Implementing Organization (EPE)

4.2.4 Primary Node Sites

The following is a brief summary of the RSN Primary Node sites. The Slope Base, base of Axial Seamount, and the Eastern Caldera sites will host an initial suite of basic seafloor instruments that include a bottom broadband seismometer coupled to a hydrophone, a pressure sensor, and a current meter.

Primary Nodes 1A-D: Slope Base (1A), Southern Hydrate Ridge (1B), Endurance Array (1C,D)

Node 1 is the focus for numerous interdisciplinary studies that address process linkages associated with gas hydrate formation, the flow of carbon from the crust and from the coast to the deep sea, and the connections between biogeochemical processes and climate change in a zone of high biological productivity. RSN cabled infrastructure at this site includes over 200 km of backbone cable and three primary nodes: Slope Base (2930m water depth), Southern Hydrate Ridge (1237m water depth) and Endurance Array (600m water depth). Slope Base hosts a full water column mooring located near the base of the slope. Southern Hydrate Ridge provides access to the gas hydrate site via two instrumented low-voltage nodes, and Endurance Array is the cable connection to the Oregon Endurance Array.

Primary Nodes 3A-B: Axial Seamount Base (3A) and Eastern Caldera (3B)

Axial Seamount is seismically, volcanically, and hydrothermally active, having last erupted in 1998. Infrastructure includes the backbone high-voltage node Axial Seamount Base that is located at the base of the volcano well away from recent eruptions. Axial Seamount Base hosts a low-voltage node that provides communication to the core suite of geophysical instruments nearby and a full water-column mooring; and a 40-km extension cable connecting to primary node and Eastern Caldera located on the southeast summit flank of the volcano providing access to the ASHES vent field and the central northern caldera. A series of low-voltage nodes and medium-voltage junction boxes will support a diverse array of core instruments designed to examine linkages among seismic activity, summit inflation, hydrothermal flow, fluid chemistry, and microbial output and temporal changes in assemblages.

4.2.5 Education and Public Engagement (EPE)

The EPE IO is responsible for the education and public engagement software infrastructure of the OOI program. As the EPE IO the Rutgers team will lead the development of educational capabilities for the OOI and leverage the system's Cyberinfrastructure capabilities by constructing a series of software and web-based social networking tools to engage a wide range of users including faculty, graduate and undergraduate students, informal science educators and the general public. Software will be designed to provide science educators with a suite of tools allowing them to enhance their graduate and undergraduate education activities and engage the general public using ocean observation data from the OOI.

5 OOI Transition to Operations Strategy

The OOI transition to operations strategy has been a major influence on the Project Execution Planning (PEP) from the earliest development stages of the program and remains a dynamic element of the PEP that continues to capture and incorporate best practice concepts as described and illustrated below. (1001-00000 OOI Project Execution Plan)

From the beginning of the MREFC construction phase, and continuing through to steady state, the two largest events that will take place in the lifecycle of each sub-system as well as the entire OOI are: Acceptance and Commissioning (figure 4.1).

Acceptance represents the milestone when a major component has been constructed, tested, readied for deployment, ultimately deployed, and has passed the functional tests. It is then operated in a monitored extended operational state until it, or the higher assembly that it belongs to, is commissioned. (1004-00000 OOI Commissioning Plan)

The Commissioning milestone is performed at the software Release level for Cyberinfrastructure and at the Array level for Coastal Global Scale Nodes and Regional Scale Nodes. When the subject subsystem has passed all acceptance criteria and completed all necessary pre-commissioning "Determination of Readiness" requirements, a Commissioning report and recommendation is signed by OL, and the subsystem is Commissioned. Responsibility for this subsystem is now fully under Operation and Maintenance. (1004-00000 OOI Commissioning Plan)

The OOI has the benefit of developing, documenting and coordinating an effective transition to the operations plan well in advance of the first commissioning scheduled in 2012

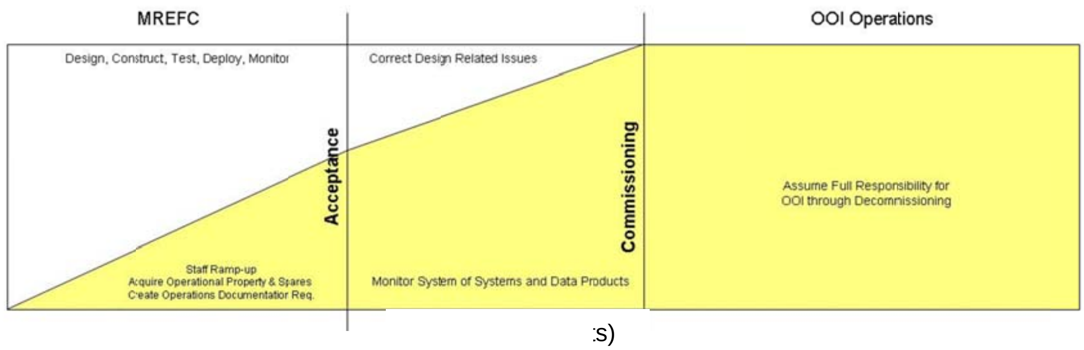

Figure 5-1 Schematic diagram of O&M Staffing through Acceptance and Commissioning.

Figure 5-1 illustrates the gradual increase in operational functionality over a planned time interval that varies with each subsystem subjected to the commissioning process. During the MREFC phase, there is a gradual ramp-up of O&M staffing and expenses as operational processes are placed in readiness for the first deployments. Between acceptance and commissioning, most of the expenses will be borne by O&M, unless corrections must be made between Acceptance and Commissioning. Finally, full O&M responsibility and funding follows Commissioning.

Parallel to the MREFC construction phase, the OOI Operations and Maintenance staff will be acquired at the PMO and IOs. During this first phase, and leading up to the acceptance of a subsystem, the O&M staff will identify the documentation and templates required to capture the information necessary to operate all components of the OOI infrastructure. This will be accomplished by integrating the construction and operations teams and promoting open participation and dialog with the PMO and IO project managers, system engineers, and operations personnel to insure that all operational, health, and safety concerns are accounted for in the developed documentation templates.

The first three years of the OOI project provide the necessary timeframe for interaction between MREFC and O&M to fully develop the parameters that will be used to approve each item during the acceptance and commissioning phases. The details for both of these milestone events will be jointly developed during this period.

The basic elements of the Transition to Operations strategy include:

1. Each OOI array, system and subsystem and its necessary components will be designed, built, tested and deployed under the appropriate MREFC funding.

2. During construction, the OOI Operations and Maintenance Team will be staffed and develop the long-term operations documentation required for all aspects of the OOI. During this process the Acceptance and Commissioning criteria will be fully vetted and accepted by the appropriate OL authority.

3. During the five-year MREFC construction phase, some operational property, such as equipment spares, will be acquired under approved O&M funding.

There are five distinct stages (years) of operational development during the construction of the OOI, each with its own tasks and deliverables. At each stage, the balance between Construction and Operations evolves until Full Steady State Operations is achieved at the end of 2014. The sixth stage, Full Steady State, involves only Operations. Each period discussed takes place from January 1st and runs until December 31st of each calendar year beginning in 2010. The details of each stage, and the associated budgets, will comprise the Annual Work Plan for O&M, submitted to NSF in accordance with Cooperative Support Agreement (CSA) 1026342. In addition to the specific work elements in each of the Annual Work Plans, regular reports will be submitted to the NSF during each O&M stage per the above referenced CSA.

Work on O&M must start in advance of the actual transition from MREFC to O&M. Thus, O&M costs begin starting in Year 1. The O&M work in the early years centers on developing the O&M plans, budgets, processes, and procedures.

Communications: Throughout the lifecycle of the OOI, Operations and Maintenance telephonic / web-enabled meetings will be held weekly. These regular meetings will facilitate the smooth transition to operations during the 5 years of construction. Additional O&M meetings will be scheduled quarterly with all IOs participating to insure that all participants are informed about program-wide O&M activities and the integration of those activities into system operations.

Beginning in 2012, with the initial data flow scheduled to be generated by coastal gliders, frequent communications will be needed between the OL O&M Manager (OMM) and all IOs O&M Managers to discuss unscheduled events and system availability issues, supporting a rapid troubleshooting process and accurate OOI status to users.

The following paragraphs were developed from the 2009 Baseline Schedule, and do not reflect adjustments to O&M staffing that may occur as a result of the 2011 schedule adjustment

5.1 Year 1 – Early Pre-Operations

By the end of this period, the Operations and Maintenance Plan document shall be reviewed and scheduled for necessary changes and updates, adhering to the OOI established change control process. Staffing and personnel adjustments shall be noted and appropriate steps put into place to expedite the addition of needed personnel.

Operations activities at the Program Management Office include, but are not limited to:

- Establish office of Operations and Maintenance within OL and each IO.
- Recruit high-level management staff to support O&M tasks.
- Insure all IO's are in compliance with PMO Conflict of Interest Policy.
- Coordinate O&M Plan refinement between all contributing organizations.

- Monitor the progress of the MREFC construction initiative, and the progress of linked tasks in the O&M project schedule.
- Analyzing and communicating O&M issues and concerns as they arise from the active design and development of the construction phase.
- Refine and submit the Year Two Annual Work Plan.

Many of the tasks related to year one involve staff recruitment and may have long lead times, therefore all recruitment activities should be scheduled as early in the year as possible to mitigate this risk. By the end of Year 1, the core operations staff and infrastructure will be in place and ready to coordinate with the MREFC engineers and related staff members.

5.1.1 Cyberinfrastructure

Release 1 Data Distribution Network provides a fully capable automated end-to-end data preservation and distribution infrastructure, supporting the immediate needs of instrument providers and observational data consumers.

Year 1 tasks for the CI include the following tasks:

- Hiring the key operational staff to build out the computer, network and communications infrastructure and provide the preliminary basis for end-user support.
- Hiring software developers to support the Use Cases for Architecture and Design, Sensing and Acquisition, Data Management, Common Operating and Infrastructure, Common Execution Infrastructure, Integration and Test components.
- Planning for building the CyberPoPs and getting the Wide Area Network operational.
- Creating trusted relationships with key commercial and academic vendors to take advantage of elastic computing (dynamic resource allocation across the cloud) and computational resources.
- Developing the first iteration of the user experience and interaction with the system.
- Ingestion of oceanic data from key modelers to gain experience in using the system.
- Development of the policies and procedures needed to run a distributed grid environment for the oceanographic community.
- Building the instrument agents and processing models to accept and process data from the instruments coming on board in Year 2.

5.1.2 Coastal / Global Scale Nodes

CGSN component activities for this period are focused on establishing the CGSN O&M Team and included:

- Establishment of sub awards from WHOI to partners OSU and SIO.
- Initial work at each partner institution for the planning and building/remodeling of each OMC.
- Hiring of O&M personnel
- Detailed planning of recurring field operations
- Determination of optimum timing of maintenance cruises
- Submission of UNOLS ship requests for all maintenance cruises
- Developing staffing plans for cruises
- Developing detailed cruise plans and timelines
- Selection of ports for cruises based on proximity to site, capability, possible synergy with partners
- Development of processes and procedures to be used during O&M
- Participate in Cross IO Working Groups on key O&M areas: Data Management, Common Operations Applications, Field Operations, Refurbishment Manufacturing and a Cross Institution Steering Committee to oversee these groups.
- Initial contact with potential partners at remote sites, Argentina and Chile and at local sites, such as the marine operations facility at the University of Washington and the OSU/NOAA facilities in Newport, Oregon.
- Engagement with the design teams and participation in design reviews to ensure O&M perspectives are taken into account.

5.1.3 Regional Scale Nodes

RSN O&M staffing will increase to approximately 0.6 FTE by the end of Year 1 to meet the demands of the O&M work schedule. RSN Operations activities for Year One include, but are not limited to:

- RSN project management and controls - monitor the progress of the MREFC construction initiative, and the progress of linked tasks in the O&M project schedule;
- Commence the development of strong processes and procedures for operating the network and supporting maintenance plan;
- Commencement of a long-term lease for the CyberPoP in Portland, OR;
- Commencement of a long-term lease for the Shore Station in Pacific City, OR;
- Commencement of Shore Station infrastructure build;
- Commencement of a long-term lease for the initial terrestrial telecommunications circuit to connect the cable station in Pacific City, OR to the CyberPoP in Portland, OR;
- Commence planning for the RSN Observatory Operations Center (OOC);
- Commence Primary Infrastructure spare acquisition. Four billing milestones associated with the Primary Infrastructure contract scheduled to be achieved:
    - Contract Award
    - Conduct System Requirements Review (SRR)
    - Conduct Simulators Preliminary Design Review (PDR)
    - Conduct Simulators and Commission Hardware Critical Design Review (CDR)
- Recruit personnel (1) to support the refurbishment and testing of the shore station in Pacific City, OR; and
- Conduct an evaluation of the O&M cost assumptions to reduce the uncertainty in O&M budget estimates for Year Two; incorporate findings in to Year Two O&M Annual Work Plan submission.

5.2 Year 2 – Mid Pre-Operations

O&M staffing at the PMO will increase by the end of Year 2 to meet the demands of the O&M work schedule. The O&M task list for Year 2 will include the following:

- Monitor the progress of MREFC construction, and the progress of linked tasks in the O&M project schedule.
- Conduct a program-wide evaluation of O&M cost assumptions to reduce the uncertainty in O&M budget estimates for Year 3 and beyond.
- Continue staff recruiting & training in coordination with construction schedule.
- Revise the Operations & Management Plan through an IO-wide meeting.
- Review the Commissioning Plan and transition to operations frameworks.
- Ensure the process used to track deliverables and activities for reporting at each IO is standardized.
- Create a model of each IO specific sparing and replacement schedule.
- Commission operational software tools associated with program management.
- Establish documentation standards across the IO's for Operations, Test, Safety, and other related deployment and sustainability manuals.
- Participate in System Engineering workshops and meetings to document emerging design and operational support issues.
- Facilitate the beginning of purchase of materials for the refurbishment turns for the Global Moorings
- Refine and submit the Year 3 Annual Work Plan.
- Perform year end analysis of schedules, results and plans for possible cost savings or extending component lifecycles.

5.2.1 Cyberinfrastructure

Release 2 Managed Instrument Network adds end-to-end control of how data are collected, supporting more advanced processes of instrument providers with managed instrument control.

5.2.2 Coastal / Global Scale Nodes

During Year 2 CGSN will continue to build the O&M team, with additional hiring, including a Deputy Project Manager for O&M and a Field Operations Coordinator as well as staff needed to build to address the pace of sustained operations. Activities will also include:

- Completing the construction of the CyberPoPs
- Implement the Wide Area Network (WAN)
- Hiring of additional support staff to support end users and quality assurance of new releases
- Continue planning and budgeting
- Assessment of risks and opportunities
- Definition and justification of the assumptions underlying O&M plans and of alternatives
- Work on the Basis of Estimates documentation
- Operations Property material and equipment acquisition will begin following Production Readiness Review (PRR)
- Updates to O&M Plan and generation of associated documents
- Continue the detailed planning of recurring field operations
- Detailed staffing plans for cruises
- Continue the development of detailed cruise plans and timelines
- Continue the development of processes and procedures to be used during O&M.
- Working Groups on key O&M areas ramp up in their assigned tasks
- Follow up contact with potential partners at remote sites.
- Engagement with the design teams and participation in design reviews to ensure O&M perspectives are taken into account
- Review the test procedures and results of scheduled glider trials.
- Participate in the Coastal Profiler Mooring Test as an opportunity to learn about operations specific processes and their results.
- CGSN will use test deployment and recovery cruises (ISMT2 and AST2) as ramp ups on O&M processes and procedures.

5.2.3 Regional Scale Nodes

O&M staffing will increase to approximately 4.0 FTE by the end of Year 2 to meet the demands of the O&M work schedule. The O&M task list for Year 2 includes:

- RSN project management and controls - monitor the progress of MREFC construction and the progress of linked tasks in the O&M project schedule;
- Participate in System Engineering workshops and meetings to document emerging design and operational support issues;
- Continue the development and refinement of strong processes and procedures for operating the network and supporting maintenance plan;
- Support the documentation of standards for Operations, Test, Safety, and other related deployment and sustainability manuals;
- Commence the input of as-built documentation to manage and visualize the network in the O&M environment;
- Continue the oversight of facility long-term leases for the CyberPoP in Portland and the Shore Station in Pacific City, OR;
- Commencement of Logistics/Maintenance facilities to support the storage and maintenance of secondary infrastructure, including instruments;

- Continue the Shore Station infrastructure build;
- Commencement of a long-term lease for the second terrestrial telecommunications circuit for diverse communication paths from the cable station in Pacific City, OR to the CyberPoP in Portland, OR;
- Continue the planning and staff for the RSN Observatory Operations Center (OOC);
- Commence planning for North American Zone Cable Maintenance Agreement membership and long-term wet plant storage;
- Commence planning for the procurement of secondary infrastructure spares;
- Continue the acquisition of Primary Infrastructure spares. Four billing milestones associated with the Primary Infrastructure contract scheduled to be achieved:
    - O&M Land Cable Procurement Order Placed
    - O&M Submarine Cable Procurement Complete
    - O&M Land Cable and Spare SLTE Installed
    - O&M Submarine Cable Delivered
- Negotiate the Cable Maintenance Agreement and depot contracts;
- Continue staff recruiting and training in coordination with construction schedule.
- Conduct an evaluation of the O&M cost assumptions to reduce the uncertainty in O&M budget estimates for Year Three and beyond; incorporate findings in to Year Three O&M Annual Work Plan submission.

5.2.4 Education and Public Engagement

- Contract for Education and Public Engagement Implementing Organization began March 2011.

- Build Software Interfaces and Web Based Tools.

5.3 Year 3 – Late Pre-Operations

O&M staffing at the PMO will increase by the end of Year 3 in order to meet the demands of the O&M work schedule. The O&M task list for Year 3 will include the following:

- Monitor the progress of the MREFC construction initiative, and the progress of linked tasks in the O&M project schedule.
- Oversee the continued purchase of materials to facilitate the refurbishment turns for the Coastal Arrays and Global Moorings.
- Formalize the process for establishing test and acceptance policies and procedures creation for all scheduled components of the OOI Network, complete with deployment schedule.
- Formalize an OOI conflict resolution process for unexpected PMO/IO issues.
- Evaluate the effectiveness of the Proposal Process for adding external scientific capability to the OOI.
- Develop the process for implementing the deliverables from the Education and Public Engagement team.
- Perform year end analysis of schedules, results and plans for possible cost savings or extending component lifecycles.
- Refine and submit the Year 4 Annual Work Plan.

5.3.1 Cyberinfrastructure

Release 3 On-Demand Measurement Processing adds end-to-end control of how data are processed, supporting more advanced processes of instrument providers and data product consumers, as well as on-demand measurements supporting event-driven activities.
Release 4 Integrated Modeling Network adds control of integrated ocean models driven by the data collection process, supporting data product developers and the numerical modeling community.

5.3.2 Coastal / Global Scale Nodes

During Year 3 CGSN will continue to build the O&M team with additional hiring. Activities will also include:

- Continue planning and budgeting
- Further development of processes and procedures based on involvement in CGSN's at-sea test 2, a test deployment of key hardware
- Maturation of definition of the role of vendor services in CGSN O&M
- Development of calibration practices and procedures
- Confirmation of cruise basing plans in remote locations (Mar del Plata, Argentina; Punta Arenas Chile) and at US ports (Seattle, WA, and Woods Hole, MA)
- Acquisition of long lead time items for the operational property
- Endurance gliders deployed under MREFC, transition to operational status and O&M responsibility
- Pioneer gliders deployed under MREFC, transition to operational status and O&M responsibility
- Corresponding OMCs are at a final stage of development and prepared for the transition to operational status of the first elements under O&M responsibility.

5.3.3 Regional Scale Nodes

O&M staffing will increase to approximately 6.2 FTE by the end of Year 3 to meet the demands of the O&M work schedule. The O&M task list for Year 3 includes:

- RSN project management and controls - monitor the progress of the MREFC construction initiative, and the progress of linked tasks in the O&M project schedule;
- Continue the refinement of strong processes and procedures for operating the network and supporting maintenance plan;
- Support the documentation of standards for Operations, Test, Safety, and other related deployment and sustainability manuals;
- Commence planning for the Network Planning and Maintenance – Fulfillment procedures including Proposal Support, Award Handling, Network Planning and Provisioning;
- Commence planning for the Monitoring and Surveillance - Assurance of Primary and Secondary Infrastructure;
- Commence planning for the procurements of secondary infrastructure spares;
- Continue the input of as-built documentation for network management;
- Continue the oversight of facility long-term leases for the CyberPoP in Portland, Shore Station in Pacific City, OR and Logistics/Maintenance facility;
- Continue long-term lease for diverse terrestrial telecommunications circuits from the cable station in Pacific City, OR to the CyberPoP in Portland, OR;
- Continue the planning for the RSN OOC;
- Continue North American Zone Cable Maintenance Agreement membership and long-term wet plant storage;
- Commence procurement of secondary infrastructure spares;
- Continue the acquisition of Primary Infrastructure spares. Four billing milestones associated with the Primary Infrastructure contract scheduled to be achieved:
    - Spare Terminal Test Equipment (TTE) Delivered
    - Spare Manufacturing Primary Nodes Complete
    - Delivery of Simulators
    - System Acceptance;
- Continue staff recruiting and training in coordination with construction schedule; and

- Conduct an evaluation of the O&M cost assumptions to reduce the uncertainty in O&M budget estimates for Year Four; incorporate findings in to Year Four O&M Annual Work Plan submission.

5.3.4 Education and Public Engagement

- Build Software Interfaces and Web Based Tools.

5.4 Year 4 – Early Operations

O&M staffing at the PMO will increase by the end of Year 4 in order to meet the demands of the work schedule. The O&M task list for Year 4 will include the following:

- Monitor the progress of the MREFC construction initiative, and the progress of linked tasks in the O&M project schedule.
- Oversee the continued purchase of materials to facilitate the refurbishment turns for the Coastal Arrays and Global Moorings.
- Conduct O&M training development and O&M management seminar at Ocean Leadership.
- Establish the schedule for regular governance meetings in Year Five.
- Establish a document library of troubleshooting procedures for the components of the OOI.
- Refine the process for incorporation of Education and Public Engagement deliverables.
- Perform year end analysis of schedules, results and plans for possible cost savings or extending component lifecycles.
- Refine and submit the Year 5 Annual Work Plan.

5.4.1 Cyberinfrastructure

Release 4 Integrated Modeling Network was released in conjunction with Release 3.

5.4.2 Coastal / Global Scale Nodes

During Year 4, CGSN will continue to build the O&M team with additional hiring. Activities will also include:

- Continue planning and budgeting
- At respective institutions, move into new space dedicated to O&M, complete acquisition and outfitting of sea-going and shore-based O&M support infrastructure, such as refurbishment jigs
- Further development of processes and procedures based on lessons from CGSN's at-sea test 2.
- Definition of the role of vendor services in CGSN O&M versus in house O&M effort
- Development of calibration practices and procedures
- Obtain personnel commitments to initial O&M cruises
- Acquisition of long lead time items for the operational property
- Argentine Basin is deployed under MREFC, transitions to operational status and O&M responsibility
- PAPA is deployed under MREFC, transitions to operational status and O&M responsibility
- Irminger Sea is deployed under MREFC, transitions to operational status and O&M responsibility
- Un-cabled elements of Newport mooring line of Endurance are deployed under MREFC, transitions to operational status and O&M responsibility
- Coastal profiler moorings of Pioneer Array are deployed under MREFC, transition to operational status and O&M responsibility
- Surface moorings, shallow profilers, and AUVs of Pioneer Array are deployed under MREFC, transition to operational status and O&M responsibility

- Corresponding OMCs are operational and prepared for the transition to operational status of elements under O&M responsibility.

5.4.3 Regional Scale Nodes

O&M staffing will increase to approximately 9.5 FTE by the end of Year 4 to meet the demands of the O&M work schedule. The O&M task list for Year 4 includes:

- RSN project management and controls - monitor the progress of the MREFC construction initiative, and the progress of linked tasks in the O&M project schedule;
- Continue the refinement of strong processes and procedures for operating the network and supporting maintenance plan;
- Continue the input of as-built documentation for network management;
- Commence the planning for Environmental Health and Safety (EH&S) including training, inspections and documentation;
- Support the documentation of standards for Operations, Test, Safety, and other related deployment and sustainability manuals;
- Implement Monitoring and Surveillance - Assurance procedures for Primary Infrastructure problem handling and resolution, quality of service, Network Inventory Management, and Network Maintenance and Resolution;
- Commence planning for the Network Planning and Maintenance – Fulfillment procedures including Proposal Support, Award Handling, Network Planning and Provisioning;
- Commence implementation of Data Quality Assurance and Quality Control, and metadata management;
- Continue the oversight of facility long-term leases for the CyberPoP in Portland, Shore Station in Pacific City, OR and Logistics/Maintenance facility;
- Continue long-term lease for diverse terrestrial telecommunications circuits from the cable station in Pacific City, OR to the CyberPoP in Portland, OR;
- Continue North American Zone Cable Maintenance Agreement membership and long-term wet plant storage;
- Continue the acquisition of secondary infrastructure spares;
- Complete the acquisition of Primary Infrastructure spares. One billing milestone is associated with the Primary Infrastructure contract scheduled to be achieved:
  - Provisional Acceptance Test Documents Complete
- Commence planning for the procurements of secondary infrastructure spares;
- Commence planning for Maintenance Cruise No. 1 (2014);
- Continue staff recruiting and training in coordination with construction schedule; and
- Conduct an evaluation of the O&M cost assumptions to reduce the uncertainty in O&M budget estimates for Year Five; incorporate findings in to Year Five O&M Annual Work Plan submission.

5.4.4 Education and Public Engagement

- Build Software Interfaces and Web Based Tools.

5.5 Year 5 – Interim Operations

O&M staffing at the PMO will increase by the end of Year 5 in order to meet the demands of the O&M work schedule. The O&M task list for Year 5 will include the following:

- Monitor the progress of the MREFC construction initiative, and the progress of linked tasks in the O&M project schedule.
- Continue the purchase of materials to facilitate the refurbishment turns for the Coastal Arrays and Global Moorings.

- Evaluate the effectiveness of the governance structure.
- In collaboration with the NSF, refine the Proposal Process to optimize the use of the OOI infrastructure by external users.
- In collaboration with the NSF, solicit development of proposals for education and outreach.
- Refine the troubleshooting procedures for OOI components based on Year 4 experience.
- Perform year end analysis of schedules, results and plans for possible cost savings or extending component lifecycles.
- Refine and submit the Year 6 Annual Work Plan.

5.5.1 Cyberinfrastructure

Release 5 Interactive Ocean Observatory adds control of data, processes, and models to drive the collection process, supporting observatory interactivity and transformative ocean observatory science for all users.

5.5.2 Coastal / Global Scale Nodes

During Year 5, CGSN will complete building the O&M team with final hiring. Activities will also include:

- Initial O&M of early deployments from the MREFC
- Implementation of calibration practices and procedures
- Implementation of O&M documentation procedures
- Obtain personnel commitments to O&M cruises for Year Six
- Final acquisition of items for the operational property
- 55°S, 90°W is deployed under MREFC, transitions to operational status and O&M responsibility
- Grays Harbor, WA mooring line of Endurance is deployed under MREFC, transitions to operational status and O&M responsibility
- Cabled elements of Newport mooring line of Endurance are deployed under MREFC, transitions to operational status and O&M responsibility
- OMCs are fully operational responsible for all of O&M property.

5.5.3 Regional Scale Nodes

O&M staffing will increase to approximately 22 FTE by the end of Year 5 in order to meet the demands of the O&M work schedule. The O&M task list for Year 5 includes:

- RSN project management and controls - monitor the progress of the MREFC construction initiative, and the progress of linked tasks in the O&M project schedule;
- Continue the refinement of strong processes and procedures for operating the network and supporting maintenance plan;
- Continue the input of as-built documentation for network management;
- Continue the implementation of (EH&S) processes including training, inspections and documentation;
- Support the documentation of standards for Operations, Test, Safety, and other related deployment and sustainability manuals;
- Continue Monitoring and Surveillance - Assurance procedures for Primary Infrastructure problem handling and resolution, quality of service, Network Inventory Management, and Network Maintenance and Resolution;
- Continue planning for the Network Planning and Maintenance – Fulfillment procedures including Proposal Support, Award Handling, Network Planning and Provisioning;
- Continue planning for Data Quality Assurance and Quality Control, and metadata management;
- Implement technical support center for proposal and maintenance support , and fault resolution;
- Continue the oversight of facility long-term leases for the CyberPoP in Portland, Shore Station in Pacific City, OR and Logistics/Maintenance facility;

- Continue long-term lease for diverse terrestrial telecommunications circuits from the cable station in Pacific City, OR to the CyberPoP in Portland, OR;
- Continue North American Zone Cable Maintenance Agreement membership and long-term wet plant storage;
- Continue the acquisition of secondary infrastructure spares;
- Commence planning for Maintenance Cruise Nos. 1 and 2 (2015);
- Conduct Maintenance Cruise No. 1;
- Continue staff recruiting and training in coordination with construction schedule; and
- Conduct an evaluation of the O&M cost assumptions to reduce the uncertainty in O&M budget estimates for Year Six; incorporate findings in to Year Six O&M Annual Work Plan submission.

5.5.4 Education and Public Engagement

- Build Software Interfaces and Web Based Tools.

6 OOI Full Operations and Maintenance

6.1 Operations

After completion of the transition from construction to operations, the management of the OOI will maintain a focus on meeting the scientific mandates of the OOI (data and expandability) at the lowest possible annual cost. The O&M staff will

- Continuously refine the process and schedule for servicing the OOI components.
- Continuously evaluate cost assumptions and cost estimation procedures.
- Continuously refine the troubleshooting procedures for OOI components based on cumulative experience.
- Continuously work in collaboration with the NSF to optimize the use of the OOI by the external science community.
- Refine and submit the next year's Annual Work Plan.

6.1.1 Overall Operations Concepts (Sustaining Operational Capability)

As the OOI infrastructure is deployed and completes its transition to operations, it can be viewed, at its highest level, as ocean infrastructure, analogous to the UNOLS vessels. Thus, as the O&M plan matures it is the intent of OOI to work with the NSF to develop an approach for supporting the potential variability in operational costs, similar to the Major Overhaul and Stabilization Account (MOSA) for UNOLS vessels. In this way, year-to-year differences in replacement, refurbishment, and field operations costs would be anticipated and planned for while variability would be stabilized by establishing a funding account to address them.

The following high-level operations concepts apply:

- The OOI shall be responsible for providing the scientific community with reliable, high quality data for the investigation of ocean science.
- The OOI shall maintain the system of systems to provide this data, and allow for NSF approved expanded capabilities and future scaling.
- All science and calibration raw data are captured and archived.

6.1.2 Operational Concepts Applied to Ocean Deployments

The OOI operational concepts for marine infrastructure can be illustrated through a description of the processes needed to deploy and maintain the fixed and mobile assets within the responsibility of the CGSN Implementing Organization.

Equipment to support recovery and replacement at the completion of Deployment Intervals will be built during the Initial Operations Phase of the O&M Project.

CGSN plans to initiate O&M with reliance on the team members who designed and built the equipment. Their knowledge and experience will facilitate carrying out initial operations and maintenance. However, over three O&M cycles, the intent is to have transferred to the team with lead responsibility for field operations the ongoing maintenance responsibilities. This, in effect, will prove the ability of the CGSN infrastructure to be maintained by future operators.

CGSN O&M planning and budgeting is task-based. In other words, there will not be a standing cadre of O&M staff to cover all needs. As needed, CGSN will use their O&M resources and draw from other operational groups at their institutions for additional personnel as needed. This approach provides the following advantages: it allows CGSN to tap into highly experienced O&M staff; having done similar work, their skills and prior experiences will allow them to come up to speed almost immediately and they will already possess a thorough understanding of safety issues. Furthermore, this approach allows CGSN to bring in and train new inexperienced staff without a full-time commitment, and it allows CGSN to address tasks without hiring dedicated staff. At the same time, this model allows CGSN personnel with specialized expertise, such as working on deck, to stay current and well-practiced by supporting many cruises (including non-CGSN). CGSN O&M plans and budgets address the resources needed to accomplish the tasks associated with O&M.

Some operational tasks and thus costs will recur each year after the MREFC is complete, and these form a base for the budgets and plans. Other costs vary over the years due to different life cycle lengths and costs. Finally, costs may vary if ship day rates change or if the timing of a given cruise is rescheduled and moves into the next budget year.

Operations and Management Centers (OMCs) will be established at WHOI, OSU and SIO as the hubs for CGSN O&M. The OMCs will provide test facilities, space for Scientific Investigators to use while integration and qualification of their instruments is conducted, maintenance facilities, the CI-provided CyberPoP installation destination, and shore station hardware and software. Co-location of these activities is important to provide closed loop and end-to-end involvement of the team from hardware to data analysis. In addition, test and assembly facilities exist and will be further developed at each institution. WHOI has refurbished the Coastal Research Laboratory and has been funded through a NIST (National Institute of Standards and Technology) grant to build a new building, a large fraction of which will be dedicated to CGSN O&M efforts when completed in June 2012.

The WHOI Mooring Operations, Engineering, and Field Support Group operate and maintain the following facilities: a fully equipped rigging shop that maintains an extensive inventory of mooring components, handling equipment, and specialized tooling to test all aspects of a mooring array. One such piece of the equipment is the Horizontal Tensile Machine, capable of proof testing to 150,000 lbs. and break testing to 112,500 lbs. It is used to test the material breaking strength of wires, cables, and terminations. The High-Bay area, shore side mobile cranes and wet-test tanks are available for testing equipment and for ballasting gliders. There are open space areas available to layout mooring instruments and arrays up to 5000 meters in length. The WHOI Pressure Test Facility is available for external pressure testing of scientific and engineering equipment. The three pressure vessels are rated to 5000 psi, 10,200 psi, and 12,500 psi, and accommodate a component up to 24 inches in diameter and 96 inches in length.

The Scripps Institution of Oceanography (SIO) Ocean Time Series Group has remodeled, with funding from the SIO's Director's Office, a 6000 sq. ft. staging and storage high bay building (T45 in "Seaweed Canyon") which will house all of the local OOI's operations, equipment and gear. The group also has access to SIO's state-of-the-art in-house facilities for instrument testing and calibration, in collaboration with groups such as the Instrument Development Group (IDG). IDG is a research and development facility housed in a 4,000 sq. ft. laboratory complex with a 2,400 sq. ft. warehouse and production site, a 250 sq. ft. pressure facility, a fully equipped machine shop, a 26 ft. enclosed research vessel (R/V Saikhon), and a 5-m RIB short-range vessel. Other facilities, such as the Marine Facility (MarFac) and the Oceanographic Data Facility (ODF) from the Shipboard Technical Support group (STS), and the machine shop are also available.

Oregon State University (OSU) is actively engaged in building facilities to successfully operate and maintain the OOI Endurance Array assets over the next 25 years. The two main facilities include: the Ocean Observatories Center located in Corvallis Oregon and the Dockside Facility located in Newport Oregon.

The Ocean Observatories Center (OOC) at OSU is a 12,500 building with 28 foot ceilings. OSU Facilities Group is managing the construction project configuring the interior space optimally for this program. The interior design is complete, including office spaces for OOI staff and visiting PIs, an operations control room, various labs, shops and high bay space which will be used to refurbish Endurance Array assets every 6 months. The OOC has 40,000 square feet of level paved and fenced space surrounding the building. This area will be used for equipment burn in testing, painting, storage, and staging for transportation.

The Newport Dockside Facility will be used to service the Newport, OR and Grays Harbor, WA Endurances lines. Two types of facility spaces are planned. The first is “working storage space” where truck loading/offloading, assembly, testing, emergency repairs, equipment cleaning, and storage (transitory and permanent) occur. The second is “dockside ship loading space” where staging for ship loading and unloading occur.

In addition to the new OSU facilities, current oceanographic services are available to support the Endurance Array. These existing facilities include the OSU glider facility, the COAS optics laboratories, the OSU Buoy Facility, and the Western Avenue machine shops.

Test equipment specific to CGSN will be developed as necessary. For example, a test bed is being designed and fabricated to enable qualification of PI instruments for use on OOI platforms. This equipment will be located at the WHOI OMC (Operations and Management Center). Test equipment to enable integration testing, including data collection and telemetry testing and shore burn-in will also be located at the WHOI, SIO and OSU test facilities.

The CGSN OMCs will house the shore facilities to support telemetry, testing of configuration items, assemblies and subassemblies, Iridium repeaters for burn-in and other facilities necessary to support the refurbishment and test of the equipment. The WHOI and SIO OMCs will have modem banks and uninterruptable power supplies (UPS) to support continuous receipt of data on shore. The CGSN OMCs will house the staff to schedule and perform monitoring and maintenance of the system. Maintenance performance will be covered under Field Operations. The CGSN OMCs will be staffed five days per week during normal business hours. Alerts for issues requiring attention will be sent to CGSN OMC staff 24/7.

The CGSN operations team will implement trouble reporting and resolution of two types. As an infrastructure provider, trouble reports generated external to CGSN will be delivered through the CI interface. CGSN will be responsible to provide status information on these trouble tickets and ultimately plan and implement corrective action. As an infrastructure provider and data user, trouble reports generated within CGSN will be input to the CI tracking system then routed back to the CGSN team for resolution as above. Internal trouble reports will include those generated during instrument testing and burn-in, during calibration, during field usage, and during post-cruise refurbishment; they also will include data quality and record length driven trouble reports generated during analysis and QA/QC of the data at any point, from burn-in to field deployment.

Space for Principal Investigators will be provided in each of the OMC facilities to enable on-site integration and qualification of the specific instruments based on the approved location within the CGSN infrastructure and to support ongoing interaction with operations staff. In selecting a space, proximity to data processing and monitoring personnel will be a priority.

A CGSN Permit List has been developed and will be maintained during the O&M period. Permitting activities have two aspects. First, maintaining current permits will be the responsibility of the OMC personnel. The Permit List includes the frequency for reapplication. Program plans will include sufficient lead to reapply as well as allocated budget for associated fees. Second, as additional instruments are added to the infrastructure, OMC personnel will make an assessment of whether existing permits are sufficient. If a PI instrument necessitates additional permitting, cost of the permitting activity will be included in the instrument implementation estimate.

Safety is of paramount importance and the UNOLS Research Vessel Safety Standards (RVSS) will be followed at sea and the Institution safety guidelines will be adhered to ashore. The CGSN Environmental Health and Safety Plan and procedures will be followed during all O&M activities. Furthermore, UNOLS and institutional (WHOI, OSU, SIO) policies and procedures will be followed during recovery and replacement of equipment using ships.

Coordination of shipping pre and post cruise falls within the scope of Field Operations. This will include preparing all shipping documents, and working with institution shipping office to prepare customs declarations and export documentation particularly for export controlled items and further detailed in CGSN Shipping Procedure (3101-00055).

Following each cruise a formal report will be released. The report will document the cruise and the equipment deployed and becomes an important part of the metadata. The Chief Scientist on each cruise is responsible for generation and release of the report.

6.1.3 Policies & Procedures

6.1.3.1 Cyberinfrastructure

CI will be the focal point of all data collection and distribution, system control and system status. CI will also have the ability to quantify system availability, the number and severity of system failures, and the level of degraded system capabilities. CI will also be responsible for Software Configuration Management, and will be able to apply data availability and quality metrics to guide system software changes.

- ***Service Level Agreements (SLA)***

A SLA refers to the contracted delivery time of a service or a performance criteria. SLAs are negotiated agreements between our user community and the CI. The CI will conduct an analysis of the existing published Service Level Agreements to determine where operation support improvements can be made.

- ***Replenishment of Equipment***

A five-year life cycle was determined for the initial implementation of the computing, networking and storage equipment. Any equipment that is still operational and functional to the required specifications will be left in operation. Obsolete equipment or equipment where significant technological advances have occurred will be upgraded or replaced.

- ***User Support***

The Help Desk is the primary interface for the user community to request support or ask questions about the operations of the software infrastructure. A yearly survey will be conducted by the Help Desk to request feedback on improving the user experience. Results of the survey will provide valuable feedback on the support requirements to OOI users of the infrastructure.

- ***Security***

As critical vulnerabilities are identified and software fixes become available, the associated patches must be applied in a systematic fashion to each of the remote systems we support. In order to provide a scalable mechanism to perform upgrades, the CI uses a combination of software deployment servers that are designed to automatically install patches to operating systems, applications and database software over a secure network. Each patch/fix is first tested in the development and staging environment before being deployed to production.

In addition, the CI will abide by all Security requirements specified in the Cybersecurity Plan (1012-00000)

- ***Configuration Control and Management***

In order to have consistent deployment of the servers we manage (web, application, and database), CI has deployed a configuration management tool called Chef. Chef is an open source configuration management and systems integration framework that creates servers as needed to our specifications. With Chef, CI can write definitions as source code to describe how each part of your infrastructure is to be built and then apply those descriptions to individual servers. The result is a fully automated infrastructure: when a new server comes on line, the only thing CI has to do is inform Chef what type of server will be deployed. These servers have the latest versions of the operating systems, application or database software implemented with the latest security fixes deployed. Chef is used for the deployment of servers in our development, staging and production servers.

InfoBlox's NetMRI is a network configuration management tool that assists in seeing the virtual impact of a change to the network, maintains the configurations for each site, assists in identifying anomalies in the system, generates statistics and monitors the health of the network.

- ***Change Management***

Changes to any production system can have dramatic impacts to the user community. All software upgrades will first be tested in the CI development and staging environments. All planned changes will have been reviewed, notifications to the user community will have been provided and a schedule for implementation will be known in advance. There will be rare instances when emergency fixes will need to be applied when little or no notification may be given.

The CI will have a published fixed window of time (if necessary) when portions of the system will be taken down and system or hardware updates can be made.

- ***Capacity Planning***

CI incorporates monitoring tools that generate automated notifications for all production servers. These automated alerts are initiated when certain system thresholds are reached. The following are examples of the alerts that are being watched:

- Storage capacity, CPU capacity, network delays
- Bandwidth utilization
- Application response times
- System resources availability

- ***Asset Management***

An asset management database will be used to track all network, compute resources and storage units at each location. Items to be tracked include: location, device, vendor, model number, serial number, description, installation date, PO number, warranty information, maintenance costs, and renewal date. An annual audit will be conducted to validate that our tracking of the assets are correct.

- ***Problem Management***

All problems or request for support and services will be tracked using the Atlassian JIRA system. All new tickets will be reviewed by the Operations Supervisor and assignments made to the corresponding responsible systems person. Follow-up with users generating the ticket will be made prior to closure.

- ***Audits***

The CI will conduct formal audits of all user accounts twice per year. Users will be asked to update their existing passwords on a schedule as identified in the Cybersecurity Plan. Accounts no longer valid will be removed from the system.

6.1.3.2 Coastal / Global Scale Nodes

- Description

Coastal Global Year Six and out will be at full pace, with all MREFC deployments complete, and with these operations:

- Northern summer service cruises for Irminger and Papa global sites
- Southern summer service cruises for Argentine Basin and 55S
- Spring and fall service cruises on UNOLS vessels for Pioneer Array
- Four to five small vessels service cruise for Pioneer AUVs and gliders
- Spring and fall service cruises on UNOLS vessels to service uncabled elements of the Endurance Array
- Annual joint service cruise with RSN to service cabled elements of the Endurance Array
- Four to five small vessel service cruises for Endurance gliders

In addition to the O&M of the core infrastructure CGSN will, during full ongoing operations, support ancillary instruments placed on CGSN platforms by PIs. Procedures for assisting Scientific Investigators as they apply for and are approved for infrastructure use will be in place (see Section 6). During the Scientific Investigators proposal period, the CGSN OMC staff, working with the other OOI infrastructure operators as necessary, will assist with estimates for instrument qualification to OOI standards, integration and implementation onto specific platform(s) and other costs associated with the specific proposal. Once approved for use, the CGSN OMC personnel will work with other pertinent IOs to integrate, operate, and maintain the new equipment into the OOI system.

It is, however, important to consider that “steady state” is not reached in the sense that year-by-year costs would remain the same. The CGSN hardware includes both expendable elements and labor costs that recur every year and costs that fluctuate year to year, reflecting life cycles, varying levels of refurbishment, replacement at end of life, incurrence of sustaining engineering costs, and changes in cruise dates or port expenses.

- Policies

CGSN equipment is designed to perform over specified deployment intervals included in the design performance requirements. At the completion of the deployment interval, equipment will be recovered and replaced with equivalent items.

Unscheduled Maintenance: Maintenance within the deployment interval will be very limited. The O&M budget does not include unscheduled trips to the arrays except as may be accommodated by re-budgeting of activities.

For Coastal Arrays, two annual trips are scheduled to recover and replace the un-cabled moorings and AUV Docks. One annual trip is scheduled to service cabled infrastructure on the Endurance line. More frequent trips (2-3 months) are planned to replace gliders and, at Pioneer, the AUVs. Because a ship will be present, there will be some flexibility to modify maintenance plans to retrieve underperforming or non-functional resources and extend In-service Periods for others. Decisions will be made on a case-by-case basis.

The complexity of the CGSN subsystems makes it possible that individual components may fail between regularly scheduled turnarounds. The two-way real time communication provided by the cyber infrastructure will allow for detection of subsystem failures as they happen. Given budget realities, it will not be possible to respond to most failures. Failures will be characterized as emergency failures, critical failures, or non-critical failures at the time they occur.

Emergency failures - Failures that require immediate decision on how to proceed, possibly including scheduling of a UNOLS vessel or the chartering of a commercial vessel. Re-budgeting to find funding will be attempted to respond to these types of failures. Examples:

Mooring failure - the breaking free and drifting of a mooring or mooring component

Communications failure - loss of all communications with a mooring

Critical failures - Failures which compromise scientific data collection by an entire subsystem or which could lead to an emergency failure. These failures require a timely decision on how to proceed which is dependent on weather and scheduling of available resources. These failures are likely to be deferred until the next scheduled maintenance trip. Funding for response to these failures would also require re-budgeting. Examples:

a) Loss of an entire instrument system (e.g., ASIMET out)

b) Loss of navigational aid (e.g. buoy lights or radar transponder)

c) Glider loss or failure (glider on surface and calling for help)

Subcritical failures - Failures that compromise scientific data of a single instrument. These failures would require a decision regarding response, possibly during a ship of opportunity visit, but more likely will be deferred until regularly scheduled maintenance. Examples:

a) Evident bio fouling of a single instrument

b) Failure of a non-core instrument

For Global Arrays, much of the maintenance expense is attributable to the cost of reaching remote locations with appropriate ships. In all types of failures, shore-side efforts will be directed at minimizing data loss using remote tools to the degree possible. Examples are powering down specific Data Concentrator Logger (DCL) ports, modifying sampling plan, modifying telemetry plan, etc.

- Relocation of the Pioneer Array

The Pioneer Array is designed to be re-locatable after fully commissioned installation at a site for five years. Items to be considered and resolved prior to relocation would be:

- Site-specific physical considerations – depth, mean currents, etc.
- Telemetry availability at the site
- Permitting evaluation of the site
- O&M re-planning for maintenance cruises – nearest ports, facilities
- Significance of site for science needs

Appendix B provides additional information about the process for the relocation of the Pioneer Array.

- Procedures

Recovered equipment will be returned to shore-side depots for the Maintenance Cycle. This includes: maintenance, refurbishment, instrument calibration, integration and test. During the maintenance cycle, equipment will be returned to the Factory Test (FT) Level and prepared for the next deployment. Following FT, the equipment will proceed to Pre-Installation Integration Test (PIT) and Burn-In.

During the Initial Operations and Maintenance phase of the Project, the equipment which supports the recovery and replacement of deployed assets will be built. Aside from the initial funding source, there is no difference between Operational Property and the MREFC equipment.

6.1.3.3 Regional Scale Nodes

- Description

O&M staffing will increase to approximately 33.5 FTE by the end of Year 6 in order to support operations. The O&M task list for full ongoing operations will include the following:

- RSN project management and controls - monitor the progress of the MREFC construction initiative, and the progress of linked tasks in the O&M project schedule;
- Implementation of processes and procedures for operating the network and supporting maintenance plan;
- Oversight and continued implementation of the upload of as-built documentation for network management;
- Implementation of Monitoring and Surveillance - Assurance procedures for Primary and Secondary Infrastructure problem handling and resolution, quality of service, Network Inventory Management, and Network Maintenance and Resolution;
- Implementation of Network Planning and Maintenance – Fulfillment procedures including Proposal Support, Award Handling, Network Planning and Provisioning;
- Implementation of Data Quality Assurance and Quality Control, and metadata management;
- Implement technical support center for proposal and maintenance support, and fault resolution;
- Continue the oversight of facility long-term leases for the POP in Portland, Shore Station in Pacific City, OR and Logistics/Maintenance facility;
- Continue long-term lease for diverse terrestrial telecommunications circuits from the cable station in Pacific City, OR to the POP in Portland, OR;
- Continue North American Zone Cable Maintenance Agreement membership and long-term wet plant storage;
- Continue the acquisition of secondary infrastructure spares;
- Commence planning for the next year summer maintenance cruises;
- Conduct annual Maintenance Cruises (2);
- Conduct an evaluation of the O&M cost assumptions to reduce the uncertainty in O&M budget estimates for following year; incorporate findings in to following year O&M Annual Work Plan submission.

As RSN progresses to full operational support, the O&M costs will consist of fixed and variable elements. Variable elements are influenced by material life cycle cost, emergency maintenance, consumables, and weather.

- Procedures

Because all operations are driven by science needs the operations staff will be direct liaisons with Users and will provide current technical information to help Users plan for specific projects. The operations staff will provide the following:

- Logistics support for pre-deployment planning, movement of hardware and personnel during operation, communications among parties, and safety, security, and environmental guidance.
- Technical support for project planning, including furnishing documentation for system operations, in-water and on-shore systems interfaces, modes of operation, and training of Users in the proper and efficient use of system assets to maximize return on investment.

- Cradle-to-grave resource planning for experiments, including planning stages prior to mobilization, dry- and wet-side pre-mobilization testing, calibration and qualification, mobilization, deployment, recovery, and demobilization.
- Design planning for the development of observatory compatible instrumentation. Development and provision of standard modules: power supplies, communications, media converters, dry-mate and ROV mate connectors, and extension cables.
- Skilled personnel trained in operational procedures of the system, vessels, rigging, and safe at-sea operations, mechanical, power, and networking functions of the installed infrastructure.

- PI Planning-Information Meeting for Field Planning

Annually in late February, the RSN Office will host a multi-day PI meeting for the purpose of planning the year's field operations. The goals of the workshop will be to update PIs on scheduling, explain PI and RSN responsibilities, and discuss ancillary studies that may help provide environmental-physical data of interest during the field programs. The two-day meeting will help build collaboration during the field season and allow PIs to talk about interdisciplinary studies and potential scheduling conflicts. The RSN Team will work closely with NSF, UNOLS, and OL to determine the appropriate schedules. A Project Scientist, Staff Scientist, and Engineer will have teleconferences with PIs following the meetings to keep the PIs updated and to address questions. Checklists will be formulated with the PI to help communication and to ensure that field operators and scientists are clear on requirements and milestones to meet all science goals.

- Project Scientist Team

The IO Project Scientists and associated staff will provide extensive assistance to PIs throughout the proposal stage, installation, and decommissioning stages. In collaboration with the CI IO, a web-based "How To" Manual will provide information crucial to proposal preparation (e.g., examples of costs for connectors, cables, and LV (Low Voltage) Nodes, J-Boxes; scheduling updates; and environmental site characterization critical to experimental design, permitting requirements, security and possible user fees). As discussed above an Annual Workshop will be held to help inform interested community members on procedures and processes required for the integration of new experiments onto the RSN.

The Project Scientists will also be responsible for oversight of the instrument data quality assurance and quality control efforts. This Team will set policy and procedures, which can be implemented across all instrument platforms to achieve consistent quality data products.

- System Engineering Team

The RSN Engineering Team and Project Scientists will work closely with PIs to provide guidance on new experimental designs, flag potential conflicts (e.g., spatial, electromagnetic, acoustics, security, permitting), and help perform additional site surveys if required. The Team will work with CI engineering personnel to assist the PI in establishing metadata requirements, installation procedure, and reasonable maintenance schedules. Statements of work and milestones will be established and will include the following timelines:

- Completion of instrument fabrication
- Completion of data system
- Bench testing of instruments
- Calibration of instruments
- Simulation of instruments in the network environment
- Testing on the Monterey Accelerated Research System (MARS), if required
- Qualification of instruments.

The RSN Engineering and CI Teams will be available to provide subcontracting assistance to PIs for their interface designs and fabrication of their instruments if required.

- Engineering Team

The Engineering Team will include a full-time Chief Engineer (CE) who will oversee the RSN Engineering Team. This team will consist of two Electrical Engineers, two Software Engineers, one Mechanical Engineer, and an Ocean Engineer. In addition, a full-time Quality Control Engineer will be assigned the task of maintaining quality-of-service in all areas of the RSN. The Team will also have a support team of a Logistics Manager, two UW Field Engineers, and two Oregon-based Field Engineers. The Team's responsibilities will include the day-to-day monitoring of the RSN equipment, managing the UW and Oregon logistics depots, mobilization and demobilization for all at-sea operations, working to assist PIs in the integration of new RSN instruments, as well as staffing the RSN test laboratories and environmental test facilities.

- At-Sea Operations

It is likely that most cruises will involve deployment of experiments for multiple PIs. To ensure that all needs of the PIs are fairly met, the RSN will provide a Chief Scientist for each cruise. A critical role of the Chief Scientist will be to make tough at-sea-decisions without conflict induced by self-interest in any one experiment (e.g., changing installation schedules of instruments due to weather or instrument failures). The Chief Scientist will interface with the PIs, Ship Captain, OOC Manager, and CE to ensure smooth operations and completion of goals. The Chief Scientist will hold shipboard science meetings to keep the science party informed of operations. Summaries of these meetings will be provided online for shore-based personnel and included in final cruise reports. To facilitate cost effectiveness of these tasks, each Project Scientist will sail as a Staff Scientist on at least one cruise. This will also ensure that the Project Scientist has intimate knowledge of engineering-science integration at sea and on shore, and has close working relationships with scientists as their instruments are installed on the network. It will be important for the Chief Scientist and CE to maintain close contact with the shore-side Operations Manager during installation procedures.

A shipboard Staff Scientist for each cruise will facilitate interaction with the science PIs and engineering team. They will also ensure the availability of complete documentation critical for site characterization, instrument deployment, and CI requirements. The Staff Scientist will be in charge of writing detailed daily operations reports and cruise reports for each cruise, ensuring that all cruise data are well organized, documented (e.g., video data, still imagery, Conductivity, Temperature, Depth (CTD) data, deployment information, and samples inventoried) and completed prior to de-mobilization. These reports will be provided online and will meet metadata requirements established by the IOs and NSF. The Staff Scientist will interface with a Data Technician on each cruise.

Cruise reports will follow a format similar to Preliminary Science Reports long established by the Ocean Drilling Program (ODP) and more recently by the International Ocean Drilling Program (IODP). These reports will include information such as cruise and shore-based participants; goals and sites of experiments; duration of experiments; environmental site characterization completed shipboard and in some cases shore-based during the cruise (e.g., bathymetry, video mosaics); and rigorous documentation of associated samples taken on the cruise (rocks, fluids, and fauna) and their distribution to ship and shore-based scientists. Final decisions on sample labeling and shipboard data archiving will be made in collaboration with the NSF, OL office, and the CI IO. Likely an OOI-wide policy will need to be adopted so that all data are collected and archived in the same manner, thus making accessibility transparent across all three components of the field portion of the OOI. Whatever policy is adopted, the RSN will provide a Data Technician on each cruise to ensure all data (bathymetric, environmental, instrument, and video) are collected and archived. The Data Technician will be in charge of processing bathymetric data as needed (e.g., EM300, side scan sonar, Imagenex sonar). These data may also be transmitted to shore for processing and for near real-time visualization of instrument deployment sites. This will be critical for scientific success and for ensuring that other scientists are able to easily access cruise information.

At sea a CE will oversee installation and testing of instruments. He/she will work closely with the Chief Scientist and ROV manager to achieve safe and smooth operations. Depending on the complexity, diversity, and numbers of instruments and infrastructure on a given cruise, the CE will oversee a typical crew that will include an Ocean Engineer, Electrical Engineer, Mechanical Engineer, Software Engineer, and two to four Field Engineers.

Prior to all cruises, there will be a minimum of an Electrical and Mechanical Engineer and two Field Engineers for the pre-deployment testing of all instruments and experiments that are to be installed during the cruise. Any final calibration checks will also be done at this time. The team will also interface with the PIs to ensure that their equipment is properly stored before the ship leaves the dock.

Each cruise will require an ROV system with cable laying and heavy lift (4,000lb) capabilities operational to 3,000 m water depth. Initially the RSN IO will contract with an available ROV for the duration of the cruise. Specific ROV requirements are more fully documented in the Regional Scale Nodes Remotely Operated Vehicle (ROV) Strategy White Paper, incorporated by reference.

Because ROV operations involving instrument deployment and site characterization are extremely intense and include a “fire hose” of data coming up the fiber, at least three members of the RSN seagoing team will be required during dive operations. These include the following: 1) a watch leader to ensure smooth dive operations and to interface with PIs and ROV crew; 2) a person to oversee data logging (e.g., real-time logging of all dive operations and communication; sampling documentation; digital documentation of site prior to, during, and post deployment/recovery); 3) a person to oversee video imagery collection (DVD burning, high definition) and operation of cameras. To use cruise time to optimum efficiency the RSN team and ROV team would be expected to be of sufficient size to allow for 24/7 operation with a minimum of downtime for equipment repair. Live 24/7 transmission of ROV operations and voice-over-IP are required for optimal communications to shore-based IO personnel for installation and maintenance of instruments and other Secondary Infrastructure and for safety during operations that involve cycling of cable power on and off from the shore station. It will also allow shore-based Users and PI’s to participate remotely during installation of instruments.

6.2 OOI Maintenance

Day to day maintenance of the OOI system of systems deployed components will be managed and performed by the three Implementing Organizations, each responsible for those elements originally designed, constructed and deployed by each. Deployed components refer to the Global Moorings, Coastal Arrays, Regional Scale Nodes, all cables, gliders and AUVs. Oversight of maintenance operations on the OOI will be performed by the Consortium for Ocean Leadership staff.

Maintenance can be defined as those activities directly relating to the repair and refurbishment of components and structures that are deployed in the ocean during and between their scheduled durations. While a Global Mooring may be untended for twelve months at a time, a Coastal Array Glider may have a scheduled maintenance turn four or more times per year.

As each major component of the OOI is designed, constructed and readied for testing, a complete and component specific maintenance schedule will be developed by the appropriate Operations and Maintenance personnel to insure that the approved maintenance procedures are documented. O&M assigned personnel will coordinate with the appropriate schedulers and develop the timelines for retrieving, refurbishing, and re-deploying all parts of the OOI.

OOI will work to develop a sophisticated understanding of the potential sources of variability in costs associated with the operational phase that follows the end of the MREFC. Equipment that wears and must be replaced or addressed with major refurbishment is one source of variation in annual costs. Some durable elements (e.g., the RSN cable, the buoy hulls of the CGSN) have long expected lifetimes, while other elements wear or require replacement due to obsolescence in a few years. In addition, ship scheduling may result in two global cruises to a given site in one 12-month period and none in the next (for example, one in January, one in December but none until the January of the year after next). These fluctuations and anticipated year-to-year variability will be modeled and that model presented to the NSF as the basis for the establishment of a maintenance cost stabilization account modeled after the MOSA that supports the maintenance of the NSF vessels in the UNOLS fleet.

Furthermore, catastrophic failure of OOI subsystems (e.g., loss of an entire mooring, cable failure due to fishing activity) could result in unexpected large spikes in maintenance expenses that exceed the annual O&M budget. The establishment of a maintenance cost stabilization account will be explored during 2011.

6.2.1 Cyberinfrastructure Maintenance

Description

At the highest level of consideration, maintenance of the Integrated Ocean Observatory is no different than the on-going concerns of any academic or commercial enterprise that supports a customer base by providing them a set of Services that are delivered as a combination of electronic and human interface processes that rely on a significant computational resource network. Recognizing this as a common concern that cuts across all forms of this type of endeavor, the OOI CI has adopted the best practices of the Telecom industry to frame the organization and management of the ongoing concerns of being a Service Provider. These best practices have been standardized as the enhanced Telecom Operations Map (eTOM). The eTOM model describes the full scope of business processes required by a service provider, defining key elements and their interactions. The eTOM was adopted as ITU-T International Recommendation, known in 2004 as M.3050.

The eTOM model consists of Level-0, Level-1, Level-2 and Level-3 processes. Each level drills down to more specific processes. The graphic representation of an eTOM model consists of rows and columns. The intersections of these rows and columns point to specific processes as specified by eTOM. The top-most row denotes the customer facing activity (i.e., marketing) while the bottom-most row indicates the supplier facing activity. In this manner, the eTOM map indicates the whole value chain. The map also gives a good indication of the interactions between the processes. The broadly classified sections are Strategy, Infrastructure & Product and Operations.

The eTOM Business Process Element Enterprise Framework (see Figure below) considers the Service Provider's (SP) enterprise, and positions this within its overall business context: the business interactions and relationships that allow the SP to carry on its business with other organizations.

The OOI CI maintenance strategy primarily focuses on the heart of the Framework, the Operations Process Area.

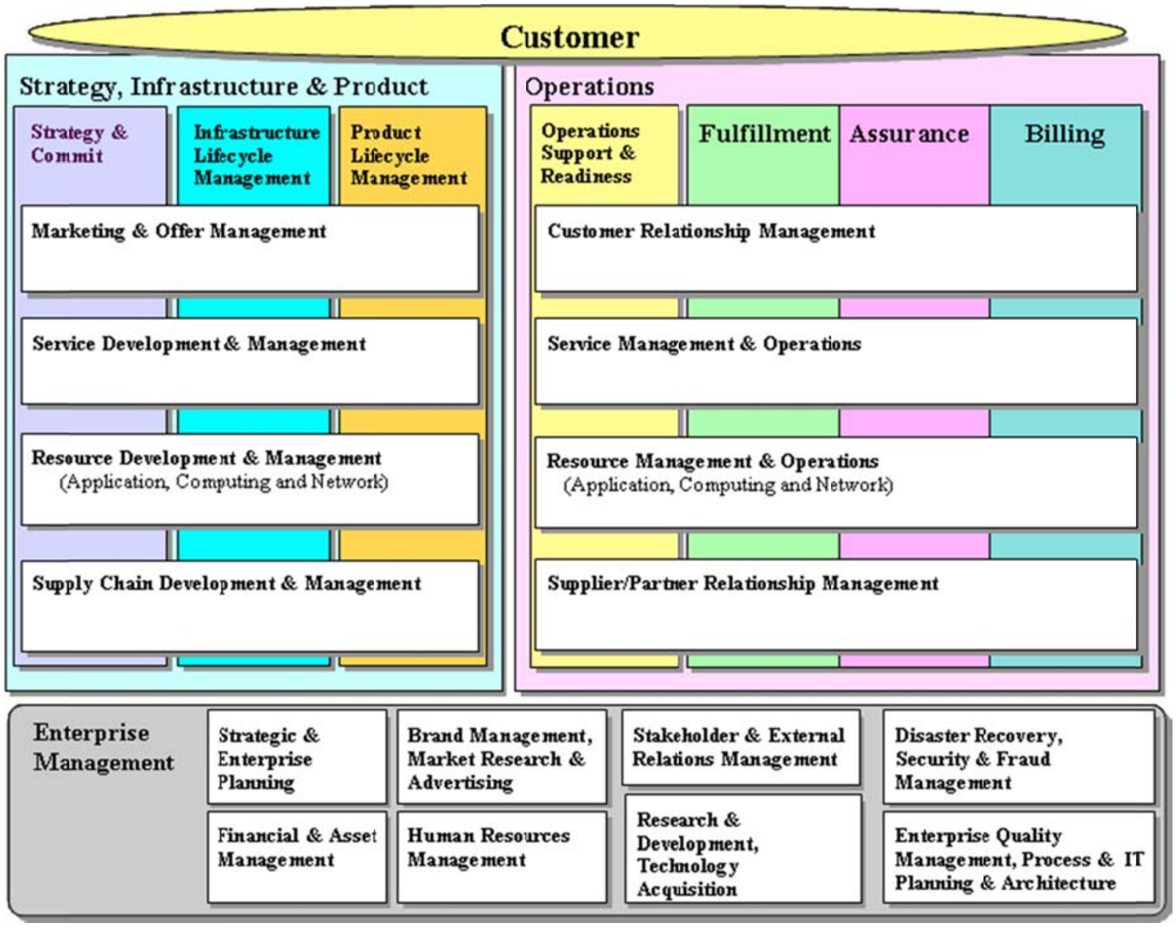

Figure 6-1. eTOM Business Process Element Enterprise Framework

<u>eTOM Conception View</u>

The eTOM Business Process Element Enterprise Framework represents the whole of a service provider's enterprise environment. At the conceptual level, eTOM can be viewed as having three major areas of concern:

1) Enterprise Management – Covering corporate or business support management
2) Strategy, Infrastructure & Product – Covering planning and life-cycle management
3) Operations – Covering the core of operational management

To understand the eTOM Business Process Framework, each process area is analyzed and decomposed into further groupings and processes. For each level of analysis or decomposition, the process area, grouping or process element itself is presented with a brief, summary-level description. At this highest level, the three basic process areas are outlined below.

The Enterprise Management Process Area includes those basic business processes that are required to run any large business. These generic processes focus on the setting and achieving of strategic corporate goals and objectives, as well as providing those support services that are required throughout an Enterprise. These processes are sometimes considered to be the corporate functions and/or processes (e.g., Financial Management, Human Resources Management, etc.). Since Enterprise Management processes are aimed at general support within the Enterprise, they may interface as needed with almost every other process in the Enterprise, be they operational, strategy, infrastructure or product processes.

The Strategy, Infrastructure & Product Process Area includes processes that develop strategies and commitment to them within the enterprise, that plan, develop and manage infrastructures and products, and that develop and manage the Supply Chain. In the eTOM, infrastructure refers to more than just the IT and resource infrastructure that supports products and services. It includes the infrastructure required to support functional processes such as Customer Relationship Management (CRM). These processes direct and enable the Operations processes.

The Operations Process Area is the heart of eTOM. It includes all operations processes that support the customer operations and management, as well as those that enable direct customer operations. These processes include both day-to-day and operations support and readiness. The eTOM view of Operations also includes sales management and supplier/partner relationship management.

The eTOM Operations Process Area has been selected as the foundation for the Cyberinfrastructure Implementing Organization's Maintenance Strategy, making it the primary focus of this section.

The eTOM as a whole, and the eTOM Operations Process Area, is a structured catalog (taxonomy) of process elements that can be viewed in more and more detail. When viewed in terms of the Horizontal Functional groupings, it follows a strict hierarchy where every element is only associated with or parented to a single element at the next higher hierarchical level. In taxonomy, any activity must be unique, so it must be listed only once.

Because the purpose of the eTOM framework is to help SPs to manage their end-to-end Business processes, the eTOM enhances the TOM practice of showing how process elements have a strong association with one (or several) end-to-end business processes such as Fulfillment, Assurance, and Reconciliation. These Vertical End-To-End groupings are essentially overlays onto the hierarchical top-level horizontal groupings, because in a hierarchical taxonomy an element cannot be associated with or parented to more than one element at the next higher level.

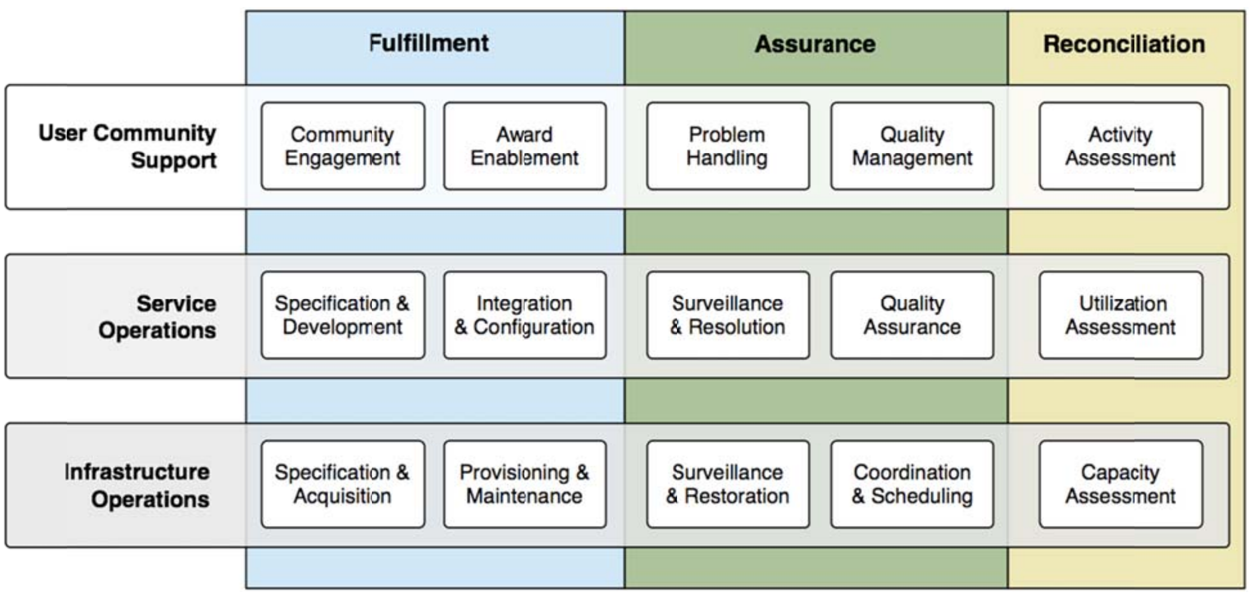

Figure 6-2. CI IO Maintenance Strategy Based on the eTOM Operations Process Area

Because eTOM was developed to help build and implement the process elements for a Service Provider, it was decided from the outset that the top-level hierarchy of process elements would be the functional (horizontal) groupings, rather than the end-to-end process (vertical) groupings.

The conceptual view of the eTOM Business Process Framework addresses the major process areas (shown in figure 5.3.2) and, just as importantly, the supporting functional process groupings, depicted as horizontal groupings. The functional groupings reflect the major expertise and focus required to pursue the business. The functional groupings are described below:

- User Community Support processes include those dealing with sales and channel management, marketing management, and product and offer management, as well as Customer Relationship Management and ordering, problem handling, and Service Level Agreement (SLA) Management.
- The Service Operations processes include those dealing with service development and configuration, service problem management, quality analysis, and rating.
- The Infrastructure Operations processes include those dealing with development and management of the enterprise's infrastructure, whether related to products and services, or to supporting the enterprise itself.

Additionally the major entities with which the enterprise interacts are shown. These are:

- Customers, to whom service is provided by means of the products sold by the enterprise: the focus of the business!
- Suppliers, who provide products or resources, bought and used by the enterprise directly or indirectly to support its business.
- Partners, with whom the enterprise co-operates in a shared area of business.
- Employees, who work for the enterprise to pursue its business goals.
- Shareholders, who have invested in the enterprise and thus own stock.
- Stakeholders, who have a commitment to the enterprise other than through stock ownership.

<u>eTOM Stakeholder-Level View</u>

Below the conceptual level, the eTOM Business Process Framework is decomposed into a set of process element groupings that provide a first level of detail at which the entire enterprise can be viewed. These process groupings are considered the stakeholder or CEO level view, in that the performance of these processes determines the success of the enterprise.

The eTOM Business Process Framework is defined as generically as possible, so that it is independent of organization, technology and service. The eTOM is basically intuitive, business driven and customer focused. To reflect the way businesses look at their processes, the eTOM supports two different perspectives on the grouping of the detailed process elements:

Horizontal process groupings, which represent a view of functionally-related processes within the business, such as those involved in managing contact with the customer or in managing the supply chain. This structuring by functional groupings is useful to those who are responsible for creating the capability that enables the processes. The IT teams will look at groups of IT functions which tend to be implemented together (e.g., the front-of-house applications in the Customer Grouping, the back-of-house applications which focus on managing information about the services sold to customers, and the network management applications which focus on the technology which delivers the services). For processes delivered by people, there is a similar separation of workgroups—the front-of-house workgroups in the Customer Grouping, the back-of-house workgroups that focus on managing information about the services sold to customers, or the network management workgroups that focus on the technology which delivers the services.

Vertical process groupings that represent a view of end-to-end processes within the business, such as those involved in providing support to customers. This end-to-end view is important to those people who are responsible for changing, operating and managing the end-to-end processes. These people are more interested in the outcomes of the process and how they support customer need, rather than worrying about the IT or the workgroups that need to work together to deliver the result.

The overlay of the Functional (horizontal) groupings of process elements and the end-to-end process (vertical) groupings forms the inherent matrix structure of eTOM. This matrix structure is the core of one of the innovations and fundamental benefits of eTOM—it offers, for the first time, a standard language and structure for the process elements that are understood and used by both the people specifying and operating the end-to-end business, as well as those people who are responsible for creating the capability that enables the processes (whether automated by IT or implemented manually by workgroups).

eTOM Operations Processes

To be useful to a Service Provider, the eTOM Process Element Framework must help the SP to develop and operate their business processes. This section shows how the matrix structure of eTOM offers for the first time a standard language and structure for the process elements that are understood and used by both the people specifying and operating the end-to-end business, as well as those people who are responsible for creating the capability that enables the processes (whether automated by IT or implemented manually by workgroups).

Vertical Process Groupings

The Operations (OPS) process area contains the direct operations vertical process groupings of Fulfillment, Assurance, and Reconciliation, shown in Figure 5.3.2 that can be referred to as Customer Operations processes. In an e-business world, the focus of the enterprise must be enabling and supporting these processes as the highest priority. Therefore, in the eTOM, the Operations Process areas of Fulfillment, Assurance, and Reconciliation are an integrated part of the overall framework.

Fulfillment

This process grouping is responsible for providing customers with their requested products in a timely and correct manner. It translates the user community's research need into a solution, which can be delivered using the specific products in the enterprise's portfolio. This process informs the user communities of the status of their purchase order, ensures completion on time, as well as a delighted customer.

Assurance

This process grouping is responsible for the execution of proactive and reactive maintenance activities to ensure that services provided to customers are continuously available and to SLA or Quality of Service (QoS) performance levels. It performs continuous resource status and performance monitoring to proactively detect possible failures. It collects performance data and analyzes them to identify potential problems and resolve them without impact to the customer. This process manages the SLAs and reports service performance to the customer. It receives trouble reports from the customer, informs the customer of the trouble status, and ensures restoration and repair, as well as a delighted customer.

Reconciliation

This process grouping is responsible for the quality assessment of support In addition, it handles customer inquiries provides inquiry status and is responsible for resolving problems to the customer's satisfaction in a timely manner. This process grouping also supports quality of services.

Horizontal Process Groupings

In the OPS process area of the eTOM Framework, the functional process groupings of User Community Support, Service Operations, and Infrastructure Operations, shown in Figure 5.3.2, support the operations processes discussed above, and the management of operations.

User Community Support

This process grouping considers the fundamental knowledge of customer needs and includes all functionalities necessary for the acquisition, enhancement and retention of a relationship with a customer. It is about customer service and support, through a multitude of different channels. It is also about retention management, cross-selling, up-selling and direct marketing for the purpose of selling to the customer. User Community Support also includes the collection of customer information and its application to personalize, customize and integrate delivery of service to a customer, as well as to identify opportunities for increasing the value of the customer to the enterprise. User Community Support is a key element of the eTOM CI Maintenance strategy because:

It expands Customer Care to Customer Relationship Management (CRM), which is a management approach to supporting and interacting with customers that enables enterprises to identify, attract and increase retention of profitable customers. CRM focuses on collection and application of customer data and managing relationships with customers to improve customer retention and customer value contribution to the enterprise. CRM is more than Customer Care or Customer Interface Management, as it is the integration of customer acquisition, enhancement and retention through managing the customer relationship over time. For eTOM, CRM also represents the integration of Service processes and ensuring a consistent customer interface across all CRM functional processes.

- It integrates Customer Interface Management for Fulfillment, Assurance, and Reconciliation across all the functional processes and with customer processes. Customer Interface Management represents any type of contact (e.g., phone, email, face-to-face, etc.). It expects an integration and coordination across these different interface types, to provide a consistent interface and highlights the requirement for customer process control and customer self-management. It also encourages the design of solutions so that systems interfaces used within the enterprise are the same as those used by customers.
- CRM processes include an expansion of Customer Care processes to:
    - focus on customer retention;
    - improve enterprise process exception customer response;
    - integrate marketing fulfillment execution

Policies & Procedures

The CI will insure that all computing, network and storage equipment is in working operation and is consistent with sound business practices, cost effective, and supported by in-house technical capabilities.

Each year the CI will undergo a thorough analysis of the support provided by the COTS (Commercial Off-The-Shelf), WAN (Wide Area Network) services provider, co-location hosts, and OEM (Original Equipment Manufacturer)/Vendors. The CI will examine the Mean Time Between Failure (MTBF), Mean Time To Repair (MTTR), and availability values for their hardware items. These values are input to the O&M Supportability Analyses for the CI System.

Supportability Analyses, provides the details of the number of returns/replacement units and other analyses that are performed from an Operations and Maintenance perspective. The results of these analyses drive the future selection of COTS hardware and software items and actual design of the system. This is a vital feedback loop to look to reduce the overall risk to the system and maintain the required levels of system availability.

Provisioning Process

The central provisioning site for the Cyberinfrastructure System is the CI Development and Maintenance Center located at the University of California, San Diego (UCSD). UCSD maintains the CI Bill of Materials (BOM) and is the central point for purchasing replacement items. UCSD is charged with providing timely provisioning turn around to the operational sites and providing unit repair at the CI Development and Maintenance Center, or vendor unit repair, at appropriate levels to meet operational availability requirements. CI Development and Maintenance Center functions nominally include provisioning, vendor support contracts, vendor repair coordination, technical support, disposition and shipping, adjustments and calibration, software upgrades, overhaul, and some preventive maintenance beyond the capability of the site personnel.

Life Cycle Cost (LCC) Modeling

Life Cycle Cost (LCC) Modeling is applied to choose the most technically effective support approach from a series of alternatives that also returns the lowest cost of ownership and highest performance and quality to the user. LCC analysis is performed throughout the system life cycle to update the baseline and includes analysis of alternative logistics support concepts.

Failure Mode Effects Analysis (FMEA)

FMEA is a systematic technique to identify potential failure modes; prioritize the failure modes according to the risk (i.e., severity, occurrence probability, detection probability, etc.); provide information to impact the product/process design; and identify actions to reduce/eliminate the failure modes.

Potential failure modes are identified based on severity of the consequences and frequency of the failure mode occurrence. The potential failure modes are ranked in terms of risk and operational impact.

- Acceptable
- Acceptable with minor changes
- Unacceptable without major improvements
- Unacceptable – Major safety risk

The identified and prioritized failure modes are fed back into the CI System development efforts and modifications to the requirements, system design, and implementation are incorporated to eliminate the most critical failure modes.

6.2.2 Coastal / Global Scale Nodes Maintenance

Description

The CGSN maintenance cycle includes: maintenance, refurbishment, instrument calibration, integration and test. During the maintenance cycle, equipment will be returned to the Factory Test Level and prepared for the next deployment. Following FT, the equipment will proceed to PIT and Burn-In as described in section 5.2.6.2.4. O&M costs started in Year 1 as the CGSN staff worked to develop the O&M plans, schedules, and budgets as well as the O&M processes and procedures. These processes and procedures need to be developed in advance and proven ready for use with the first maintenance cycle.

Recovered equipment will be returned to shore-side facilities for maintenance. In most cases, these facilities are those at WHOI, SIO or OSU. However, large and bulky material that does not require specialized attention and can be stored away from the OMCs until used again will be maintained, where possible, at sites closer to the cruise ports to save shipping costs and delays. Specifically, buoy hulls, glass balls and some mooring hardware will be refurbished in Mar del Plata, Argentina and in Punta Arenas, Chile.

Some costs will recur every cycle and are predictable. However, equipment that wears out unexpectedly or is damaged during deployment or recovery incurs a replacement cost outside of the anticipated cycle. The plans and budgets have been developed using experience-based rates of replacement due to wear and/or damage.

Upon the receipt of the recovered array element, all equipment exposed to seawater will be washed down. This wash down will only be conducted in the approved area to assure that no environmental impact is sustained. The wash down will be conducted in accordance with applicable IO procedures to prevent the migration of invasive species or other harmful substances into the environment.

Properly cleaned equipment will be inventoried and entered into the Materials Resource Planning (MRP). Any discrepancies in quantity, any obviously failed instruments or mooring elements, or other obvious problems will be noted and the appropriate trouble tickets will be generated. Any data not previously downloaded will be downloaded to the appropriate database and all metadata will be logged as per OOI operational procedures.

Upon completion of the testing, the item will be returned to secure storage until it can be assembled into the appropriate subsystem or system element. Any item deemed unremarkable, or can be cost effectively repaired, will be retired in accordance with OOI disposal of asset procedures.

Each component or sub-assembly will have a traveler attached. The item will then be securely stored until it can enter the refurbishment or repair process. As each item enters the refurbishment cycle it will have the appropriate maintenance and replacement of items as described in the applicable procedure. The traveler will be updated at each step to reflect the current state of the item.

After refurbishment, the item will be tested in accordance with the applicable test procedure.

The CGSN MREFC effort was structured in Integrated Design and Cross-design Teams to foster commonality of equipment within and between arrays. Designs are modular to accommodate varying degrees of implementation for specific installations. Implementation is planned to be incremental to provide operational insights and opportunities to correct failures in sequentially deployed equipment.
Maintenance will be based on a recover, replace and refurbish model. Equipment will be deployed for a specific deployment interval then recovered and replaced with equivalent equipment. The recovered equipment will return to the depot to be refurbished to support future “recover and replacement” operations. Because maintenance will be a cyclical process, corrective actions will be folded in as equipment is recovered and refurbished. Maintenance depots will be established at each of the CGSN partner institutions for specific equipment. Equipment assemblies and subassemblies procured from third-party suppliers will be returned to the supplier to the greatest degree possible for refurbishment. This includes but is not limited to calibration of instruments.

Design commonality allows the program to minimize the amount of equipment necessary to support the “recover and replace” cycle. Refurbishment is further optimized by our use of commonality, which benefits the operation by reducing inventory, training, and build test process diversity.

CGSN plans to use a mix of partner institution and manufacturer facilities and expertise to maintain the equipment. Most of the instruments and some commercial off-the-shelf (COTS) items will be returned to the OEM for maintenance, refurbishment, and calibration. CGSN partner institutions will maintain appropriate levels of non-COTS components, assemblies and subsystems. Personnel trained and familiar with the equipment will participate in deployment and recovery of equipment. O&M will start with equipment returned for the first few cycles to the partner responsible for the fielding in the equipment during MREFC. Equipment will transition to O&M coordinated at the array level by a single partner institution.

CGSN plans to initiate O&M with reliance on the team members who designed and built equipment to carry out operations and maintenance. However, over three O&M cycles, the intent is to have transferred to the team with lead responsibility for field operations the ongoing maintenance responsibilities. This, in effect, will prove the ability of the CGSN infrastructure to be maintained by future operators.

Sustaining engineering will be in place to plan and implement changes to the system as part of the maintenance based on changing technology and interfaces.

Planned Upgrades/Tech Refresh: As technology advances are made, some of them will be incorporated into the CGSN equipment. These will be spread out over the course of years and will not necessitate out-of-cycle maintenance. They will be proposed and approved through the Configuration Management Process.

Obsolete Components: Component obsolescence will require replacement of components and documentation update. When a direct replacement is not available, engineering will be required to define, design, develop, document and implement an alternate solution. The changes will be recorded using the Configuration Management Process.

Interface Software/Hardware: Changes to the interfaces with CI and RSN will necessitate corresponding changes on the CGSN side. Sustaining engineers will support the interface requirement change negotiation as well as define, design, develop, document and implement an alternate solution. All changes will be recorded using the Configuration Management Process. All changes will be tested in the burn-in process.

Failure Analysis: Failure analysis to determine root causes will be conducted. Status of the failure analysis will be tracked on a trouble report. The failure analysis will be led by the Systems Engineering Lead. Corrective action will be determined. When design changes are necessary, the Configuration Management Plan will be followed.

Policies

Material QA/QC procedures will be as defined in the CGSN QA/QC Plan. QA and QC procedures defined in the TDP will be used during refurbishment. QA and QC procedures will be defined and modified to maintain the QA/QC integrity of the system as hardware and software changes are made.

Procedures

Refurbishment: Refurbishment will combine original manufacturing practices and specific maintenance procedures to return equipment to its factory acceptance level. Instruments and equipment subsystems, systems and configuration items are cleaned, disassembled for repair or replacement, inspected and disposed of. Parts shall be re-tested per their original processes to meet the original equipment requirements. Some structural parts are systematically replaced due to structural duty cycle limits. Records of refurbishment will be analogous to construction records – test results, as-built configuration, PIT and Burn-in. Following Burn-in, an Installation Readiness Review will be performed to move the equipment to the Field Operations domain.

Property management: Property management will follow the institutional procedures for government/customer owned equipment. There will also be OOI-specific property management tasks that will impact logistics planning, inter-IO coordination, and science use of data. A database including the information described in the following paragraphs and will be established by the OOI project. CGSN personnel will have responsibility to populate access and analyze the data in the database. Detailed information can be found in the CGSN Property Management Plan.

Property location tracking: To facilitate logistics planning and to meet the OOI Property Management Plan, location of material and equipment will be known at all times. The history of the locations will also be maintained. Current and historical location/installation data for instruments will be particularly important because it will be used as part of the metadata set.

Asset tracking: Instrument Tracking -Instruments will be tracked for their entire life cycle including deployed and non-deployed periods. Reference designator locations will be matched with instrument serial numbers during particular deployment intervals to completely define the roles of specific instruments over time.

Repair History: Repair history of property will be maintained to assist with logistics planning as well as to isolate systemic problems (e.g. all instruments of one type are unreliable) and specific problems (e.g. a particular instrument is not reliable). A link to those engaged in instrument QA/QC and data processing would be required. Data QA/QC staff will be able to annotate property management records and request consideration of repair action.

Calibration records: calibration records will be maintained within the property system to facilitate data analysis and to complete the metadata set. Calibration records will be accessible to repair and data QA/QC processes.

Spare and Operational Equipment: All serialized equipment purchased by CGSN will be recorded and tracked in the Property Management system.

Material Resource Planning: A separate Material Resource Planning system will be used to plan required maintenance items, manage inventory and to track as built configurations.

6.2.3 Regional Scale Nodes Maintenance

Description

The RSN will have a number of maintenance layers addressing the varying needs of the multiple sub-system components. The cornerstone of an effective maintenance plan is monitoring and surveillance, which can anticipate and address network problems. The RSN OOC will address these problems using the Observatory Management System (OMS) as well as, the CI provided, instrument-monitoring tools. The Shore side infrastructure, such as the shore station, CyberPoP, and land cables will be maintained by small, local RSN staff, supplemented by specialized contractors. The Primary Infrastructure will require specialized tools and skills and will be maintained through a standby contract with a commercial undersea cable maintenance ship. The Secondary Infrastructure will be maintained by a UNOLS ship with an ROV.

The yearly cycle of RSN maintenance will be coordinated to correspond to the operations schedule planned for the same period of time. In many instances, the same facilities and personnel will be used for both functions. This annual maintenance plan will be presented along with the required budget in the AWP. The plan will cover each of the RSN subsystems and facilities as well as plans to refurbish or repair major components of the system. Maintenance must always deal with unexpected emergencies. The AWP will therefore be required to include a budget to cover emergent requirements.

Monitoring and Surveillance

An RSN system requirement is that the vendor of the Primary Infrastructure will provide an appropriate Network Management System (NMS) for monitoring and surveillance of the network. The capabilities of the discreet alarm points of the NMS will be exploited to enhance the ability to monitor other areas of the network such as the Secondary Infrastructure, as well as environmental or building alarms associated with the shore station. These enhancements to the Primary Infrastructure NMS will form the basis of the OMS to be provided by the UW. The capabilities of the OMS are expected to be augmented by management tools provided by the CI IO. The OMS will be configured for automated alerts to all on-call personnel for Critical and Major alarms. As back-up to the automated alerts, all OMS alarms are passed on to the CI Network Operations Center where procedures will be established to confirm that an RSN Network Specialist has been alerted to an alarm condition.

The OMS will be protected by high-security validation features, which enable secure remote access to appropriately trained RSN Network Specialists. Active surveillance of the Network will take place during the normal business day from a virtual RSN OOC. After-hours support will be provided through a tiered on-call support list, with predetermined escalation lists.

- Transmission Facilities

Shore Station Maintenance

Shore Station and Outside Plant – Pacific City
For the initial period it is expected that the RSN will be the sole tenant of this facility. The facility landlord will be responsible for maintaining building infrastructure including such items as fire/security, heating ventilating and air conditioning (HVAC), and emergency generator power.

Outside Plant refers to infrastructure between the shore station and beach manhole, which will include fiber-optic cables, power/conductors, and ducts/sub-ducts. Because this infrastructure is owned by the landlord, he/she will maintain contracts with the appropriate vendors to provide services covering the maintenance and repair. These service contracts will maintain service level agreements that document the vendor’s response time, as well as time to repair various faults.

Power and transmission equipment associated with the wet plant and the backhaul, will be maintained by the RSN. Planned maintenance activities will be conducted by RSN local technicians augmented on an as-needed basis by engineers from the UW Seattle campus. It is expected that the majority of the planned maintenance can be accomplished by a two-person RSN team located proximate to the shore station. The RSN Oregon team will work a normal business day. Outside of business hours, an on-call technician will be able to respond to the site within four hours.

PoP (Point of Presence) Maintenance

The CyberPoP, located in the Pittock Building in Portland, OR, is the interconnection point between the RSN and CI with a demarcation point located within the Landlord Meet Me Room (LMMR) or Collocation Space.

RSN will be sub-contracting for approximately 225 sq. ft. of caged floor area and fiber connectivity to the LMMR, in support of the terrestrial transport equipment. Routine preventive maintenance visits will be scheduled and completed by the shore station support staff. All other emerging requirements will be met through a remote-hands contract with a competent telecommunications services company working from the Pittock Building. The remote-hands contract will require no more than two-hour response time in response to requests outside of normal business hours. The equipment located at the CyberPoP will be standard telecom grade and a number of service companies can cost effectively support fault isolation and resolution for this type of equipment. An RSN Engineer will be available to immediately resolve and coordinate any assistance required by the remote-hands technician. The RSN Engineer will be responsible for updating the status to the associated trouble ticket.

Backhaul Maintenance

Managed bandwidth is the lease or purchase of specific units of capacity between specific locations with a defined quality of service. RSN will be leasing managed bandwidth from the shore station in Pacific City, OR to the POP in Portland, OR. The service provider will be responsible for all maintenance; troubleshooting and repair of the backhaul.

Wet Plant Maintenance

Wet Plant Maintenance is divided into Primary and Secondary Infrastructure. The two categories are differentiated based on the type of maintenance tools as well as the complexity of the infrastructure.

- ***Primary Infrastructure Maintenance***

The Primary infrastructure is the cable and components starting at the beach manhole and extending seaward to the Primary Nodes. With the exception of the Nodes themselves, all components are expected to be commercial off-the-shelf products of the undersea cable industry. Based on the specialized equipment required to properly install and repair these cables, it is anticipated that wet repairs will be conducted by a traditional cable ship. This cable ship would be dynamically positioned supported by a highly accurate navigation system and equipped with specialized cable laying machinery; as well as an ROV capable of assisting in cable recovery and reburial in water depths from 15 –1,500 meters for shallow work, and up to 3,000m for the deeper, unburied cable and Primary Nodes.

RSN anticipates joining the North America Zone (NAZ) Cable Maintenance Agreement, a consortium of undersea cable owners jointly procuring cable repair services from a cable ship owner. The Agreement provides a large cable ship with ROV stationed in Portland, OR. All portions of the RSN are within two days steaming time of the cable ship’s berth. By contract the ship is ready to depart within 24 hours of notification that a cable is broken. The ship's maintenance coverage zone is the eastern half of the Pacific Ocean, and is available on a first come, first serve basis.

A portion of the cable ship's depot is allocated to the storage of undersea cable, splice kits, and other components. A cable ship is not capable of carrying spare for all the cables under its maintenance responsibility, so the depot provides appropriate storage facilities configured for rapid loading upon mobilization. The RSN intends to store splice kits, primary nodes, and Primary Infrastructure cable at the cable ship depot in Portland, Oregon.

In the event of a fault in the Primary Infrastructure, RSN Management will review the data from the NMS and determine the service impacts of the fault. Analysis of the service impacts will determine the immediacy of the repair response. Some undersea networks have continued to operate for long periods of time despite a fault condition, so a rush to repair is not always prudent. Close coordination with the CI IO will be required to keep the User Community aware of the Network status. In the event of a complete loss of service, technicians will be dispatched to the shore station for electrical and optical isolation of the fault. The cable repair ship will be placed on standby, but will not be dispatched until a reliable fault location is determined. In the event of diminished service, coordination will take place with the User Community to ensure that no critical experiments are taking place, at which time intrusive testing will take place to identify and isolate the fault. After careful evaluation of the fault and determination that a repair is required, an appropriate repair window will be identified. The repair window will take into account such events as upcoming experiments and network maintenance schedule, as well as financial considerations.

At-sea repair operations of the Primary Infrastructure will be led by the cable ship's Engineer in Charge. The RSN will have at least one technical representative onboard to act as the Owner's representative. The cable ship will coordinate all activities directly with RSN personnel located in the shore station.

- ***Secondary Infrastructure Maintenance***

RSN plans to use a UNOLS Global class research ship with a ROV for the maintenance and repair of the Secondary Infrastructure. At present, the National Deep Submergence Facility does not have an ROV with appropriate capabilities; therefore, the RSN anticipates use of the Canadian Remotely Operated Platform for Ocean Science (ROPOS) vehicle. RSN has developed a Regional Scale Nodes Remotely Operated Vehicle (ROV) Strategy White Paper, incorporated by reference, to evaluate RSN requirements for installation of the Secondary Infrastructure and the capabilities of three ROV systems currently used by US institutions.

Currently, two maintenance cruises for the RSN Secondary Infrastructure are planned each year. Based on the sea-keeping abilities of the UNOLS Global class, and the expected weather conditions, the maintenance cruises will be scheduled in the beginning of the weather window (late spring/early summer) and the second cruise at the end of the weather window (late summer/early fall). An added benefit of including the Primary Infrastructure in a commercial cable maintenance agreement is reduced rates for ship and ROV use. This maintenance ship is home ported in Portland, OR, is available on 24-hour call out, and becomes a valuable asset if the UNOLS ship is unavailable or if an urgent Secondary Infrastructure repair is required during the poor winter weather conditions.

The RSN will develop an Annual Maintenance Plan for the Secondary Infrastructure. The maintenance plan will draw upon planned maintenance intervals of the specific infrastructure and emergent failures or abnormalities. The RSN will submit a prioritized maintenance plan to the Facilities Operation Group for endorsement. It is recognized that in some instances, based on financial or operational requirements, the entire maintenance plan may not be accomplished and items will roll to the next year's plan.

During at-sea operations the RSN Operations Director and shipboard Engineer/Scientist-in-Charge shall be given latitude to adapt to emerging requirements based on predetermined maintenance philosophies developed in conjunction with the Facilities Operation Group.

Secondary Infrastructure spares will be maintained at a storage facility in Oregon and/or Washington. These facilities will provide both environmentally controlled inside storage as well as outside storage capability. The facilities will be proximate to piers that at a minimum can accommodate an UNOLS Global class research ship.

RSN has developed the OOI-RSN Secondary Infrastructure Spares Plan to detail the plans for acquisition of redundant and spare Secondary Infrastructure including the LV Node, J-Boxes, Vertical Mooring, Deep and Shallow Profilers, and associated spare equipment. In addition, RSN has developed the OOI-RSN Sensor Maintenance, Risk, and Replacement documents to detail the plans for acquisition of redundant and spare instruments on the RSN and associated FTEs for maintenance and QA of the instruments. Both documents are incorporated by reference.

- Support Facilities

RSN Test Facility

An RSN Test Facility will be installed at the UW Applied Physics Laboratory (APL) to allow the RSN Engineering Team to test any subsystem or instrument used on the system. The area will be designed to simulate each type of subsystem used on the RSN. Engineering Development Models (EDM) or other prototypes of each subsystem component will be located at APL. Items such as the LV Nodes, J-Boxes, and Winch Controllers will be connected via sets of test cables that are similar but shorter than the real underwater units. If funding allows, the internal electronics of a Primary Node will be housed at the Test Facility. If there is not sufficient funding, a simulated Primary Node will be developed for the facility.

A complete set of Input Simulators will be developed for the Test Facility that will enable the Engineering Team to provide controlled input signals to each system component. Load Simulators will also be developed to ensure that each component under test is treated as though it were actually installed in the system.

All new sensors, instruments, and subsystems will be required to undergo a test phase at the Test Facility to certify that the unit can be installed on the RSN without harming or degrading the system's operation. This testing will include a physical examination of the unit-under-test (UUT) as well as a complete review of the accompanying documentation package.

Environmental testing of the UUT will be done primarily at external facilities. Contracts with companies that are qualified to do certified environmental testing will be set up for that phase of the testing program. Similar contracts will be developed with external Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC) testing facilities to handle all required electro-magnetic testing requirements.
UW facilities such as the School of Oceanography's pressure tank will be used to qualify all new and repaired instruments and subsystems before installation on the system.

The Test Facility will be installed in a laboratory at APL. The Test Facility will be maintained as a controlled-entrance room under the supervision of the lead Test Engineer. The Facility will be manned by the RSN Engineering Team.

RSN Logistics Depot

An RSN Logistics Depot will be established to handle the storage and accounting of all RSN components that are in the state of Washington. All RSN items in need of a repair that can't be handled in the Oregon storage/staging facility will be sent back to the UW for repair and/or calibration. The Logistics Depot will be managed by a full-time Logistics Manager who reports to the Chief Engineer. The Manager will have a full time Field Engineer as an assistant.

It will be the Logistic Manager's job to account for all RSN components both installed in the system and on shore as to their location, readiness to install, calibration schedule, repair status, installation cycle and availability of spare components. All movement of parts, between different RSN activities, will be the responsibility of the Logistics Manager. All vendor repair or calibration subcontracts will be developed and controlled by the Logistics Manager.

RSN Repair and Calibration Facilities

As part of the RSN Logistics facilities, an RSN Repair and Calibration facility will be established by APL and will handle the repair of non-commercial components and subsystems; and the calibration of all RSN sensors and instruments that are sent to it. Responsibilities for the repair of Core MREFC instruments await finalization of RFP's and awards for these instruments. However, where required, RSN will establish contracts with different instrument and component manufacturers to handle the repair and calibration of units purchased from them. This will greatly speed up the repair cycle and in many cases will combine both the repair and calibration of the commercial unit.

All components and subsystems developed by the RSN Engineering Team will be repaired under the supervision of the lead design engineer for that unit. Electronic and mechanical Field Engineers will be assigned to the facility as required from the RSN Engineering Team. The Logistics Manager will be responsible for scheduling the manpower requirements of the facility.

A facility will be established with the benefit of understanding the CG Endurance requirements, for the purpose of performing final checkout of RSN equipment before it is loaded onto a ship for installation on the system.

Storage Facility

A leased or purchased storage facility in Oregon will be located by the RSN IO that will have approximately 2,000 square feet of internal storage space and an adjacent 5,000 square feet of external storage. The internal storage area will have security and safety monitoring, secure access, and heating and lighting sufficient for members of the RSN team to work on cleaning, repairing, and testing RSN equipment. This facility could be part of the Oregon staging facility or the shore station in Pacific City, OR.

Simulators

During the MREFC phase of the program a set of Input Simulators will be developed for each of the RSN subsystems. These Simulators will generate the appropriate input voltages, digital data streams, clocks, and command/control signals to allow the unit under test to operate in a realistic manner. Similarly, Load Simulators will be developed that will properly simulate the real-world loading of each of the subsystem. During the MREFC phase these Simulators will be used in the Engineering Laboratories as test equipment during the development and fabrication phases of the program.

Once the program has entered into the OA&M (Operations, Administration and Maintenance) phase, the Simulators will be used in all areas of the field program. One set at the UW will be used in the Engineering Laboratory and in the Logistics Depot for the final checkout of equipment that has been repaired or upgraded. All formalized testing of RSN subsystems will be done utilizing these Simulators to ensure that the testing is done in a consistent manner.

Another set of Simulators will be located at the Oregon Staging Facility. This set will be used for all RSN testing at this facility as well as for any testing at the Oregon Staging Facility.

A portable Simulator system will be developed from a subset of the Simulator assemblies. This portable system will be used for all shipboard and in-field type testing. The portable unit will have a limited range of testing functions but will be able to adequately test the capabilities of the different RSN components.

Shipping & Receiving

Shipping and Receiving for the IO will be handled by the APL Shipping & Receiving (S&R) Department. This group consists of a staff of two full-time trained employees who are responsible for all S&R done by the Laboratory. The S&R staff will be responsible for all movement of RSN components moving through the University. Packaging for all RSN equipment will be handled by the S&R staff working in conjunction with the RSN Field Engineers. The S&R staff will also work closely with the Logistics Manager to ensure that all equipment movement is properly tracked and incoming inspection is performed on all RSN material.

The S&R Team will also work with the RSN Oregon members to provide shipping and receiving services as required. All shipping contracts will be set up by the UW's S&R team but the actual packing, shipping, receiving, and incoming inspection will be performed by the Oregon staff.

UW Training Center

A UW Training Center will be set up to instruct visiting PIs and their engineering staff on requirements for installing a new instrument or subsystem on the RSN infrastructure. The Center will be staffed by different members of the Engineer and PS Team and will be held in the Test Facility at APL. No new space or staff will be required.

RSN Procedures

That "all work is part of a process" and "process improvement never ends…" are tenets of the RSN Operations Plan. RSN Quality processes will be tiered with multiple levels. The highest level process, Level 1, provides a description, at the highest level, of the major RSN Operations Functions. Level 2 Process Flows further define these major functions inclusive of suppliers and their inputs, the RSN value-added functions, and the Users (or Customers) and the products provided. Level 3 Process flows are more specific to sub-functional areas (e.g.,. if RSN Maintenance is a Level 2 Process, then Backhaul Maintenance would be a Level 3 Process). Level 3 Process flows also detail the tools and resources required for the subject function area as well as direct measurements of quality (DMOQ). DMOQ are metrics required to evaluate key inputs, outputs, and internal activities, all of which are needed to manage RSN Quality. Finally Level 4 Process flows are detailed to the work task level.

Process Development

Process development begins with the RSN mission and documented goals. The processes are bounded by agreed interface agreements and contractual commitments. At the same time, work processes require the commitment and engagement of the teams directly involved in the work, and therefore Level 3 and Level 4 process development will not be presented in this issue of this ROP.

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Process and Quality Management

The RSN Quality Assurance (QA) Manger will ultimately be responsible for Process Management and Improvement. An RSN Quality Committee will be established at least six months prior to RSN Commissioning. The QA Manager, with the assistance of the Quality Committee, will perform the following functions:

- Process review
- DMOQ analysis and reporting
- Post-event analysis
- Corrective action tracking
- Quality audits
- Development and evaluation of operational readiness test
- Management of supplier quality
- Management of user expectations
- Training review and recommendations.

- RSN Level 1 Process

The Level 1 RSN Process is a restatement of the RSN Mission: "The RSN primary mission is to support the Science User community by providing and maintaining an infrastructure and core sensors with access to quality data that meets the Science User Requirements."

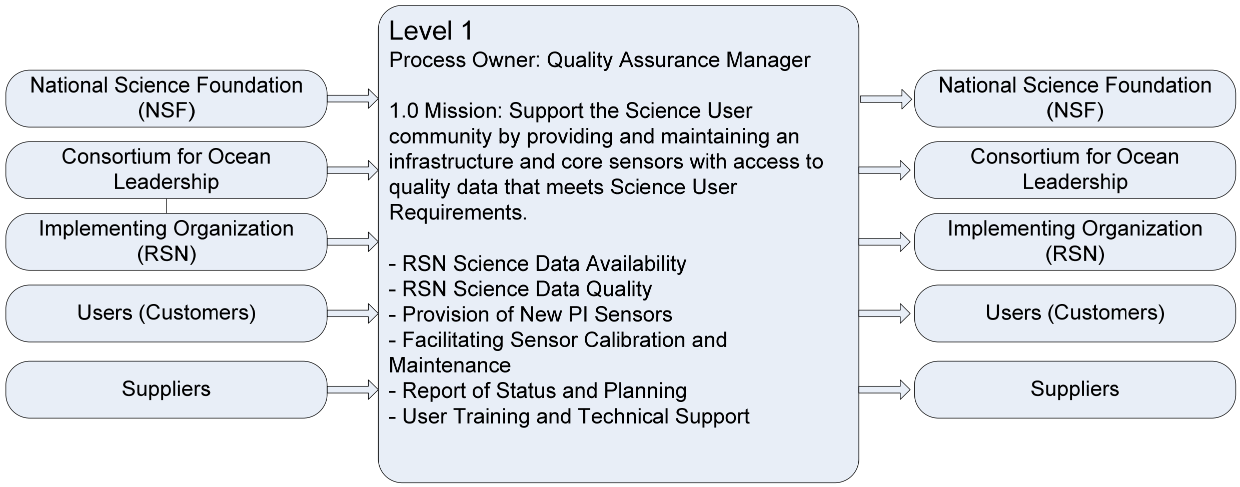


Figure: 6-3. Level 1 Process Flows

- RSN Level 2 Process Flows

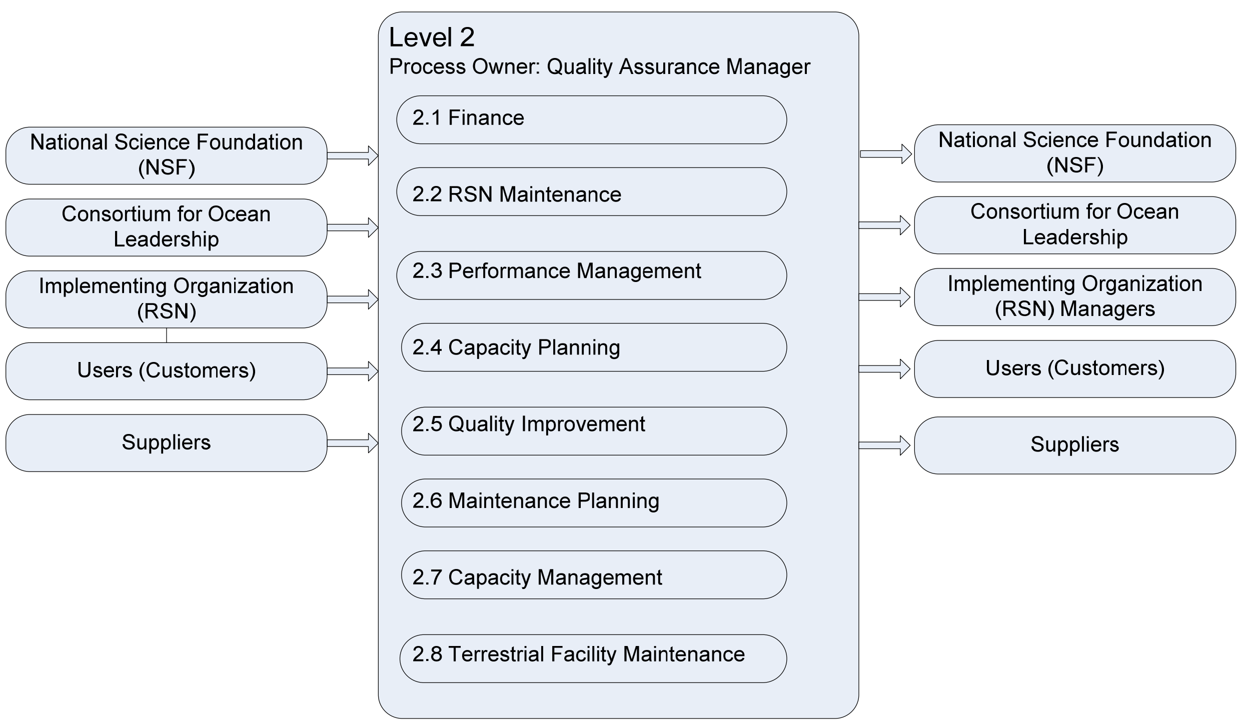


Figure: 6-4. Level 2 Process Flows

Sub-Process Description

- Finance - All billing, payments, budget planning and management functions.
- RSN Maintenance – All demand and preventative maintenance activities
- Performance Management – Monitoring and activities to insure all required performance levels
- Capacity Planning – Planning and implementation of all hard and soft assets.
- Quality Improvement – Process management, process reviews, quality and training audits and corrective actions.
- Maintenance Planning – Development of Annual Work Plans, Repair Plans and maintenance activities.
- Capacity Management – Inventory of all assets and utilization of power and bandwidth
- Terrestrial Facility Maintenance – Managing the third party maintenance of backhaul facilities.

RSN Level 3 Process Flows

Level 3 Process Flows will be developed by the RSN Staff at least six months prior to Commissioning. The specific process flows will relate directly to a parent Level 2 Process Flows and the expected Level 3 processes are listed below:

Finance
- Budget/Proposal Development
- Annual Work Plan costing
- Invoicing to Consortium for Ocean Leadership (COL)
- Payments & Disbursements
- Budget Management and Reporting

RSN Maintenance
- CyberPoP and Cable Station Maintenance
- Backhaul Maintenance
- Primary Infrastructure Maintenance
- Secondary & Tertiary Infrastructure Maintenance
- Instrument Maintenance

Performance Management
- Primary Infrastructure Performance
- Backhaul Performance
- Secondary & Tertiary Infrastructure Performance
- Sensor Data Quality Performance

Quality Improvement
- Quality Performance Assessment
- Post Event Analysis
- Corrective Action Management
- Quality Audits and Inspections
- Training Administration

Maintenance Planning
- Development of the annual UNOLS (or UNOLS equivalent) Maintenance Cruises
- Managing External Maintenance Provider Agreements
- Development of Primary Infrastructure Repairs Plans (as required)

Capacity Management
- Physical Asset Inventory Management
- Resource Management & Planning

Terrestrial Facility Management

- Inventory and Planning of Backhaul Capacity Requirements

  - RSN Level 4 Process Flows

Level 4 Process Flows will be developed by the RSN Staff at least six months prior to Commissioning. The specific process flows will relate directly to a parent Level 3 Process Flow.

6.3 Operational Data Policy

An OOI Data Policy was developed during the planning stages of the OOI. That document is included as Appendix E.

6.3.1 Cyberinfrastructure

Data collected by OOI are valuable resources and must be carefully managed. Procedures are in place governing inquiry and download access, dissemination, usage, collection, provenance, maintenance, and protection of the data. Data will be collected through the acquisition sites (Portland and WHOI). At no time will OOI users be able to access data directly from the acquisition sites. Requests for data will be through the distribution sites (Seattle and Chicago).

CI will make data available upon receipt.

Derived data created by end users from OOI data and published to OOI will be stored in an OOI repository. However, it is the responsibility of the user creating the data to backup this derived data.

High definition video data and hydrophone data will be kept for a period of 90 days and then the oldest data will be over written by new incoming data. Users wishing to retain parts of this data will be responsible for moving it to another location of their own choosing.

Backup of Data

The main data source will be housed at the Portland CyberPoP. Two distinct copies of the data will be housed at the Portland facility. Copies of WHOI data will be sent to Portland. UCSD will provide a remote backup facility for data collected at the Portland CyberPoP.

Data Security

Data must be effectively protected from accidental or intentional modification, destruction, or loss. Data shall be safeguarded to ensure its integrity, reliability and availability.

At points where OOI is connected to external parties, an actively managed Firewall coupled with an Intrusion Prevention System will be in place. In addition antivirus and antimalware solutions will be in place.

For remote access, secure tunnels (using SSL) will be used.

6.3.2 Coastal / Global Scale Nodes

All CGSN sites will flow some data in near-real time, relying on satellite and RF telemetry. The cabled elements of the Endurance Site will provide data via the RSN cable. CGSN platforms (moored instruments, gliders, AUVs) will provide data upon recovery; that data will be sent to CI via internet. In every case as the data becomes available, it flows to the Cyber Infrastructure (CI) of OOI.

Application of the appropriate QA/QC procedures will be done by CI with the involvement of the CGSN and domain experts. These procedures shall include the incorporation of all relevant metadata. CGSN is responsible for the metadata and ancillary data sets. Ancillary data sets include the shore side pre- and post-deployment calibrations as well as any in-situ validation/verification data sets. Ancillary data sets also include documentation of the operations procedures (including cruises) and the maintenance procedures, including refurbishment. The engagement of domain experts will be done on an instrument by instrument basis to assure that the data QA/QC procedures are current and appropriate.

The CGSN OMCs will monitor the health and performance of the infrastructure using telemetered and cabled scientific and engineering data on an ongoing basis.

Data operations responsibilities begin at collection and continue as more complete data sets are developed through the addition of metadata and quality control (QC) processes. CGSN data responsibilities derive from the role of CGSN as the PI for the core instrumentation.

As data advances in maturity, the Data Distribution Network will store data at all levels although not all levels may be supported for all instruments. Multiple data sets are expected from each instrument, including but not limited to:

- Native instrument format collected during the deployment interval
- Metadata annotated data collected during the deployment interval
- QC annotated data collected during the deployment interval
- Native instrument data enhanced during the deployment interval (e.g. collected by a ship near-by)
- Metadata annotated data of the enhanced, deployment interval set(s)
- QC annotated data of the enhanced, deployment interval set(s)
- Native instrument data collected post-deployment
- Metadata annotated data of the post-deployment
- QC annotated data of the post-deployment set

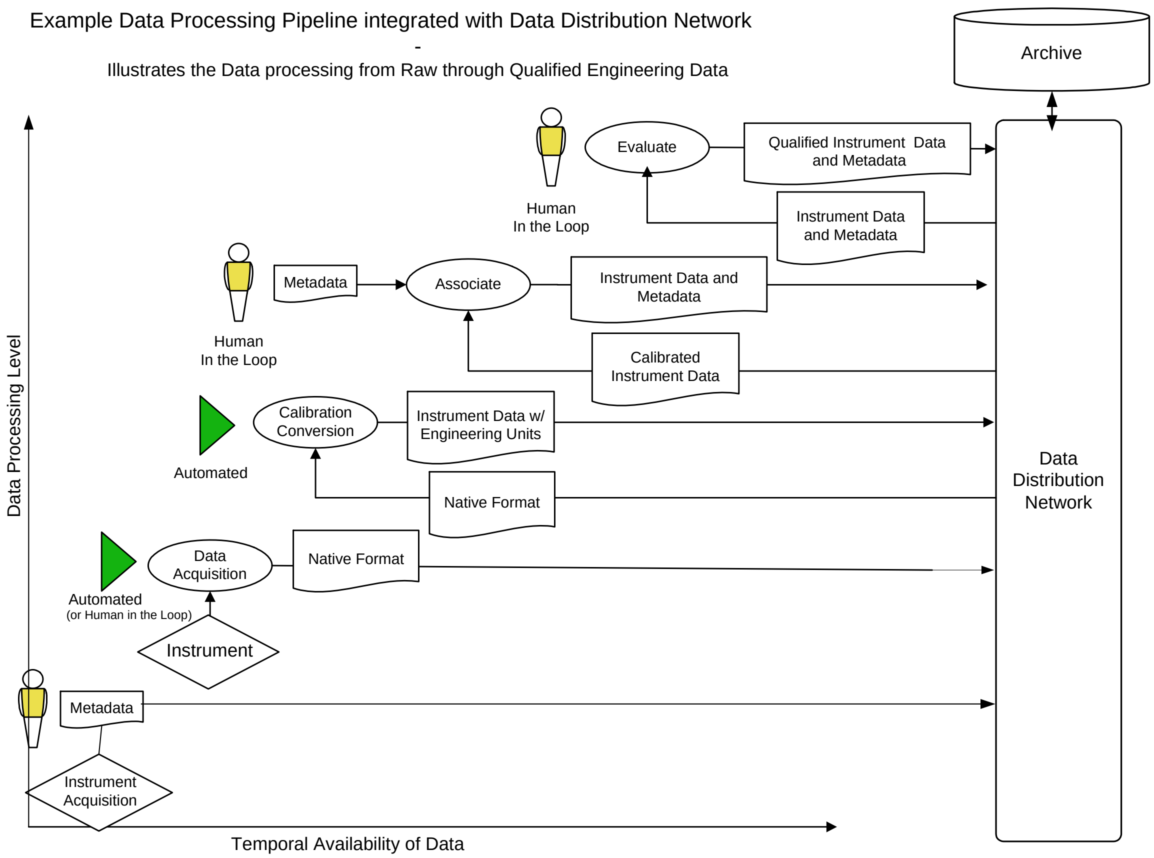


Figure 6-5. Data operations with data distribution network

CGSN Data Quality Control (QC)

Data QC provides assurance that data has been reviewed to verify, validate and document discrepancies. Data QC Levels indicate the degree to which the data has been verified, validated and documented. CI will provide the storage repository of record for the OOI data. CGSN will provide verification, validation and documentation for the core instruments. PIs will be responsible for verification, validation and documentation associated with other instruments.

The diversity of instruments leads to “native format” entering the system at various levels with respect to the units recorded and the processing applied. Following ingest of the “native format” additional metadata annotations will be made and data quality assessment will occur.

CGSN will establish and follow standardized QC procedures for each instrument type to ensure consistent application of processing and assessment steps. CGSN will decide whether array-based or measurement-based divisions of labor are the best fit for particular instruments.

CGSN Metadata

Metadata additions at defined data levels will vary depending on the level at which the instrument delivers data. A data ingest path for each instrument will be developed to show where data enters the system and how the metadata and QC annotations are added.
OOI and CGSN will establish metadata annotation ontology. The ontology will be maintained at the program level. The Asset Tracking database (e.g. sensor deployment, calibration and repair histories), system monitoring notations and shipboard instrument measurements will figure in the application/annotation of metadata.

CGSN Data Repository and Access

CI will maintain the data repository and provide access consistent with its role as the Customer Interface Manager. CGSN will have access directly and through the CI provided interface to instrument native data, at a minimum, for the instruments for which performance monitoring and/or QC services are provided. CGSN will re-post data after each processing step as defined by the OOI data management procedure.

OOI Ship data requirements

CGSN: Data collected by meteorological and oceanographic instruments on the vessels used to service the CGSN platforms should be collected and available at the end of each cruise. That data will be collected to carry out in situ verification/validation of the data collected from the platforms. Shipboard instruments should be freshly calibrated, with documentation of the calibrations; their data should be in engineering units along with the raw data and all algorithms used to compute the data in engineering. Ship data shall include: time, position, water depth, surface meteorology (wind speed and direction, air and sea temperature, relative humidity, incoming shortwave and incoming longwave radiation, barometric pressure), thermosalinograph, ADCP, and CTD (with bottle samples and with T, S, oxygen, fluorometer). Ship data must be provided with documentation of sampling heights/depths and sampling and averaging schemes. For ships equipped with multi-beam depth mappers; processed maps as well as raw data should be provided.

OOI Instrument data requirements

Internally recorded data will be recovered from CGSN instruments as soon as feasible. All raw data and any data computed by processors in the instruments or recorded for engineering purposes shall be recovered, as well as all relevant calibration and instrument tracking information (serial number, firmware version, etc.). The associated metadata (depth, platform to which it was attached, deployment date, recovery date, etc.) must be recovered or created. Ancillary instrument data shall also be collected, including insertion in the data records of timing marks (e.g. submerging an instrument in an ice bath at a specific, recorded time before and after deployment to verify instrument clock performance), pre-deployment and post-deployment calibrations, pre-deployment bench testing and burn-in, and any post-deployment test data.

Shore facilities will support reception and collection of telemetered data (Iridium and RF). The WHOI, OSU, and SIO OMCs will have modem banks and Uninterruptable Power Supplies (UPS) to support receipt of data and the forwarding of that data to CI.

Contextual Data

To support the CGSN operations, CI will provide tools to access weather, wave/sea state, and ocean state (currents, temperature, salinity) data at the CGSN platform locations; that access shall be at the CGSN OMCs and from the vessels engaged in CGSN operations. To set the context for the CGSN platforms, CI will collect and archive remotely sensed, in-situ, and model data from the regions spanning the locations of the CI platforms.

6.4 Calibration Plan

As the final design and equipment selections are made during Year 2 of construction, a comprehensive calibration plan will be developed and incorporated by reference into this document. ***Calibration of instruments will be approached as an OOI-wide process, with a careful evaluation of the cost-effectiveness of centralized versus distributed calibration facilities.***

The following parameters have been defined as a part of the OOI Calibration Subgroup (part of the Data/Products Working Group) to explore Operations and Maintenance calibration-related issues

Nature of calibration

Instrument Certificates of Calibration (CoC) requested from manufacturers will include, to the extent practicable for a particular instrument type and calibration procedure:

1. As-received calibration (serves as post-cal for prior deployment)
2. Post cleaning, post repair calibration (pre-cal for next deployment)

Pre-deployment calibration

1. Instruments will be calibrated prior to deployment to the extent practicable for a given instrument type
2. An instrument scheduled for deployment will be re-calibrated if the *calibration due date* is prior to the deployment date.

Calibration due date

The date when the next calibration is due for a freshly calibrated instrument will be determined by the shorter of the following three dates:

1. Date provided by manufacturer
2. Date estimated by OOI based on (mfg drift rate x time to deployment) <= specified accuracy
3. Maximum interval declared by OOI (e.g. “not to exceed 24 months”)

6.4.1 Coastal / Global Scale Nodes

CGSN will coordinate pre- and post-deployment calibrations of all instruments unique to the CGSN. Calibration histories will be analyzed to identify anomalous calibrations and/or changes to instruments. CGSN will use either in-house or vendor services, with the decision guided by cost-effectiveness, ability to support the data QA/QC process effectively and efficiently, timeliness (to meet schedules), and past experience.

In some cases, in-house calibration practices and equipment are well established. WHOI supports a CTD Calibration Laboratory to provide high accuracy pressure, conductivity, and temperature calibrations for CTDs, thermistors and transfer temperature standards. The WHOI Upper Ocean Process (UOP) Group operates the Meteorological Calibration Laboratory, including a wind tunnel. This facility will allow OOI meteorological instruments to be tested and calibrated in-house. In addition UOP supports an external burn-in site for meteorological instruments, located away from buildings and obstructions, which will enable instruments to be tested and calibrated on site.

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. They 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 sensor performance: a goal that differs significantly from, but is just as necessary as the goals of a commercial calibration lab. SIO’s Hydraulics Laboratory also operates a temperature and pressure calibration facility with a temperature calibration tank (0.51 m deep by 0.51 m wide by 1.83 m long or 0.48 m3) with temperature control of several millidegrees and temperature measurement of one millidegree. The Hydraulics Laboratory also operates two separate pneumatic pressure standard measurement control systems ranging from atmosphere to either 100 or 300 PSIG with < 0.01 % full-scale accuracy.

6.4.2 Regional Scale Nodes

The UW will develop a RSN Repair and Calibration Facility that will be responsible for the calibration of sensors and instruments that are unique to the RSN. For commercial instruments, contracts will be initiated with the original equipment manufacturers of each instrument whenever possible. The main responsibility of the Calibration Facility for commercial instruments will be to track the unit’s calibration schedule and make sure installed instruments are removed whenever they approach the end of their calibration cycle. For unique PI-type instruments on the cabled system, the UW will work with the PI to implement a plan whereby the instrument can be calibrated to the PI's specifications. This may involve developing special calibration devices at either the PI's facility or at the UW depending on the instrument's unique requirements. Once the PI calibration plan is in place, these types of instruments will be tracked in the same manner as for the commercial devices.

Staffing for the Calibration Facility will be assigned from the Engineering Team on an as-needed basis. If the need proves sufficient, a full-time Field Engineer will be assigned to the Facility. The Engineers, working in conjunction with the Project Scientist and the Logistics Manager, will be responsible for instrument calibration. Space for the facility will be assigned in the Logistics Depot with the exception of unique calibration tools that may require a specialized or existing test area specifically for PI type instruments.

6.5 IO Specific Sparing & Service Life Replacement Strategies

6.5.1 Cyberinfrastructure

The Portland CyberPoP is designed as being fully redundant in all components so that if a piece of equipment fails, no outages should occur. Both the Seattle and Chicago CyberPoPs are designed to back each other up so that if a piece of equipment fails, the site will operate in degraded mode until the equipment is replaced by the vendor. If necessary, the San Diego facility can also act as a distribution site. We are relying on vendor-supplied warrantees rather than keeping spares at each location. We expect all equipment to be replaced on site within 1 to 2 business days. We are assuming a 5-year component replacement policy for all equipment. Redundant communication paths will be provided for the Wide Area Network.

6.5.2 Coastal / Global Scale Nodes

- Spares: Items procured or produced to replace broken or expended like items.
- O&M Property: Items required to enable maintenance to occur as planned. If used as a spare, the O&M Property would have to be replaced or maintenance could not continue as planned.
- Built into the O&M plan at present are initial replacement strategies based on experience to date. Basically, there are several different strategies:
- Expendables. Mooring line components such as plastic jacketed wire rope, synthetic line, chain, and hardware such as links and shackles are used once. Their submergence in seawater, their exposure to corrosion, cyclic stresses, and their exposure to air that accelerates corrosion during turn-around, point to these items being only reliable for one use.
- Durable hardware. Some elements of mooring hardware do not degrade due to exposure. These include glass balls (flotation), buoy hulls (closed cell foam), titanium load bars, and other durable mechanical assemblies (MFNs –multi function nodes-, benthic nodes, anchors). These will be inspected and refurbished after use and returned to inventory for redeployment.
- Mobile platforms. The powered AUVS and the gliders have a number of moving parts that wear and potential for corrosion. Intermediate refurbishments will at some point not be able to return these platforms to serviceable condition. Similarly, profiling platforms are expected to have finite lifetime before full replacement is required.
- Discrete instruments. The experience to date indicates that mooring recovery and deployment on occasion leads to extensive damage to an instrument (hitting the ship during a high sea state operation, for example) or that an O-ring may fail and flood an instrument. Discrete instrument replacement life cycles are longer than those of the platforms with moving parts.

- Sustaining engineering. Overlaying the planned strategy of periodic replacement to cope with damage and or wear, CGSN will carry on a sustaining engineering effort to mitigate failures, cope with obsolescence of instruments or components, and examine more cost-effective and efficient technical approaches to meeting requirements.

6.5.3 Regional Scale Nodes

Primary Infrastructure

To reduce the life cycle cost, the system is segmented to make the parts with the greatest probability of requiring repair easier to service. Three levels of repair are possible for the system. The shore hardware is easiest to repair, and repairs can be done in a few hours at low cost and in almost any weather. The next level of repair is performed with a research type vessel and an ROV. The parts of the submarine system with the highest failure rates are in a module that can be brought to the surface, and a replacement reinstalled with an ROV. The third level is hardware that would require a cable ship to repair. Only parts with a high probability of surviving for the 25-year mission time are located in the system where they require a cable ship for repair.

Submarine Cable and Repeaters

Submarine cable and repeaters are designed with a 25-year design life; and failures, not related to external aggression, are low. A simple serial system with eight repeaters, each with a 20 FIT failure rate was modeled. The eight repeaters have a 98.6% chance of not requiring repair, a 1.4 % chance of one required repair and a 0.02% chance of two required repairs. This indicates only a single cable ship repair would have to be budgeted for the 25-year mission time.

Primary Nodes – Backbone Interface Assembly (BIA)

For the proposed 7-Node system, the calculations show that for a 25-year mission time, there is a 72% chance that no repairs are required for the BIA, a 24% chance of 1 repair and a 3% chance of more than one repair. Failures of the Power/Fiber Distribution Assembly in the BIA will require a cable ship repair, however all other BIA components would require an ROV to repair.

Primary Node - Science Interface Assembly (SIA)

The Primary Node SIA is close to neutrally buoyant and has Wet-Mate Connectors to allow relatively easy servicing with an ROV. This hardware has considerable redundancy, but not nearly enough to last 25 years without maintenance. Therefore, failed components will need to be repaired annually, during schedule maintenance cruises, to maintain high reliability and availability. If failed components are replaced on an annual basis, there is only a 3% chance of needing an unscheduled repair.

Secondary Infrastructure

The RSN plans for acquisition of redundant and spare Secondary Infrastructure are summarized below, and in accordance with OOI-RSN Secondary Infrastructure Spares Plan, Document No. 4314-00001. Justification for equipment is based on expected lifetime of equipment, maintenance intervals, system configuration and the frequency that attached sensors must be replaced.

LV Nodes

There are eight LV Nodes, all with identical configuration, in the RSN. The LV Nodes are not connected with dry mate connectors to any equipment that needs to be serviced on an annual basis. The LV Nodes have a 10 year maintenance schedule. The strategy will be to have two LV Nodes at the start of O&M that will function as both Spares and Replacements, and build one new LV Node every 5 years. After 5 years of service, the LV Nodes will be replaced 2 a year for refurbish / maintenance; this will always leave one available for Spare.

Medium Power Junction Boxes (MP-JBox)

There are eleven Medium Power Junction Boxes in the RSN. Five (5) sites have an identical MP-JBox with two instruments hard wired that must be recovered every 3 to 5 years and two ROV wet mate connectors. Two more MP-JBoxes have a mix of dry and wet mate Connectors and the rest have only ROV wet mate connectors. They have a 10 year maintenance schedule. The strategy will be to have two MP-JBoxes at the start of O&M that will function as replacements for the 7 MP-JBoxes that must be swapped out every 3-5 years. One more MP-JBox will be for the rest with all ROV wet mate connectors that must be swapped one by one at year 5. An additional spare MP-JBox will be allocated for failure.

Low Power Junction Boxes

There are six Low Power Junction Boxes in the RSN. All have a mix of dry and wet mate connectors and instruments that need to be replaced on an annual basis. The strategy will be to have seven Low Power Junction Boxes at the start of O&M - one for spares and 6 for replacement and build one new one every 5 years.

Interface Boxes

There are fifty Interface Boxes in the RSN. The Interface Boxes have no active electronics, but they must be recovered with the instruments that are attached. The strategy will be to recover the instrument with the interface box, disconnect the used instrument and attach a new instrument to the interface box using the dry mate connector, and then redeploy the new sensor with the interface box. RSN will purchase common parts so that a replacement can be built to replace and failed interface box.

Cable Assemblies

There are over 230 cable assemblies in the RSN, 93 of which have at least one ROV wet mate connector and 30 of which are at least 1,000m or longer. The strategy will be to stock a number of the shorter common cable assemblies and have spare parts available to make the longer cable assemblies when a failure happens. Cables with ROV wet mate connectors have a design life of 25 years and are not expected to fail unless there is an external aggression. Cable with dry mate connectors are shorter (1 meter) instrument cables that will be replaced during routine instrument maintenance every 10 years. These can be made up each year as needed.

Vertical Mooring

There are three Vertical Moorings in the RSN part of the OOI. They have a fixed cable with a 200 meter platform that have a 25 year life expectancy with no scheduled maintenance. They are meant to be deployed once and not recovered. There will be one spare of this system for failures.

Deep Profiler

The deep profiler is a buoyancy driven platform with instruments that need to be recovered once a year. Each Mooring will have a redundant Profiler and spare for failures.

Shallow Profiler

The shallow profiler is a winch drive profiler that needs to be recovered once a year. Each Mooring will have a redundant Shallow Profiler and a spare for failures.

200m Platform JBox

Each 200m Platform has a JBox for instruments that must be replaced every year. Each Mooring will have a redundant 200m JBox and a spare for failures.

200m Platform Mooring Controller

Each 200m Platform has a Mooring Controller that must be maintained every 10 years. There will be two spare 200m Platforms.

Instruments

Each RSN instrument has been reviewed by the RSN team and classified by Class (durability) and Risk (estimated operational duration) to determine spare instrument quantity and anticipated replacement interval. The RSN plans for acquisition of redundant and spare instruments for the Secondary Infrastructure are summarized below, and in accordance with OOI--RSN Sensor Maintenance, Risk, and Replacement, Document No. 4308-00005.

Core Seafloor Instruments

The total number of different kinds of seafloor instruments on the RSN totals 17, of which 8 are Class 1 instruments. The OOI--RSN Sensor Maintenance, Risk, and Replacement document (Document No. 4308-00005) includes a summary of these instruments, their cost and location on the RSN, and the justification for their class; and provides a summary of the Risk versus Maintenance (class) considerations for each seafloor instrument. Instrument class and risk determination are based on field experience and knowledge of these instruments. There are 68 total seafloor instruments, of which 92% are Low Risk, 6% are Medium Risk, and 2% are Medium/High Risk.

Water Column (Hybrid Mooring) Instruments

The total number of different kinds of water column instruments on the RSN totals 17, of which 7 are Class 1 instruments. The OOI--RSN Sensor Maintenance, Risk, and Replacement document (Document No. 4308-00005) includes a summary of these instruments, their cost and location on the RSN, and the justification for their class; and provides a summary of the Risk versus Maintenance (class) considerations for each instrument.

6.6 OOI User Support and Helpdesk

The science community, educational institutions, and the general public all will have access to the OOI data and products. This access will be through a series of portals that allow various levels of interaction with the OOI in accordance with the various classes of users established.

The system shall administer to these different types of users through interfaces maintained by the Cyberinfrastructure (CI). The CI will employ a Service Oriented Architecture to manage log-ins, passwords, user classes, and permissions for interactivity. In addition, the CI will send notices to users for planned events and regular updates on unplanned outages.

6.6.1 Cyberinfrastructure

The CI will provide a Helpdesk to support users with accessing data, resolving network and connectivity issues and providing training on the user interfaces. The Helpdesk will be manned for a 12 hour period from 8 AM eastern time to 5 PM Pacific Time. The Helpdesk staff will also follow up with problem resolution and to make sure that user concerns are being addressed.

6.6.2 Coastal / Global Scale Nodes

Procedures for assisting PIs, as they apply for and are approved for infrastructure use, will be developed and in place. Requests are expected to be initiated through the CI interface or through the NSF. Soon after that, a human interface will be established. During the PI proposal period, the CGSN OMC staff, working with the other OOI infrastructure operators as necessary, will assist with estimates for instrument qualification to OOI standards, integration and implementation onto specific platform(s) and other costs associated with the specific proposal. Once approved for use, the CGSN OMC personnel will work with other pertinent IOs to integrate the new equipment into the OOI system. Space will be available at the CGSN institutions to support PI staging and preparation.

CGSN operations team will implement trouble reporting and resolution of two types. As an infrastructure provider, trouble reports generated external to CGSN will be delivered through the CI interface. CGSN will be responsible to provide status information on these trouble tickets and ultimately plan and implement corrective action. As an infrastructure provider and data user, trouble reports generated within CGSN will be input to the CI tracking system then routed back to the CGSN team for resolution as above. Internal trouble reports will include those generated during instrument testing and burn-in, during calibration, during field usage, and during post-cruise refurbishment; they also will include data quality and record length driven trouble reports generated during analysis and QA/QC of the data at any point, from burn-in to field deployment.

Advance planning and coordination of adding hardware to the CGSN infrastructure and/or carrying out ancillary activities during or linked to CGSN field operations is essential and will be done by CGSN staff in coordination with NSF, COL, and potential investigators. Request for changes to sampling by CGSN infrastructure will be handled by the policies and procedures developed by COL and NSF and routed via the CI-community interface to the CGSN OMC. Visiting investigator participation that adds to or lines to CGSN sampling and field operations will be supported by CGSN in accordance with the guidelines established by the NSF and the COL. NSF-funded investigators will follow the technical and scientific review process established for use of the CGSN infrastructure. Development of their proposals will be facilitated by CGSN; once funded, CGSN will work with investigators to ensure compatibility with CGSN infrastructure. The engagement of investigators with funding other from the NSF will be coordinated through COL.

6.6.3 Regional Scale Nodes

The IO Project Scientists and associated staff will provide extensive assistance to PIs throughout the proposal stage, installation, and decommissioning stages. Each proposal will have a Project Scientist and Engineering advisor to work closely with PI's throughout the proposal process to insure that all technical – costing information is appropriate. In collaboration with the CI IO, a web-based "How To" Manual will provide information crucial to proposal preparation (e.g., examples of costs for connectors, cables, and LV Nodes, J-Boxes; scheduling updates; and environmental site characterization critical to experimental design, permitting requirements, security and possible user fees). As discussed previously an Annual Workshop will be held to help inform interested community members on procedures and processes required for the integration of new experiments onto the RSN.

The RSN Engineering Team and Project Scientists will work closely with PIs to provide guidance on new experimental designs, flag potential conflicts (e.g., spatial, electromagnetic, acoustics, security, permitting), and help perform additional site surveys if required. The Team will work with CI engineering personnel to assist the PI in establishing metadata requirements, installation procedure, and reasonable maintenance schedules. Statements of work and milestones will be established and will include the following timelines:

- completion of instrument fabrication
- completion of data system
- bench testing of instruments
- calibration of instruments
- simulation of sensors in the network environment
- testing on MARS (if required)
- qualification of instruments.

The RSN Engineering and CI Teams will be available to provide subcontracting assistance to PIs for their interface designs and fabrication of their instruments if required.

7 OOI Proposal Management (Draft)

The NSF and Ocean Leadership have outlined a proposal process for use of the Ocean Observatories Initiative and its data products. This process is summarized below. A more complete description will be developed into a Proposal Process document in 2011, incorporating details of the technical feasibility evaluation process. The document will describe the expected involvement of the Ocean Observatories Initiative Implementing Organizations (IOs), the National Science Foundation (NSF), University-National Oceanographic Laboratory System (UNOLS), and the Navy in facilitating the OOI proposal process, and assisting in the scheduling and implementation of work outlined in successful awards. Given the technical specifications and performance requirements of the OOI infrastructure, investigators who request alterations or additions to aspects of the OOI data stream will require guidance and mentoring in the early stages of proposal preparation.

The proposal process outlined below will provide potential investigators with information and operational considerations that will be important for the development of proposals. This overall plan and structure is anticipated to allow the flexibility needed for OOI implementation. This information will include feasibility assessments, budgeting guidelines, technical and Cyberinfrastructure requirements, and security requirements. The information also will include approaches for risk mitigation, facility usage and maintenance, education and engagement, and milestone adherence.

There are two general categories of potential proposals, one that would require no technical intervention by observatory personnel or advisory committees (*simple*), and one that would require technical involvement during the proposal and approval process (*complex*). These two broad proposal categories are split based on the need for technical advice and/or intervention.

***SIMPLE**: Proposals that request NSF funding and **do not require technical involvement** with OOI staff or facility committees*

- Proposals that use OOI common data, solely or in combination with other data, for analysis and/or modeling uses with no modification to OOI instrumentation or data sampling rates.

***COMPLEX**: Proposals that may or may not request NSF funding and **require technical involvement** with OOI staff or facility committees*

- Proposals for process or exploratory research (ships, autonomous vehicles) in and around OOI installed assets with no modification to OOI instrumentation or data sampling rates; and
- Proposals that require adjustments to OOI instrumentation (new instruments or changes to core instruments) or modifications to OOI data sampling protocols.

The following sections outline the steps to be followed by investigators who propose to use the OOI infrastructure, with particular emphasis on proposals for field campaigns around, and instrument deployment on, the OOI infrastructure.

Information for potential investigators

Potential investigators will be able to obtain information about the OOI from several sources:

- **Workshops:** A series of technical / thematic workshops will introduce investigators to the full scope of the OOI infrastructure, attributes, processes, protocols and constraints, and to the use of the OOI as a framework for advancing scientific understanding. In addition to addressing science issues, each workshop will provide details of the proposal submission process, with specific examples and guidelines. These workshops will be led by OOI Project Scientists, Engineers, and Cyberinfrastructure representatives.
- **User Guides:** The OOI will provide online user guides that contain detailed information about access to the infrastructure; data requirements; physical and electrical interfaces for sensors; communication protocols; environmental compliance considerations and restrictions; pre-

deployment requirements, calibration and testing; policy guides, liability and security issues; and scheduling time lines.

- **Budget Scenarios**: The OOI will provide online proposal guides and templates that will illustrate costs associated with connectors, connection, deployment, technical support, dry and wet side pre-mobilization, testing, recovery and demobilization. The goal of this web interface would be to provide the user with an interactive guide for assessing technical costs and for developing project budgets.

Particularly in the early phases of community involvement with the OOI, it is anticipated that significant mentoring of this user community will be required by OOI Project Scientists, Engineers and the Cyberinfrastructure team. Many operational concepts and requirements will be new to users and it is likely that the user community will require technical, logistical and budgetary advice.

Submission of Proposals

SIMPLE *Proposals:* Once the investigator(s) is(are) satisfied with his/her background knowledge of the OOI, proposals that require no technical intervention can be submitted to the appropriate NSF units according the standard submission protocols (formats, target dates or deadlines). The NSF review will follow standard merit review processes (See section 3.0 below).

COMPLEX *Proposals:* proposals that will involve technical intervention will require a '***planning letter***' in advance of proposal submission. Once the investigators are satisfied with their background knowledge of the OOI,

- Investigators will submit a short planning letter to the relevant OOI Facility Operators (specific contacts identified on OOI web page) for feedback on technical feasibility, project scope, power, data, and potential security issues. The OOI Project Scientists and the System Engineers will assist and advise the Facility Operators in addressing the issues raised by planning letters.
- The planning letter should include a topical outline of the planned project with emphasis on what is needed from the OOI.
- Following receipt of feedback from the OOI Facility Operators, investigators will submit revised planning letters to the appropriate NSF unit. These letters will provide advance notification to NSF about community interests, intents etc., but will not play a role in subsequent proposal submission or approval.

This step will assist investigators in the development of credible proposals by providing additional familiarization with OOI technical requirements and constraints. The planning letter process may be an iterative process for investigators as they receive feedback and recommendations from Facility Operators, OOI scientists and engineers. Once the initial feasibility requirements are addressed in a Planning Letter and then checked off by the Facility Operators, a full *COMPLEX* proposal may be submitted to NSF. This proposal would include a copy of the response to the Planning Letter from the Facility Operators. In assessing the Planning Letter, the facility operators should include an NSF representative to insure that investigators obtain a balanced assessment of a Planning Letter.

NSF Proposal – Merit Review

- OOI *SIMPLE* and *COMPLEX* proposals (including Planning Letter check-off) shall be submitted according to published NSF target dates and deadlines. *COMPLEX* proposals will likely require some advance budget guidance by the NSF OOI program officer in consultation with the Facility Operators to ensure realistic estimates of time/effort to conduct the proposed work within the OOI infrastructure.
- Merit Review - Proposals will be reviewed and evaluated according to normal NSF procedures. All ad hoc and panel reviewers will consist of un-conflicted members of the community.
- Proposals that involve the use of the system for science (data only or impacting the infrastructure through sensor addition, modification or field campaigns) should submit to the pertinent scientific

programs (e.g., Biological, Chemical, or Physical Oceanography; Marine Geology and Geophysics; a combination thereof); proposals that involve sensor development are encouraged to submit to Ocean Technology and Interdisciplinary Coordination (OTIC) or Major Research Instrumentation (MRI)

Proposals to other agencies – merit review

- OOI *SIMPLE* and *COMPLEX* proposals (including Planning Letter check-off) may be submitted according to published agency target dates and deadlines. *COMPLEX* proposals may require some advance budget guidance by the relevant program officer, with likely coordination with the NSF OOI program officer, and in consultation with the Facility Operators to ensure realistic estimates of time/effort to conduct the proposed work within the OOI infrastructure.
- Merit Review - Proposals will be reviewed and evaluated according to normal agency procedures.

Technical, Environmental and Security Assessment Committee (TESAC)

- Successful (highly ranked) *COMPLEX* proposals (NSF and non-NSF) will be subject to a more intensive and formal technical, environmental compliance and security review in order to meet final approval for funding/support and implementation. This review will involve NSF, external (non-OOI) community participants, and IO and Navy representatives. This step will provide a more rigorous technical assessment of the instrument, sampling or data usage plan than was conducted during the Planning Letter step. The committee will assess the proposal's compatibility with existing OOI sampling protocols and instrumentation, as well as with any other outside projects already funded and interacting with the OOI data or infrastructure. It is anticipated that OOI Project Scientists and System Engineers will function both as members and advisors to the TESAC. The TESAC review process would identify possible scheduling or connectivity issues that might alter the scope/timing of the proposed project. The goal of this review is to ensure that the proposed project can be implemented within the technical, environmental compliance and security constraints of the OOI. This review will help inform the OOI Facility Advisory Committee discussion and NSF award/support decision.
- The TESAC would assign a key "mentor" from the relevant IO to each highly ranked *COMPLEX* proposal. The mentor would serve as the program expert for that specific proposal, particularly with respect to its technical and environmental compliance assessment, and would be available to the investigator(s) over the anticipated lifetime of the funded project.

NSF OOI Facility Advisory Committee (FAC)

- A review by the FAC will be the final step before the award recommendation by the supporting agency (NSF or non-NSF). NSF representatives, with input from the external community and other agencies as necessary, will conduct a final evaluation of NSF and non-NSF *COMPLEX* proposals for scientific merit, feasibility, and prioritization. They will engage with the Observatory Operations Team (OOT, see below) to coordinate scheduling and logistics. Changes in environmental conditions, status of environmental compliance activities, status of OOI infrastructure, scheduling requirements, science drivers, new discoveries, funding levels etc., will be factors in the prioritization of projects.

Award/Support Decision

- The award (for NSF proposals)/support (for external proposals) decision by NSF will be based on consideration of the results from the normal review process as well as the comments and recommendations of the TESAC and the FAC.

Coordination with Observatory Operations Team (OOT)

- For each funded *COMPLEX* project, the OOT will work closely with the Facility Operators to determine a project implementation schedule that can be aligned with availability of required assets (e.g., UNOLS vessels, cable ships, mooring test beds, calibration facilities). In particular, the OOT will work with the investigator(s) to ensure that the project implementation milestones can be met within the scheduling and operating constraints of the OOI.

Integration of funded work with the Facility Operator

- Successful implementation and integration of *COMPLEX* projects into the OOI infrastructure will require coordination amongst the investigator(s), the Marine IOs and the CI IO to ensure that all requirements and schedules are met. The investigator will provide the IOs with clear statements of work and milestones based on the outcome of the OOT meeting. Project-specific details about modifications to the OOI infrastructure will need to be explicitly delineated. The integration of *COMPLEX* projects will require significant attention by project mentors and regular reporting of project impacts on the OOI infrastructure.

7.1 Definitions:

Core Instrument: An instrument purchased with MREFC or O&M funds - designed to provide key data for addressing key science questions.

Facility Operator: Marine and Cyberinfrastructure Implementing Organizations (IOs)

For-Profit User: A for-profit user is an individual or organization that is deploying an instrument or instrument package for commercial purposes.

Metadata: Data that describes other data.

Observatory Advisory Team (OAT): An advisory group composed of NSF and the members of the external (non-OOI) user community and other agencies, as necessary, that evaluates NSF and non-NSF proposals feasibility and prioritization. They work closely with the OOT in scheduling and logistics.

Observatory Operations Team (OOT): An advisory group composed of members from the IOs, with possible representation from UNOLS, serves, as part of the proposal process, to schedule deployment of new instruments or changes to the OOI infrastructure (including mission changes), and works with the OOI Facility Advisory Committee regarding project scheduling and logistics.

Principal Investigator (PI): An investigator that proposes to use the OOI that does not request NSF funds.

PI Instrument: An instrument that is proposed or that will be provided to the OOI infrastructure outside of the MREFC and O&M account.

NSF Principal Investigator: An investigator that is interested in proposing work on the OOI using NSF funding or who is funded by the NSF to deploy instruments, infrastructure, or utilize data from the OOI infrastructure.

Technical Environmental and Security Assessment Committee (TESAC): Committee composed of IO representatives, external (non-OOI) community members, and Navy representatives to provide a final technical, environmental compliance and security assessment for proposals (NSF and non-NSF) that are ranked highly following merit review.

Program Mentor: Member of an IO team who is the designated overseer of a proposal to help provide expert advice to TESAC regarding status of a proposal, be proactive with PI insure that all milestones are met, may work closely with program manager at NSF.

8 O&M Program Metrics

During each phase of the O&M Plan, metrics will be gathered.
The following are examples of what will be measured:

- Years 1, 2 and 3:
    - Schedule & Budget Performance to Plan
- Additional metrics beginning in Year 4
    - System Availability Statistics
    - Cyberinfrastructure use and helpdesk response rates

Additional metrics will be developed by established O&M Working Groups.

9 OOI Operations Budget

The budget for Operations and Maintenance is built upon a series of cost assumptions for each module (component, subsystem, system) of the OOI. Each year the cost assumptions will be examined for validity and alternative assumptions will be assessed. The OOI Assumptions are listed in Appendix C of this document and are reviewed on a regular basis by the OOI O&M Staff and updated as necessary. Beginning in Year 2, this annual process will be documented in the O&M budget

9.1 High Level Assumptions

- O&M property build takes place under O&M funding.
- Where possible, UNOLS ships will be scheduled to perform the required cruises.
- O&M will be conducted with the minimum number of personnel needed to sustain safe operations above the threshold for acceptable performance.
- Data QA/QC plan will be developed to use the best automated practices possible to reduce human intervention and minimize the number of personnel needed to provide the required data products
- Equipment necessary for at-sea deployment will be designed to allow packing into shipping containers, or in the most efficient way, for transfer to seaport closest to the mooring to reduce needed sea days.
- Ships will use ports closest to deployment sites whenever possible.
- Equipment located at the CyberPoPs will follow a five (5) year replacement cycle.

Coastal / Global Scale Nodes

- *Global Moorings*
  - Refurbishment turns scheduled to align with the annual 'weather window' at each high-latitude site.
- *Coastal Moored Arrays*
  - Maintenance turns every 6 months (major and a minor refurbishment each year) to align with instrument service schedules under coastal bio-fouling conditions

Regional Scale Nodes

- Post-warranty budgets to include calibration and future technical support costs.
- Spares, consumables, and defective component replacement procured with O&M funding.

- *Shore Facilities*:
  - O&M budget includes long-term monthly facility leases for the Shore Station, Portland POP, and the Maintenance/Logistics facilities; and long-term monthly lease for terrestrial communications from the Shore Station to the Portland POP.
  - Operations support to be shared between Shore Station and Portland POP
- *Primary Infrastructure*:
  - Primary Infrastructure to utilize insurance or other funding vehicle for emergency repairs.
- *Hydrate Ridge*:
  - Two (2) maintenance cruises per year to replace/repair required instruments
- *Axial Seamount:*
  - Two (2) maintenance cruises per year to replace/repair required instruments
- *Mid-plate Nodes:*
  - Maintenance cruises as required in conjunction with Axial Seamount

9.2 Budget Overview

At the heart of the OOI O&M program is the annual budget process. Planning for each year leading up to steady state operations and beyond begins with a full and comprehensive review of the base requirements, the assumptions derived, and all information available from the previous reporting periods. Each annual budget is constructed in a standardized manner.

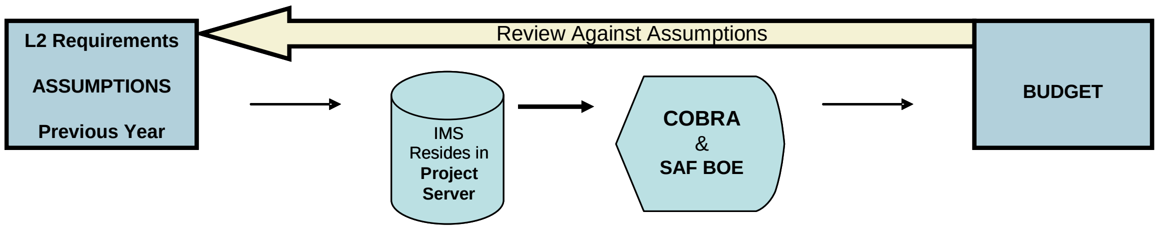


Figure 9-1. Budget Process

1. All MREFC and O&M schedules reside in Project Server, and are loaded with their respective resources (material & labor). The build items in MREFC are linked to like items in the O&M schedule.

2. Basis of Estimate information for each work package is represented in the OOI Software Application Framework (SAF). This Basis of Estimate tool provides an interface to review the data and answer questions about how budget item costs were derived.

3. Project Server data feeds into COBRA where project schedules are synchronized with variable costs, fringe, etc. and a snapshot of performance or the rising year budget preparation data can be accessed for reporting or creating next year Annual Work Plans.

4. All IOs undergo one in depth budget review each year, as well as planned spot checks by OL O&M staff members to constantly strive to better understand our estimated costs, current budgets, and on-going performance.

Apart from inflation rates, the major uncertainty in this budget process is the construction delivery schedule. Obviously the budget profile will have to be updated if the construction delivery schedule is revised, a process aided by the linking established between the construction and O&M integrated master schedules in Project Server. Since each position in operations and all associated running costs are tied to construction milestones, it is possible to regenerate the budget projection if such milestones are revised.

9.3 Transitions from Construction to O&M that have budgetary impact

As indicated in Section 4, Transition to Operations, the growth of the O&M budget during the MREFC phase of the OOI will be linked to explicit milestones in the construction schedule. Some of these can be grouped on an annual basis.

2011 – O&M Year 2

- Release 1 of the Integrated Observatory Network (ION) is deployed, accepted, and transition to operational status and O&M responsibility for user and software support activities is assumed by CI.
- National backbone and Terrestrial CyberPoPs are installed and CI manages the transition to operational status and assumes O&M responsibility for their maintenance and recurring charges.
- Establishment by RSN of Maintenance / Logistics facilities in Washington and on the Oregon Coast.

- Commence long-term lease for diverse terrestrial telecommunication circuit from the shore station in Pacific City, OR to the Portland POP. RSN manages the operations of this communication circuit.
- Primary Infrastructure telecommunications cable deployed under MREFC; L-3 MariPro Communications responsibility until commissioning of Primary Infrastructure. RSN manages the transition to operational mode.

2012 – O&M Year 3

- Release 2 of the Integrated Observatory Network (ION) is deployed, accepted, and transition to operational status and O&M responsibility for user and software support activities is assumed by CI.
- Endurance gliders deployed under MREFC, and CGSN manages the transition to operational status and assumes O&M responsibility.
- Pioneer gliders deployed under MREFC, and CGSN manages the transition to operational status and assumes O&M responsibility.
- Primary Nodes deployed under MREFC; L-3 MariPro Communications responsibility until commissioning of Primary Infrastructure at which time RSN assumes O&M responsibility.
- Establishment of RSN Observatory Operations Center (OOC).
- Primary Infrastructure commissioned under MREFC, RSN manages the transition to operational status and assumes O&M responsibility.

2013 – O&M Year 4

- Release 3 of the Integrated Observatory Network (ION) is deployed, accepted, and transition to operational status and O&M responsibility for user and software support activities is assumed by CI.
- Argentine Basin is deployed under MREFC, and CGSN manages the transition to operational status and assumes O&M responsibility
- PAPA is deployed under MREFC, and CGSN manages the transition to operational status and assumes O&M responsibility
- Irminger Sea is deployed under MREFC, transitions to operational status and assumes O&M responsibility
- Uncabled elements of Newport mooring line of Endurance are deployed under MREFC, and CGSN manages the transition to operational status and assumes O&M responsibility
- Coastal profiler moorings of Pioneer Array are deployed under MREFC, and CGSN manages the transition to operational status and assumes O&M responsibility.
- Surface moorings, shallow profilers, and AUVs of Pioneer Array are deployed under MREFC, and CGSN manages the transition to operational status and assumes O&M responsibility
- Secondary Infrastructure instruments deployed at Hydrate Ridge and Axial Seamount under MREFC, RSN manages the transition to operational status and assumes O&M responsibility.

2014 – O&M Year 5

- Releases 4 and 5 of the Integrated Observatory Network (ION) are deployed, accepted, and transition to operational status and O&M responsibility for user and software support activities is assumed by CI.
- Southern Ocean global mooring at 55°S, 90°W is deployed under MREFC, and CGSN manages the transition to operational status and assumes O&M responsibility
- Grays Harbor, WA mooring line of Endurance is deployed under MREFC, and CGSN manages the transition to operational status and assumes O&M responsibility
- Cabled elements of Newport mooring line of Endurance are deployed under MREFC, and CGSN manages the transition to operational status and assumes O&M responsibility.
- Secondary Infrastructure vertical moorings deployed at Hydrate Ridge and Axial Seamount under MREFC, RSN manages the transition to operational status and assumes O&M responsibility.
- Initial maintenance cruise for deployed secondary RSN infrastructure to be conducted.

10 Staffing Outline for O&M

The Operations & Maintenance processes are a series of coordinated efforts between Ocean Leadership and the IO's with the full knowledge and support of the construction COTRs (Contracting Office's Technical Representatives) and Project Managers located at each IO. These efforts involve some staff with shared MREFC and O&M responsibilities, as well as staff with full-time O&M responsibilities. (The organizational charts for the PMO and the IOs are included as Appendix F).

The following tables were developed from the 2009 Baseline Schedule, and do not reflect adjustments to O&M staffing that may occur as a result of the 2011 schedule adjustment

10.1 Consortium for Ocean Leadership Staffing Plan

The Program Management Office at Ocean Leadership provides coordination and leadership for the entire project. During the transition to operations, the Management component remains stable at 2-3 and those directly involved in Operations grow to a steady-state level of 5 FTEs by year 3. Science support remains stable while administrative support staff grows from 3 to 6 as the project reaches full operations. Many of the individuals within the Admin & Support category have fractional FTE commitments.

Year	Management **(FTE)**	Operations (FTE)	Science (FTE)	Admin & Support Staff (FTE)	TOTAL (FTE)
2010 – O&M Year 1	2.37	1.2	1.37	3.45	8.41
2011 – O&M Year 2	2.34	4.5	1.34	3.07	11.25
2012 – O&M Year 3	2.37	5	1.37	3.75	12.49
2013 – O&M Year 4	2.57	5	1.57	4.42	13.56
2014 – O&M Year 5	2.8	5	1.8	5.5	14.60
Full Operations	3	5	2	6	16.00

Executive Level – President: (Admin, Special FTE) **The** President of the Consortium for Ocean Leadership's main responsibility is to provide leadership by developing and articulating its vision, mission and objectives externally through strong and positive relations with the policy and government community, through partnerships with research and education institutions nationally and internationally, through the media, and through productive relationships with the Consortium. The President also serves as co-PI for the OOI.

Program Director – Principal Investigator: (Mgmt. & Science, partial FTE) The Program Director is the Principal Investigator (PI) for the O&M program and will be the primary point of contact between the IOs and OL and NSF program managers. He/she provides overall leadership for the construction and operation the Ocean Observatories Initiative, including development of proposals, annual program plans, and budgets and is responsible for coordination with and technical and programmatic oversight of implementing partners.

Associate Science Director: (Mgmt. & Science, partial FTE) The Associate Science Director supports the Program Director in providing leadership to the program science staff and community for Ocean Observing Activities. He/she provides lead science expertise for the Ocean Observatories Initiative within the program office. With the Program Director, he/she leads the development, organization, management, and delivery of science plans and programs related to OL's implementation of the Ocean Observatories Initiative.

Operations & Maintenance Manager: (Mgmt.) The Operations & Maintenance Manager for the OOI is responsible for providing supervision, direction and leadership to O&M staff including the OL support engineers, hardware, software and communications engineers and other O&M program support staff. He oversees the day-to-day O&M activities of the OOI, ensuring efficient network operations, environmental compliance to Federal and State regulations, and ensuring that the facility is operated in a safe, reliable, manner consistent with O&M sub-award agreements, permits, rules, regulations, and written instructions. He/she coordinates with the O&M efforts at all Implementing Organizations. The Operations Manager (OM) will develop annual O&M budgets and, assist with permitting, risk, contracts, insurance, and intellectual property. The OM will be responsible for the day-to-day management of the OOI O&M project team and for keeping the program on schedule and within budget, and for items such as controlling quality, project costs, operations' schedules, and risk through the project lifespan.

Quality Assurance & Control Manager: (Operations, partial FTE) The QA Manager will provide expert QA oversight of the OOI Program Management Office and of the OOI Integrating Organizations (University of Washington, Woods Hole Oceanographic Institution and University of California, San Diego) and will evaluate their quality systems to policies, plans and procedures. The QA Manager will report directly to the President of OL. The QA Manager will advise the OL President and the OOI Principal Investigator of all QA activities in support of the OOI project.

Environmental Health and Safety Manager: (Operations, partial FTE) The Environmental Health and Safety (EH&S) Manager will coordinate EH&S actions and events that occur on the program. He/she will ensure implementation of the OOI EH&S Plan and will assist and evaluate the IOs implementation of their institutional EH&S plans and procedures.

Operations Specialist: (Operations) The Operations Specialist supports the Ocean Leadership (OL) OOI Systems Engineering and integration group in the synthesis of engineering design and systems between OL and sub-awardees for the operations and maintenance of the system of systems that comprise the OOI. The position supports the development of the Operations and Maintenance aspects of the project for initiation during construction and the period following transition to operations.

Planner / Master Scheduler: (partial Operations) The Master Scheduler's prime responsibility is to maintain the program schedule and to insure the Integrated Master Schedule (IMS) is fully integrated with the Implementing Organizations' master schedules and the other program management tools, i.e., Budgets, Earned Value Management System (EVMS), Work Breakdown Structures (WBS), Statements of Work (SOW), Risks, Critical Path Method modeling and Schedule Risk Management.

Communications Manager: (Admin, partial FTE) The Communications Manager has primary responsibility for developing, implementing and overseeing communications and programmatic outreach strategies. These include, but are not limited to internal and external communications activities, branding, outreach and education, messaging, and marketing activities as well as collaborating with leaders of other major research programs.

Staff Scientist: (Science, partial FTE) The Staff Scientist provides scientific and technical expertise for the Ocean Observatories Initiative within the program office. He/she analyzes science requirements, coordinate discussion with community experts and the OOI's implementing organizations, and provide liaison with the scientific community. The Scientist will develop, organize, edit, and manage the delivery of OOI science documentation in preparation for design reviews, project reports and publications, and presentations.

Finance Manager: (Admin, partial FTE) The Finance Manager provides leadership and oversees the financial infrastructure of the OOI. This role ensures the development, implementation, and monitoring of financial systems and controls, compliance with regulatory mandates, responsible financial management, and comprehensive financial reporting to maintain a solvent and financially successful organization.

Director of Communications: (Admin, Special FTE) The Director of Communications is a senior management position reporting directly to the President/ CEO. The person plans and manages public policy activities, including relationships with Congress, the Executive Branch, federal agencies, and other non-governmental organizations (NGOs). He/she is responsible for developing and implementing legislative and outreach strategies, building and maintaining relationships with key congressional and federal agency staff regarding ocean research and education issues, and ensuring an up-to-date information flow to the oceanographic community.

Deputy Director of Communications: (Admin, partial FTE) The Deputy Director of Communications primary responsibilities include overseeing, planning and managing the Consortium for Ocean Leadership's internal and external communications activities including branding, policy advocacy, messaging, media and marketing activities as well as developing and implementing the organization's strategic communications plans.

Senior Cost Analyst: (Mgmt., partial FTE) The Sr. Cost Analyst leads and drives broad and complex analyses and reporting related to project costs utilizing funding agency guidelines. Performs analyses and develops reports to ensure compliance with negotiated and agreed-upon parameters and established cost control guidelines. Collaborates with Project Directors/Managers to develop and prepare budgets and schedules for contract work; conducts and/or assists with financial analyses such as funding profiles and variance analyses.

10.2 CI O&M Staffing Plan

The Cyberinfrastructure Implementing Organization is responsible for the effective operation of the hardware and software that forms the pathway and archive for the data that streams through the OOI network. The Operations staff increases steadily through the transition to full operations, with minimal management and administrative staff.

The Cyberinfrastructure Implementing Organization is responsible for the effective operation of the hardware and software that forms the pathway and archive for the data that streams through the OOI network. The Operations staff increases steadily through the transition to full operations, with minimal management and administrative staff.

Year	**Management** (FTE)	**Operations** (FTE)	**Science** (FTE)	**Admin** (FTE)	**TOTAL** (FTE)
2010 – O&M Year 1	1.00	1.42	0	0.00	2.42
2011 – O&M Year 2	1.33	5.50	0	0.00	6.83
2012 – O&M Year 3	1.75	8.50	0	0.50	10.75
2013 – O&M Year 4	2.00	11.00	0	0.50	13.50
2014 – O&M Year 5	2.33	12.00	0	1.14	15.47
Full Operations	2.50	12.00	0	1.33	15.83

The following roles are needed to provide User Community Support:

Principal Investigator: (Mgmt.) Responsible with overall authority and responsibility for the project. He serves as principal point of contact with the OL (Ocean Leadership) Program Office, and appoints the Deputy Project Director, and in consultation with the Deputy Project Director, the Project Manager, Project Scientist, System Engineer, Quality Manager, Chief Architect and EPE Manager. The Project Director is the final and binding arbiter of all internal project conflicts that cannot be resolved satisfactorily at lower levels.

Financial Analyst: (Admin) Maintains, monitors, and controls the project's cost and schedule data, monthly financial status reports, and all official contract correspondence. Position reports to the Project Manager.

Quality Analyst: (Admin) Responsible for the quality assurance/quality control for all of the CI processes and procedures in the CI Project Office and Project Management. Position reports to the Principal Investigator.

Project Analyst: (Admin) Provides support to the Project Manager in process analysis and development, as well as project tracking. Performs technical tracking and reporting; developing complex reporting processes, policies, and procedures; alignment of the CI program to the policies of the University, the national OOI program, and funding agencies; and presentation of results on the project's behalf. Position reports to the Project Manager.

Graphic Artist: (Admin) independently coordinate and supervise the production of special publications, books, printed materials, reports, posters, websites, CD-ROMs and DVDs, and preprints/reprints of scientific journal articles for the OOI CI program. Position reports to the Product Manager.

Observatory Manager: (Mgmt.) Responsible for the day-to-day management of the user support and service operations of the OOI Integrated Observatory. Position reports to the Principal Investigator.

Support Engineer: (Ops) Responsible for the End User operational assurance of the OOI Integrated Observatory operations as primary support interface to the User Community providing help desk support. Position reports to the Observatory Manager.

Observation Coordinator: (Ops) Responsible for planning and coordinating the use of the OOI resources across different User Community objectives and requirements. Position reports to the Observatory Manager.

Observation Trainer: (Ops) Responsible for the End User training in the use and operations of the OOI Integrated Observatory. Position reports to the Observatory Manager.

Data Curator: (Ops) Acts as the steward of the scientific data collected by the OOI CI. Establishes resource requirements for the data; participates in technical and scientific workshops to evaluate and advance uses of data sets, including their annotation and access; ascertains what information should be readily available; and works to advance the data's overall utility and impact on environmental and ocean science discovery. Position reports to the Product Manager.

Data Engineer: (Ops) Conducts database administration and development in the area of scientific data management in support of various functional database applications. Conceives designs, develops, and deploys tools for web and database services. Position reports to the Operations Manager.

Integration Engineer: (Ops) Responsible for the integration of End User processes and resources with the OOI Integrated Observatory service and resource network providing programming and testing support. Position reports to the Observatory Manager.

Service Engineer: (Ops) Responsible for the maintenance and upgrade of the service operation software to include: surveillance, quality of performance, and problem resolution. Position reports to the Observatory Manager.

Resource Engineer: (Ops) Responsible for the maintenance and upgrade of the resource operation and application software including surveillance, quality of performance and problem resolution. Position reports to the Observatory Manager.

Operations Manager: (Mgmt.) Reports to the Project Manager and leads the Operations Team. The Operations Manager and System Engineer are responsible for deployments of the CI, and the Operations Manager is responsible for post-deployment operations and maintenance. The Operations Manager also provides critical input to the System Engineer, Product Manager, and subsystem IPTs, with the goal of raising the production quality and minimizing the life cycle cost of the OOI CI. Position reports to the Project Manager.

Operations Supervisor: (Ops) Responsible for technical leadership of the infrastructure operations and secondary support to the Help Desk, Level one support. Position reports to the Operations Manager.

Quality Supervisor: (Ops) Responsible for the assurances and reconciliation for all Observatory Operations and System Engineering activities in quality management. Validates that all changes in the Integrated Observatory Network go through systematic testing and verification prior to release. Position reports to the Operations Manager.

Infrastructure Engineer: (Ops) Executes the OOI CI operations and maintenance program, including user support; monitoring of all systems for security, integrity, and operational status; software system administration; and coordination of information resources. Supports all aspects of the software engineering environment... Position reports to the Operations Manager.

Network Engineer: (Ops) Provides design materials describing the design of the deployed network components for the OOI CI. Helps install, configure, and test network components and troubleshoot design and deployment issues. Ensures that best practices are followed for networking configuration and security. Position reports to the Operations Manager.

Deployment Engineer: (Ops) Acts as a functional leader, addressing: software system administration; federation of information resources; deployment of the system middleware software on all real and virtual servers; and setting up the criteria for the monitoring of all OOI systems. Ensures that best practices are followed for data management and setting up of database servers. Ensures the security and integrity of our deployed systems. Position reports to the Operations Manager.

10.3 CGSN O&M Staffing Plan

The CGSN IO is led by staff at the Woods Hole Oceanographic Institution (WHOI), further supported by staff at the Scripps Institution of Oceanography (SIO) and at the Oregon State University (OSU). The three institutions bring together expertise in coastal and global field operations. WHOI and SIO staff addresses the O&M of the Global Nodes; WHOI and OSU staff addresses the O&M of the Coastal Nodes. The O&M approach by CGSN uses commonality of infrastructure and of shore side and at sea handling gear, practices, and procedures wherever possible. The plan, thus, permits personnel load leveling across the three institutions, interchangeability of certain staff, and cross-training.

The team includes administrators, scientists, engineers, and their staffs. The main responsibility of the Administration Team will be to provide operational oversight to ensure that all essential CGSN mission requirements are met. The Team will also provide the external communications link to the National Science Foundation (NSF) and the Consortium for Ocean Leadership (OL), as well as the various OOI users and the public in general. The Team will also oversee the daily operation of the CGSN, provide detailed financial accounting, and develop installation, maintenance, and ship schedules. The Administration Team will prepare and present to the sponsoring agency monthly and annual budgetary information and reports and prepare the Annual Work Plan (AWP).

In addition to the Key Personnel, the CGSN will require a combination of full- and part-time staff to implement the O&M Plan. O&M personnel can be functionally categorized as Management, Operations, Engineering, or Science. Operations staff supports the shore-side activities and fieldwork and are subcategorized below as Field Operations and Equipment Management and Data Supervision. The table below identifies the estimated number of personnel by functional category that will be required each year, starting at the transition to operations through the first full year of operations.

Year	Management (FTE)	Operations (FTE)	Engineering (FTE)	Science (FTE)	TOTAL FTE
2010 – O&M Year 1	1.8	0	1	1	3.8
2011 – O&M Year 2	6.4	6	1.2	1	14.6
2012 – O&M Year 3	7.5	25	2	3.3	37.8
2013 – O&M Year 4	10	31.4	2.4	4.4	46
2014 – O&M Year 5	11.5	29.6	3.1	5.2	49
Full Operations	11.6	20.5	5	5.7	42,8

Project Director

The Director is the Principal Investigator (PI) for the O&M task and will be the primary point of contact between the CGSN and OL and NSF program managers. He/she will lead the overall direction of the project and interface to communities outside the IO team. The Director will be responsible for Education and Public Awareness, delegated to OSU, and for coordination with CGSN-related activities at WHOI, SIO and OSU. He/she will delegate implementation and day-to-day management of the CGSN IO project team to the Project Manager.

Project Management

The CGSN Project Manager will be supported by a Deputy Project Manager for O&M. The Project Manager will have day to day oversight over both MREFC and O&M activities and planning as well as proposal assistance to prospective system users. The Deputy Project Manager for O&M will focus on O&M and be a primary point of contact for O&M for COL. They will be supported by administrative, financial, and scheduling staff. The Project Manager and Deputy Project Manager for O&M will be resident at WHOI. Deputy Project Managers for O&M will be at both SIO and OSU with support staff. PM is responsible for overall schedule and cost planning, performance and reporting of CGSN activities and for coordination with Ocean Leadership, RSN and CI.

Project Scientists

The CGSN Project Scientists will be responsible for ensuring that the operational CGSN meets the science requirements set for the program and for newly funded projects. A major responsibility will be to provide extensive assistance to PIs from the proposal to installation and decommissioning process, and to inform the community on science aspects of the CGSN. They will serve as liaisons between the engineering team and investigators, as well as with members of Education and Public Engagement (EPE) programs. The Project Scientists will work closely with the OL office and NSF to ensure optimal communication and engagement of the community. CGSN Project Scientists will also, in many cases, serve as Chief Scientists on the O&M cruises. There will be CGSN Project Scientist(s) at SIO to support the Global Nodes, at WHOI to support the Pioneer Array, and at OSU to support the Endurance Array.

O&M Sustaining Engineering

A Lead Engineer for O&M will be resident at WHOI to oversee ongoing operational and sustaining engineering efforts; the Lead Engineer will be supported by a mechanical engineer for O&M and an electrical engineer for O&M. Additional engineering support staff will be at SIO and OSU. Responsibilities include support to the core CGSN infrastructure including failure analysis and resolution, design modifications to compensate for obsolete components (parts, subsystems, etc.), design modifications to maintain interfaces with CI and RSN as components in those systems change. Additionally, sustaining engineers will support separately funded, as needed, integration and qualification tasks for OOI users.

Education Lead

The Education Lead will be a liaison between the CGSN and the EPE IO to help facilitate communications and EPE activities. They will also help develop and oversee implementation of CGSN EPE pilot programs. These programs, which will initially focus on ship-based learning and translation of science to the public, will expand to cover the full CGSN capability. The Education Lead will work closely with public information specialists and will have training and significant experience in developing and managing education programs for K-12, university, and the public.

Field Operations
Field Operations will be accomplished by a team of engineers, engineering assistants and technicians with guidance from the assigned cruise lead. The field operations team will deploy fresh equipment and retrieve equipment that has reached the end of its deployment interval. Field operations will begin immediately following installation readiness review and will continue until the retrieved equipment has been returned to the maintenance facility.

Equipment Management
Maintenance and refurbishment of the OOI CGSN equipment will be accomplished by a team of engineers and technicians with the goal of restoring retrieved equipment to factory acceptance levels in preparation for the next deployment. Prior to the start of recurring operations, the Equipment Management team will construct Operational Property that supports the O&M strategy of replace, retrieve and refurbish. The team will include a dedicated Manufacturing Engineer and a Material QA/QC Engineer who will oversee the work and audit processes.

Data Supervision
The CGSN IO is responsible for monitoring system health and status, performing Data QA/QC and vetting revised mission requirements prior to transmittal to the installed equipment. To accomplish these tasks, CGSN will employ engineers and technicians to monitor engineering and scientific data as it is received. Specific assignments will include glider and AUV piloting, system health status monitoring and reporting, and Data QA/QC to advance the data level. A hierarchy of Data QA/QC will be established to allow for issues to be advanced to Project Scientists for review as needed.

Prior to acceptance and commissioning, O&M funds will be restricted to build of O&M Property to support the Maintenance Strategy. As elements of the arrays are accepted and commissioned, Operations functions will commence. During the period of overlapping O&M and MREFC projects staffing will transition from MREFC to Operations. Operations staffing will include a mix of personnel formerly tasked with MREFC work and personnel new to the project. The mix will ensure carry-over of knowledge base while transitioning the character of the project from construction to O&M.

10.4 Regional Scale Nodes O&M Staffing Plan

Administration of the RSN O&M program will be handled by a full-time team of individuals experienced in the types of field operations for which the RSN was designed. This team will be drawn from the RSN MREFC development team, and augmented with trained experts in field operations and logistics.

Administration has cross-functional responsibility for such activities as Project Oversight, Planning and Contract Management. The RSN IO located at the University of Washington and will be staffed by a team of administrators, scientists, engineers, and their staffs. The main responsibility of the Administration Team will be to provide operational oversight to ensure that all essential RSN mission requirements are met. The Team will also provide the external communications link to the National Science Foundation (NSF) and the Consortium for Ocean Leadership (OL), as well as the various OOI users and the public in general. The Team will also oversee the daily operation of the RSN, provide detailed financial accounting, obtain all necessary permits and insurance, and develop installation, maintenance, and ship schedules. The Administration Team will prepare and present to the sponsoring agency monthly and annual budgetary information and reports and prepare the Annual Work Plan (AWP).

Year	Management **(FTE)**	Operations **(FTE)**	Engineering **(FTE)**	Science (FTE)	TOTAL (FTE)
2010 - O&M Year 1	0.2	0.4	-	-	0.6
2011 - O&M Year 2	1.2	0.8	2.0	-	4.0
2012 - O&M Year 3	1.2	3.0	2.0	-	6.2
2013 - O&M Year 4	1.5	3.0	3.0	2.0	9.5
2014 - O&M Year 5	2.5	6.0	6.5	7.0	22.0
Full Operations	3.5	6.0	13	11.0	33.5

Project Director

The Principal Investigator (PI) for the OA&M task and will be the primary point of contact between the RSN and OL and NSF program managers. He/she will lead the overall direction of the project and interface to communities outside the IO team. The PI will be responsible for Education and Public Awareness and for coordination with RSN-related activities at the UW. He/she will delegate implementation and day-to-day management of the RSN IO project team to the Project Manager.

Operations Manager

The RSN Operations Manager (OM) will be supported by a full time Fiscal Manager to assist with budgets, permitting, risk, contracts, insurance, and intellectual property. The OM will be responsible for the day-to-day management of the RSN OA&M project team and for keeping the program on schedule and within budget, and for items such as controlling quality, project costs, operations' schedules, and risk through the project lifespan of the RSN. He/she will work with the Associate Director for Science and the Chief Engineer (CE) to ensure that the scientific requirements, engineering design requirements, scope, cost, and schedule of each aspect of the program are managed in a consistent manner.

The OM will be responsible for providing the team to support all phases of the RSN operation. During the winter months this will include a small staff of technicians and assistants responsible for planning and preparing for the upcoming summer operations schedule. He/she will work closely with the Chief Scientist and CE to bring together responsible parties for the interfacing of new sensors to the RSN. He/she will also be responsible for overseeing the coordination and financing of the different logistics operations such as sparing, depot repair, calibration etc. During the summer months of operations he/she will be responsible for increasing the staff to handle the typical 24/7 operations both aboard the ship as well as at the different shore facilities.

Project Scientist(s)

The Associate Director for Science and Project Scientists will be responsible for ensuring that the operational RSN meets the science requirements set for the program and for newly funded projects. A major responsibility will be to provide extensive assistance to PIs from the proposal, to installation, to decommissioning process, and to inform the community on science aspects of the RSN. They will serve as liaisons between the engineering team and investigators, as well as with members of Education and Public Engagement (EPE) programs. The Associate Director for Science and Project Scientists will work closely with the OL office and NSF to ensure optimal communication and engagement of the community. These positions will normally be filled with two full-time and one part-time employee who bring different scientific expertise to the RSN IO team. They will have expertise in plate tectonics, ocean dynamics, and other specialties consistent with science and field operations and will have a working knowledge of the use and development of instruments.

They will assist the CE in the system definition phase and will provide an assessment of the science impact of various design trade-off studies. Their responsibility will include developing the science plan describing how scientists will use and interact with science operations and the system during the operational phase.

Chief Engineer

The CE will be responsible for the technical performance of the system and for leading the engineering team that will handle the lifetime technical maintenance and refurbishment of the RSN system. The CE will also provide coordination between the engineering staff and the program's financial managers. He/she will be directly responsible for developing the engineering portion of the AWP.

Education Lead

The Education Lead will be a liaison between the UW and the EPE IO to help facilitate communications and EPE activities. They will also help develop and oversee implementation of UW EPE pilot programs. These programs, which will initially focus on ship-based learning and translation of science to the public, will expand to cover the full RSN capability. The Education Lead will work closely with public information specialists and will have training and significant experience in developing and managing education programs for K-12, university, and the public.

OA&M Staff

In addition to the Key Personnel, the RSN will require a combination of full- and part-time staff to implement the OA&M Plan. OA&M personnel can be functionally categorized as Management, Operations, Engineering, or Science. The below table, RSN OA&M Staffing, identifies the number of personnel by functional category that will be required each year, starting at the transition to operations through the first full year of operations.

Oregon Permanent Staffing

Two permanent UW employees will be hired in Oregon to provide the local logistical help needed for the program. One will be a Logistics Manager responsible for tracking location of equipment, determining readiness for installation, status of upgrades, etc. The second employee will be an electrical-mechanical Field Engineer who will be responsible for equipment repairs, performing diagnostic checkouts, and handling the packing and shipping of RSN equipment.

Staffing at the Seattle-based OOC will begin near the end of contract year 2 in preparation of the installation and commissioning of the RSN infrastructure during contract year 3.

11 Security

Security will be integral to the OOI on several levels. First, the OOI must be concerned about the physical security of the observatory hardware both at sea and in the development laboratories. Second, it must be concerned about the security of the data that is collected from the observatories. Finally, it must be concerned about the operational security of the integrated system.

11.1 Cyberinfrastructure

The OOI data policy envisions that all basic OOI data streams will be open and freely available to any potential user; however, some access privileges will vary by user class. The CI IO will have responsibility for implementing the data policy. It is expected that all users (of data) and instrument PIs will be required to register for usage of OOI facilities and data and they will be required to fulfill the obligations of the OOI data policy. The implementation of these processes is the responsibility of the CI IO.

The CI IO will also have responsibility to ensure that the OOI data and programs are not susceptible to cyberattacks in the form of viruses, malware, denial of service attacks, etc. and to ensure that the data cannot be corrupted by outside influences. A formal tracking system that documents the cause and resolution of each attack or intrusion will be implemented. The system will utilize two virtual and physical network and service environments: one for the CI data interactions (Public WLAN – Wireless Local Area Network) with the users via the public Internet/Internet2 and the other for the CI interactions with instruments (Service and Marine VLAN – Virtual Local Area Network) via the OOI network infrastructure as exemplified by the conceptual system view within the FND. Similarly, Virtual Local Area Networks will be utilized to separate out varied functionalities within the physical infrastructure.

The CI IO is also responsible for implementing data and system back-up designs for service interruptions or disasters. There will be a full off-site backup for all OOI-related data and software.

The CI IO will enforce the procedures and policies that are defined in the Cybersecurity Plan (1012-00000).

11.2 Coastal / Global Scale Nodes

CGSN hardware on land will be maintained in secure storage. CI will hold CGSN data and be responsible for its security. CGSN will provide cyber-security for CGSN OMCs and protect the points where telemetered data is collected and passed to CI as well as the points where internally recorded data, cruise data, and all ancillary data are collected and passed to CI. CGSN will work with COL and NSF to liaise with the communities likely to be at sea in the regions of CGSN nodes and thus mitigate accidental or purposeful damage to the deployed infrastructure. CGSN will also monitor the operation of deployed infrastructure, including tracking its position.

11.3 Regional Scale Nodes

Security will be integral to the RSN on several levels. The RSN team must be concerned about the following: 1) the physical security of the RSN hardware both at sea, on shore, and in the development laboratories; 2) security of the data that are collected from the observatories; and 3) security of the integrated system. The UW will plan and implement appropriate security throughout the design, implementation, installation, and operational phases of the RSN.

11.3.1 Physical Security

Ensuring the physical security of the RSN will primarily be the responsibility of the UW. On-shore facilities will be locked and protected from illegal entry and access. The UW will implement security systems or guards. For leased spaces the UW intends to secure discrete and separate facility monitoring capability, including security and environmental alarms.

Physical security of the wet plant is also the responsibility of the UW. The UW will consider physical security in the design phase, specifically route and burial planning. The UW is participating in community preventive measures by publishing route position lists and communicating with the fishing industry.

The security of assets under development, testing, or repair will also be guarded and kept secure. A common database to track every module (by serial number) and its location and status have been defined and will be available prior to installation activities.

11.3.2 Data Security

In cooperation with the IO for the CI portion of the OOI Program, the RSN IO will implement processes and safeguards to ensure the integrity of all data from origination at the instrument level to the interface point with the CI. In addition to the scientific data, there will also be continuous infrastructure data necessary for the health and wellbeing of the RSN itself. These data are critical for both real-time and historical purposes for the correction of problems and system faults, but can also be predictive and, therefore, allow preventive processes to be considered.

Acquisition and public distribution of acoustic and other geophysical data in some regions along U.S. coastlines pose a national security risk. Deploying arrays in some areas could lead to the need to restrict data access, prevent data acquisition at random intervals, or restrict publication of results. OL and NSF are discussing this issue with U.S. military representatives. The RSN and CI IOs will implement the conditions levied as a result of the discussions.

In a similar vein, individual PIs who have developed a data source that becomes part of the RSN network may, per the OL data policy, have exclusive rights to the data produced by that data source for a period of no more than one year from the onset of the data stream. The RSN will honor any restrictions imposed on data access by the data policy or any subsequent revisions of this policy.

Data users will need assurance that the data provided by the RSN are accurate. The OOI data policy requires data providers to provide information regarding the provenance, description, quality, maturity level, calibration, and collection context of their data. This metadata will help users understand the quality level of the data.

Scientists will have a number of experiments running on the RSN system. During system upgrades or maintenance, it may be necessary to remove power on parts of the RSN system for a brief period. The OOI operating center, in coordination with the RSN IO, will develop procedures and tests to ensure that this can be done without harming any instruments on the observatory. Similarly, upgrades of the observatory software will be coordinated through the OOI operating center and will be tested by the RSN IO to ensure backward compatibility.

Finally, any new sensors must first be approved for use on the RSN according to a formal process that is under development as part of operations planning. The RSN IO, as part of operational security, will confirm that any sensors planned to be placed on the RSN have been approved by the necessary entity or entities.

11.3.3 Operational Security

For the purposes of this document, Operational Security is defined to be the maintenance of a high level of availability of the entire RSN. Therefore the everyday science operations, as well as operations and maintenance of the RSN, must be carefully planned and tested (whenever possible) to ensure unexpected consequences will not occur or, if they do, that a recovery plan is in place to be implemented immediately.

Contracts with the Shore Station owners (landlords) will be implemented with clear requirements for advance notification of any facility activities that could impact the RSN or of any hazardous conditions that might arise. Remote alarms and surveillance for the station will be secured to ensure security compliance.

The continuous monitoring of the system's health and its utilization will be performed; trending analysis will be performed by the UW operations staff. A detailed and accurate inventory of both "in service" and spare equipment as well as the availability of key maintenance or repair tools (inclusive of ships and ROVs) will be maintained.

12 Environmental Health & Safety

OOI will staff an Environmental Health and Safety (EH&S) Manager to coordinate EH&S actions and events that occur on the program. The EH&S manager will assist and evaluate the IOs in the implementation of their institutional EH&S plans and procedures. Particular emphasis will be placed on safety, proactively implementing safety policies and procedures and the immediate reporting of any safety related issue or event to program staff at Ocean Leadership. (1006-00000 OOI Environmental Health and Safety Plan)

CGSN: Safety is of paramount importance. The UNOLS Research Vessel Safety Standards (RVSS) will be followed at sea and the Institution safety guidelines will be adhered to ashore. The CGSN Environmental Health and Safety Plan and procedures will be followed during all O&M activities. Furthermore, UNOLS and institutional (WHOI, OSU, SIO) policies and procedures will be followed during recovery and replacement of equipment using ships. (3101-00009 CSGN Environmental Health and Safety Plan)

RSN: Safety is of paramount importance. The UNOLS RVSS and UW policies and procedures will be followed during marine operations; and UW safety guidelines will be adhered to ashore. The RSN Environmental Health and Safety Plan, incorporated by reference, will be followed during all O&M activities. . (4011-00001 RSN Environmental Health and Safety Plan)

13 Quality Assurance & Quality Control

13.1 PMO

A full-time Quality Assurance Manager will supervise the QA/QC aspects of the project, in accordance with the OOI Quality Assurance Plan (1003-00000), with reporting responsibility to the President and CEO of Ocean Leadership. The QA/QC manager will coordinate quality activities during the transition from construction to operations in coordination with the QA managers at each Implementing Organizations.

13.2 Cyberinfrastructure

A CI Quality Assurance Manager validates that we are meeting the requirements specified in the DOORS (Dynamic Object Oriented Requirements System) database for all Level 1, 2, 3 and 4 items. The Quality Assurance Manager also assists each of the Operations and Development managers to identify potential risks, identify mitigation strategies and follows up to make sure that these are addressed in the project deliverables.

13.3 Coastal / Global Scale Nodes

Material QA/QC procedures will be as defined in the CGSN QA/QC Plan. QA and QC procedures defined in the TDP will be used during refurbishment. QA and QC procedures will be defined and modified to maintain the QA/QC integrity of the system as hardware and software changes are made.

13.4 Regional Scale Nodes

The responsibility for the overall quality assurance of the RSN will be controlled by the RSN Project Manager. This quality assurance and quality control function will be managed and overseen by the RSN team and performed by the different system suppliers in accordance with the RSN QA/QC Plan, incorporated in this document by reference.

13.4.1 Quality Plan

The UW APL Electronic Systems group creates specific quality plans tailored to meet individual customer requirements on a program-by-program basis. The quality plan specifies procedures for all aspects of a program include system design, construction, testing, and maintenance. Detailed procedure specifications that fall under the agreed-upon quality plan include the following:

- Engineering Documentation Control
- Engineering Change Order Approval
- Design and Assembly Documentation Requirements
- Manufacturing Practices Specifications
- Material Tracking Procedures
- Testing and Acceptance Requirements at the Board and System Level
- Design Review Processes
- Budgetary Tracking and Reporting Processes
- Software Revision Control and Documentation Procedures, and
- Inspection at Subcontractors.

These procedures have been critical to the long-term success of the complex data recording systems built for the U.S. Navy that demand a high level of availability.

The RSN team and APL/UW will work with OL to create, document, and agree to the procedures needed to achieve the level of quality needed for the RSN. The procedures will be completed early in the life of the project and will be reflected in the requirements imposed on any subcontractors to APL. It is envisioned that the procedures will follow many of the established and proven procedures at APL but will be modified to meet the specific needs of OL and other RSN partners.

14 The Educational Component of Operations and Maintenance

Ocean Leadership and the IOs will support ongoing education during the operational phase of the project. This educational effort will be developed from the foundation established during MREFC through the Education and Public Engagement (EPE) Implementing Organization.

As outlined in Final Network Design document, the Education and Public Engagement infrastructure will enable education users in the design and implementation of activities for two types of audiences:

1) Online post-secondary education and technical training programs with a focus on increasing participation and diversity in ocean science and technical careers; and

2) "Free choice" learning environments, both physical and virtual, with a focus on increasing public engagement with ocean science and technology.

This infrastructure development will be carried out in a “design-build” strategy by an implementing organization (the Rutgers EPE IO) to be identified approximately 3 months prior to the beginning of MREFC funding. The development will be responsive to high-level Education User Requirements stating that the EPE infrastructure will provide:

- <u>Tools</u> for web-based interfaces, visualization, interactions with models and simulation runs, digital merger with non-OOI databases, and educational models;
- <u>Resource storage, archiving, and retrieval</u> including an educational resource database and a library of cultural formats;
- <u>Virtual participation</u> via virtual laboratories and work environments;
- <u>People resources</u> for scientist/educator/student networking; and
- <u>Education and Public Engagement</u> via participation in crafting the program-wide web presence.

The opportunities created by the EPE infrastructure established during the MREFC period will permit the education community to develop innovative linkages between the OOI, students, and the general public.

Appendix A: Operations and Maintenance Requirements

O & M Requirements List is in the L2 Operational Requirements in DOORS.

The latest baseline of the L2 Operational Requirements is posted in Alfresco.

Appendix B: Concept for Future Pioneer Array Deployment

Future deployments of the Pioneer Array will be determined via a proposal/selection process in accordance with NSF review and selection policies with the primary evaluation criteria being science justification. The transfer of the Pioneer infrastructure will be managed by OL and accomplished in collaboration with the CGSN IO. The OOI Program Office, the NSF OCE Program Directors, the CGSN IO along with the Facilities Governance Group will develop the procedural steps for selection of the next array location including the process and schedule for the transition of the array to the new location.

Advanced planning for the Pioneer array site move must take place years before the move actually takes place. Science planning to determine the new array location should start three to four years prior to the move. The staff at Ocean Leadership, the CGSN IO scientists and the Observatory Advisory Team (OAT) would be key to managing the various aspects of the move, including decommissioning of the current site and timing of the installation of the array at the new location. Increased costs for the Pioneer array move would affect the “steady state” budgeting during the O&M phase. Therefore, budget planning for the move should be performed two to three years prior to the array move. NEPA planning and permitting for the new array location should start at least two to three years prior to the move. The current Pioneer array design for the array location would change. New hardware and software design changes would be incorporated into the existing design. Previously established technical data would change. Operations and Maintenance schedules would change. OL would develop a work breakdown structure and project schedule for the various aspects of the move. The Pioneer array move would have the scope of a sub project within the greater OOI O&M project that would be underway.

Appendix C: OOI Program Assumptions

Background: OOI-wide Features by Site

In order to provide a spatial (horizontal) footprint of the Global nodes, the global design calls for deployment of 3 gliders at each Global Array. The Global gliders will include instruments to measure salinity, temperature, depth, dissolved oxygen, fluorescence, chlorophyll-a, and optical backscatter.

The gliders will be used in conjunction with the central and the flanking Mesoscale moorings at each global location. The gliders communicate acoustically with moorings when they come within 5 km of them and this would be used routinely with the gliders operating within/between the triangle of moorings.

The surface and subsurface mooring will be designed for turnaround on a one-year cycle. Turnaround will consist of recovery of the moorings and deployment of replacement systems that have been refurbished. Operations and Maintenance funding will be used to acquire system equipment in sufficient quantity to support this maintenance strategy. Due to the limited number of Global Arrays, 100% redundant material will be purchased so downtime can be limited. Durable items such as the surface buoy, instrument frames, and acoustic releases are refurbished ashore and are expected to last in excess of 10 years. EM chains will be replaced yearly, but may eventually be used for two years or more. Mechanical wire rope, nylon, polypropylene, and chain mooring elements as well as all mooring hardware such as shackles and links will be replaced with new material at each turnaround.

IO High Level Assumptions

- O&M Operational property build takes place under O&M funding.
- UNOLS ships will be scheduled to perform the required cruises where possible and non-UNOLS vessels will be sourced when required.
- Smaller, non-UNOLS vessels will be used for additional glider and AUV turn-around cruises at the coastal sites.
- UNOLS ships have been used to prepare budgets and these budgets were based on using ships from the closest ports.
- Array turn-around cruises are scheduled to align with the annual ‘weather window’ at each site.
- The number of ship days requested for each cruise is based on the days needed for mobilization/demobilization and operations only, and do not include time for weather, equipment, or ship issues.
- No Marine Operations out of phase or additional time for operations or maintenance or servicing has been budgeted.
- O&M will be conducted with the minimum number of personnel needed to sustain safe operations above the threshold for acceptable performance. Personnel training and development should be carried out as possible.
- Data QA/QC plan will be developed to use the best automated practices possible to reduce human intervention and minimize the number of personnel needed to provide the required data products.
- CI will provide a single control center for managing data products and provide the user interface.

- Impacts from the marine environment and constraints on power availability for uncabled platforms require recovery and redeployment. Impacts of the marine environment include bio-fouling, wear, fatigue, and corrosion.
- Operations and Maintenance funding will be used to acquire system equipment in sufficient quantity to support planned maintenance strategies.
- Equipment necessary for at-sea deployment will be designed and purchased to allow packing into shipping containers for transfer to seaport.
- The O&M work in the early years centers on developing the O&M plans, budgets, processes, and procedures.
- Internally-recorded data will be downloaded from uncabled instruments onboard during the cruise.
- Data from ship provided instruments will be collected during the turn-around to support data QA/QC processes.
- CGSN Cabled maintenance cruises are coordinated with RSN, using a global ship with ROV capabilities.

CGSN

A set of assumptions was used to develop the Operations and Maintenance (O&M) budgets developed in conjunction with the Final Design Review (FDR). The CGSN team has, since the FDR, continued to mature the assumptions and the understanding of the options possible during O&M.

Work on O&M must start in advance of the actual transition from MREFC to O&M. Thus, O&M cost begin to be seen starting in Year 1.

The O&M work in the early years centers on developing the O&M plans, budgets, processes, and procedures.

The impacts of the marine environment together with constraints on power availability drive the need to recover and redeploy CGSN platforms. The impacts of the marine environment include bio-fouling, wear, fatigue, and corrosion. Some elements can be returned to service. Other elements cannot be used again.

Durable items such as the surface buoy, instrument frames, and acoustic releases are refurbished ashore and can continue in service for a number of years.

Past use experience at present guides the estimation of the lifetime of these items.

Items subject to wear, fatigue or corrosion must be replaced more frequently. EM chains will initially be replaced after deployment but may eventually be recovered, inspected, refurbished, and used for two years or more. Mechanical wire rope, nylon, polypropylene, and chain mooring elements as well as all mooring hardware such as shackles and links will be replaced with new material at each turnaround. Corrosion degrades wire rope very quickly once it is brought back to the surface and exposed to air.

Turnaround will consist of recovery of the platforms and deployment of replacement systems that have been refurbished and tested ashore.

Operations and Maintenance funding will be used to acquire system equipment in sufficient quantity to support this maintenance strategy. For a number of reasons, 100% redundant material will be purchased. First, in some cases the gear on the ship will be deployed before the gear in the water is recovered; for example, this is done for the global surface moorings to obtain overlapping data critical to data quality and calibration processes. Second, the cruises are of lengths that do not permit at sea servicing of equipment. Third, recovered instruments will be returned for post-calibration. Fourth, the condition of recovered gear may be such that significant rework ashore is needed.

Instruments were planned for annual calibration during the maintenance part of a turn cycle at the time of the FDR. This assumption is one of the areas of further discussion for the O&M plans for the coastal arrays, which are turned around twice per year.

Calibration cost is estimated as 10% of the initial sensor cost.

Instruments are assumed to have an average life of five years.

O&M includes support of the end to end life cycle of the CGSN infrastructure, with an Operations and Management Center at each of the CGSN institutions, including data QA/QC, support of users, and sustaining engineering along with other functions.

CGSN data flows to the Cyberinfrastructure (CI) team as soon as possible, and the CI provides the user interface to the CGSN infrastructure.

CGSN Operations and Management Centers (OMC)

Data is the product of the OOI System. The shore-side Operations and Maintenance Centers will support the core mission in a number of ways:

- Planning and Coordinating scheduled field operations and maintenance activities
- Monitoring and reporting health and status of systems, making shore-based corrections as necessary to optimize availability
- Checking and approving proposed mission changes prior to submittal to platforms
- Piloting Mobile Platforms (Gliders and AUVs) to adjust courses based on actual conditions and current situation
- Accumulating and checking real-time data and for off-loading and checking post-deployment full data sets
- Supporting visiting principal investigators – assessing feasibility, assisting in budget preparation, working space, scheduling equipment additions, qualifying equipment, equipment modifications to integrate, collaboration with CI for data acquisition
- Updating designs to compensate for obsolete or failed equipment
- Interfacing to CI for data acquisition and archival, and for operational mission planning and execution

Assumptions for OMCs:

- CGSN will divide the work among three OMCs – WHOI, SIO and OSU – to provide extended coverage and redundancy. OMCs will be staffed 40 hours per week with automated alarms for emergencies.
- Glider pilots can manage six simultaneously deployed gliders per person
- At the time of the FDR the plan was that data QA would be accomplished by four people; work is underway now to mature the staffing of data QA and develop options to match updated understanding of the sensors and instruments to be selected for use on CGSN infrastructure.
- Qualification and integration of visiting PI instruments on the facility will be separately funded

Equipment:

- The OMCs will be equipped with displays and hardware needed to monitor the infrastructure, capture and forward to CI data that was internally recorded, and support the calibration and data QA processes.

Global Moorings

In order to provide the ability to sample horizontal scales within and around the spatial (horizontal) footprint of the moored array of the Global nodes, the global design calls for deployment of 3 gliders at each Global Array. The gliders will be used in conjunction with the four moorings at Argentine Basin, 55°South, and Irminger Sea locations, including a surface mooring and adjacent profiler mooring and two subsurface or ‘flanking’ moorings that create a 4-element moored array to sample the ocean mesoscale. At the PAPA site a surface mooring maintained by NOAA will serve as the surface mooring of that global array. The flanking moorings have no surface expression, and for data access and control the gliders communicate acoustically with instruments on the flanking moorings.

The surface and subsurface moorings and the gliders will be scheduled for turnaround on a one-year cycle. Turnaround will consist of recovery of the moorings and deployment of replacement systems that have been refurbished and tested ashore. Operations and Maintenance funding will be used to acquire system equipment in sufficient quantity to support this maintenance strategy. For a number of reasons, 100% redundant material will be purchased.

Argentine Basin

Location: 42°S, 42°W; Water Depth: 5200 meters

Mooring Types: Surface Mooring with Subsurface Hybrid Profiler Mooring and Mesoscale Flanking Mooring Pair

Description of Infrastructure:

- One Global Surface Mooring, with standard power (wind and solar) buoy and satellite telemetry
- One Global Hybrid Profiler mooring with one wire-following profiler and one surface-piercing profiler
- Two subsurface Mesoscale Flanking Moorings with fixed sensors and acoustic communications to glider
- Hard wire link or inductive telemetry link within upper 1500 m of the Surface Mooring
- Three gliders with acoustic communications to the Mesoscale Flanking Moorings

Planning for and occupation of the Argentine Basin Array will be coordinated with international research programs such as Climate Variability and Predictability (CLIVAR), the international ocean time series scientific steering group (OceanSITES), and colleagues in Argentina, including at the University of Buenos Aires and the Hydrographic Service of the Argentine Navy. Ship time requests will be made through UNOLS (University-National Oceanographic Laboratory System). In addition, the timing of the mooring servicing will be made known to international ship operators through POGO (Partnership for the Observation of the Global Ocean) and other ship resource sharing groups. Planning at the time of the FDR was based on the assumption that the cruises would sail to and from Montevideo, Uruguay, with all equipment coming from and returning to the United States each cruise. Recent dialog with Argentine colleagues is developing further options: they have offered the use of a lab in Mar del Plata. Equipment could be staged in Mar del Plata, Argentina; and some equipment could be serviced there. Alternate, possible cruise plans will be considered to cover possible UNOLS scheduling and cruise track constraints.

Irminger Sea, SE of Greenland

Location: 60°N, 39°W; Water Depth: 2800 meters

Mooring Types: Surface Mooring with Subsurface Hybrid Profiler Mooring and Mesoscale Flanking Mooring Pair

Description of Infrastructure:

- One Global Surface Mooring, with standard power (wind and solar) buoy and satellite telemetry
- One Global Hybrid Profiler mooring with one wire-following profiler and one surface-piercing profiler
- Two subsurface Mesoscale Flanking Moorings with fixed sensors and acoustic communications to gliders
- Hard wire link and inductive telemetry link within upper 1500 m of the Surface Mooring
- Three gliders with acoustic communications to the Mesoscale Flanking Moorings

Planning for, and occupation of the Irminger Sea Array will be coordinated with European partners and their plans for observations off southeast Greenland through the OceanSITES program. Staging is planned to be done from Woods Hole, MA and ship time requests have been made using Woods Hole as the start and end ports. Alternate, possible cruise plans will be considered to cover possible UNOLS scheduling and cruise track constraints.

Southern Ocean, SW of Chile

Location: 55°S, 90°W; Water Depth: 4800 meters

Mooring Types: Global Surface Mooring with Subsurface Hybrid Profiler Mooring and Mesoscale Flanking Mooring Pair

Description of Infrastructure:

- One Global Surface Mooring, with high-power (fuel cell) buoy and high-bandwidth (active antenna) satellite telemetry
- One Global Hybrid Profiler mooring with one wire-following profiler operating and one surface-piercing profiler
- Two subsurface Mesoscale Flanking Moorings with fixed sensors and acoustic communications to gliders
- Hard wire and inductive telemetry link within upper 1500m of the Surface Mooring
- Three gliders with acoustic communications to the Mesoscale Flanking

Planning for and occupation of the 55° South Array will be coordinated with Chilean colleagues (Chilean Navy Hydrographic and Oceanographic Service and the University of Concepcion) and with the NSF Office of Polar Programs. The initial plan is to ship all gear to and from the staging port. Work is underway to investigate if staging could be done at the NSF staging facility in Punta Arenas, Chile and if some gear could remain in Punta Arenas and be serviced there.

Station Papa, North Pacific

Location: 50°N, 145°W; Water Depth: 4250 meters

Mooring Types: Subsurface Hybrid Profiler Mooring with Mesoscale Flanking Mooring Pair

Description of Infrastructure:

- One Global Hybrid Profiler mooring with one wire- following profiler and one surface-piercing profiler
- Two subsurface Mesoscale Flanking Moorings with fixed sensors and acoustic communications to gliders
- Three gliders with acoustic communications to the Mesoscale Flanking Moorings

Planning for and occupation of the Station Papa Array will be coordinated with colleagues at the NOAA Pacific Marine Environmental Laboratory (PMEL), the Institute of Ocean Sciences, British

Columbia, Canada, the RSN and CGSN Endurance O&M efforts, and the University of Washington. PMEL provides the surface mooring on a separate and independent cruise. The plan at FDR was to ship all gear to and from Seattle. Work is underway to investigate if some gear could remain in Seattle and be serviced there.

Coastal Moored Arrays

Pioneer Array:
Location, Central Mooring: 40° 02'N, 70°47.5'W; Water Depth: 210 meters

Cross-shelf mooring line extent: Approximately +/- 15 km from central mooring

Upstream moorings: Approximately 10 km from cross-shelf line

AUV sampling area (approximate): 80 km (across shore) by 110 km (along shore) box centered on moored array

Glider sampling area (approximate): 150 km x 150 km box over outer shelf and slope sea

Description of Infrastructure:

- Three EOM surface moorings
- Three Multi-Function Nodes at the base of EOM surface moorings (two supporting AUV docks)
- Five coastal wire-following profilers
- Two coastal surface-piercing profilers
- Two AUV docking stations
- Three AUVs
- Six gliders

Endurance Array:
Location:

Oregon Moored array line (OR): 44° 39'N, 124° 58'W to coast; Water Depth: 500-25 meters.

Washington Moored array line (WA): 46° 59'N, 124° 59'W to coast; Water Depth: 500-25 meters.

Glider sampling area: 44° 30'N to 48° 00'N, 126°W to coast.

Description of Infrastructure:

- Two EM surface moorings with wind and photovoltaic power generation, iridium communications, and meteorological sensors (OR 80m, OR 500m)
- Two EOM surface moorings with wind, photovoltaic and fuel cell power generation, high speed and low speed satellite communications, and meteorological sensors (as at Pioneer) (WA 80m, WA 500m)
- Two hardened EM surface moorings with battery power and iridium communications (OR 25m, WA 25m)
- Four bottom-mounted surface-piercing profiler moorings; three stand-alone (OR 25m, WA 25m, WA 80m) and one cabled to RSN (OR 80 m)
- One hybrid profiler mooring with deep profiler and shallow profiler cabled to RSN (OR 500m)
- One Coastal Profiler Mooring (coastal wire following profiler) with deep profiler (WA 500m)
- Two un-cabled benthic multifunction nodes (MFN) with sensors, electrical communications to the surface, and supplementary battery power provided by the surface buoy (OR 25m, WA 25m)
- Two un-cabled benthic multifunction nodes (MFN) with fiber optic communications to the surface and power provided through surface moorings (WA 80m, WA 500m)

- Two cabled benthic experiment packages (BEP) with fiber optic communications and power provided through primary nodes attached to the RSN (OR 80m, OR 500m)
- Six gliders

Regional Scale Nodes:
Primary Infrastructure

- Shore Station: Pacific City, Oregon
- Cable: 903 km
  - o Buried309 km
  - o Surface Laid: 594 km

Summary of Secondary Infrastructure Components

- Secondary Extension Cable: ~ 35 km (in sections of 10 m to 5 km)
- Low and Medium Power Nodes: 5
- Junction Boxes (J-Boxes): 13
- Sensors: 108
- Sensor Types: 31
- Moorings:3

Hydrate Ridge:
Description of Infrastructure:

Primary Node	Secondary Node ID	Water Depth (meters)	Number of LVNode, JBox & Sensors
Hydrate Ridge (1A)	Hydrate Ridge	2909	1 JBox + 4 sensors
	Hydrate Mooring	2906	1 LVNode + 1 JBox + 7 (bottom) and 26 (Profiler, Float Platform & Winch) sensors
Southern Hydrate (1B)	Southern Hydrate (Summit 1)	807	1 LVNode + 1 JBox + 8 sensors
	Southern Hydrate (Summit 2)	811	1 JBox + 4 sensors

- Two (2) planned maintenance cruises per year

Axial Seamount:
Description of Infrastructure:

Primary Node	Secondary Node ID	Water Depth (meters)	Number of LVNode, JBox & Sensors
Axial (3A)	Axial	2654	1 JBox + 4 sensors
	Axial Mooring	2597	1 LVNode + 1 JBox + 7 (bottom) and 26 (Profiler, Float Platform & Winch) sensors
Eastern Caldera (3B)	Ashes-1	1552	1 JBox + 6 sensors
	Ashes-2	1551	1 JBox + 5 sensors
	Ashes-3	1554	1 JBox + 3 sensors
	Eastern Caldera/Slope	1518	1 JBox + 4 sensors
	Northern Caldera	1584	1 JBox + 4 sensors

- Two (2) planned maintenance cruises per year

Mid-plate Nodes:
- Maintenance cruises as required in conjunction with Axial Seamount

Schedule Based Assumptions

Cyberinfrastructure Related
- Cost for cloud computing. for both computer processing capacity and data storage;
- Computer hardware refresh cycle;
- Cost of wireless communications over time;
- Turn-around time to resolve trouble tickets;

Seaborne Related Resources
- Mooring turns
  - Why 6 and 12 months?
  - Consider aspects of hardware, instruments, etc.
- Mobile asset durability and reliability;
- Assumed weather delays;
- Personnel requirements during cruises, refurbishment, pre-cruise preps;
  - Relative balance between senior and junior staff;
  - Training expenses;
- Global cruises from nearest harbor with no out of phase operations or maintenance budgeted;
- Internally-recorded data will be downloaded from instruments onboard during the cruise.
- Ship-based data will be collected during the turn-around to support data QA/QC processes;
- Life of components (buoy structure, foam, releases, instruments);
- Sparing assumptions;
- Component burn in testing;

- Maintenance turns of gliders/AUVS six times per year, and recovery and replacement of the moorings twice a year. Note that two of the six glider/AUV turns are shared with mooring turn cruises. No out of phase operations or maintenance has been budgeted.
- CGSN Cabled maintenance cruises are coordinated with RSN, using a global ship with ROV capabilities.
- A 12500 sq. ft. facility has been purchased by OSU for refurbishment, testing, operations, and storage. A staging facility in Newport OR provides working space, storage, and dockside loading/unloading
- Argentine Basin - UNOLS ships have been requested and budgeted, with the initial plan developed around the use of Montevideo, Uruguay as the port. Work is underway to investigate Mar del Plata, Argentina as the cruise port and as a staging base.
- Irminger Sea - UNOLS ships have been requested and budgeted, with Woods Hole, MA as the desired port of departure and disembarkation.
- Southern Ocean - UNOLS ships have been requested and budgeted, with Punta Arenas, Chile as the desired port.
- Station Papa - UNOLS ships have been requested and budgeted with Seattle, WA as the desired port.
- Endurance Array - UNOLS vessels requested and budgeted, with Newport as the desired port for the un-cabled platform cruises.
- Pioneer Array - UNOLS vessels requested and budgeted, with Woods Hole as the desired port for the mooring cruises.
- Pioneer Array - RV Connecticut requested for glider/AUV cruises.

Instrument & Data Product Related

- Different approaches to data product delivery (data QA can be done several ways);
    - Mostly automated, few human experts;
    - Less automated, more human experts;
    - Wide range of instrument types and instrument platforms requires multiple approaches to delivery of QA data;
- Calibration and validation of instrument performance;
    - In-house vs. vendor vs. other contracted source (i.e. NDBC, MARS);
    - Maintenance contracts vs. as-needed repair;

Regional Scale Nodes Related

RSN Operations

- UW will operate an Observatory Control Center with 24 X 7 X 365 monitoring of RSN
- UW will Operate RSN which includes
    - Core instruments – QA/QC
    - Secondary Infrastructure,
    - Primary Infrastructure (Science ports to Portland Cyber-POP)
    - Support facilities
    - OCC
    - Oregon Logistic Facility
    - Cable Depot
    - Terrestrial leased bandwidth facilities
- Operations Costs
    - Recurring Rents (shore station, cyber-pop, logistic and depot space)
    - Capacity Lease costs
    - OCC operational and consumable costs

RSN Maintenance

- UW will manage the maintenance of RSN to meet or surpass all requirements for Quality, Availability and reliability.
    - Primary Infrastructure maintenance and repair will be contracted to a competent entity

    - Secondary infrastructure will be maintained on a planned basis expected to utilize two annual cruises of 20 days duration.
    - Shore station and other rental facilities maintenance will be managed with related landlords or facility operators.
- UW will manage suppliers for leased and rented facilities to insure the required levels of performance are maintained, these include:
    - Shore station and it's environmental systems
    - Terrestrial facilities
    - Logistic and Depot space
- UW will implement maintenance agreements for:
    - Submarine Cable Maintenance & Repair (Primary Infrastructure)
    - UNOLS & ROV maintenance events
    - Instrument maintenance, repair, and calibration
    - Support Services (remote hands) for Shore station and Cyber-POP support

RSN O&M Administration

- UW will provide the administrative support required by RSN O&M including
    1. Trained resources
    2. Maintenance Planning
    3. Spares Management
    4. Provisioning (growth) planning
    5. User Support and training
    6. Contract and supplier management
    7. Reporting and Performance Compliance
    8. Financial Management & Planning

Financial Related

- Inflation assumptions;

Emerging Assumptions & Alternatives

The CGSN team will in Year 2 work on further development of O&M costs and on the supporting documentation.

At this point the team has identified a number of areas of concern with respect to the assumptions used at the time of the FDR:

- The length of the cruises, and the adequacy of the number of weather days
- Participation on cruises of personnel dedicated to event logging, record keeping, inventory control, during- and post-cruise reporting, and ensuring QA procedures
- Participation in cruises of personnel for training to prepare for future roles
- The possibility of alternate ports
- Consideration of the achievable duration of glider deployments
- The staffing level and effort required to support data QA/QC
- Automation of glider piloting and planning vs. staffing pilots
- Support for ship-based sampling during cruises
- Definition and support for water sampling during cruises
- CGSN and RSN duplication of support, differences in O&M procedures
- The lifetime of the profilers
- Strategies for the spring and fall turn-around for the coastal platforms in which the O&M effort for one of the two turns is less extensive than for the other

- Integration of community science users (including their gear, their logistics requirements and associated procedural and reporting requirements) on cruises

At the same time a number of areas of discussion point to possible scenarios for more cost-effective O&M processes; these need further development:

- Staging large and heavy gear in remote locations, reducing shipping cost
- Use of ships of opportunity for glider turn-around
- Involvement in an NSF IGERT (Integrative Graduate Education and Research Traineeship) proposal to bring students to the CGSN institutions for their training
- Learning curves
- Improvement in the bandwidth of available telemetry systems
- Improved pricing scenarios for Fleet Broadband
    - In combination with UNOLS
    - Negotiation based on OOI quantity
- Iridium service pricing negotiated based on OOI quantity
- Synergistic participation in cruises by additional science groups
- Reduction in ship time costs compared to what was budgeted
- Improved performance data for budget forecasts

Appendix D: Data Management Plan

The OOI Data Management Plan is a separate document, Number 1102-00000.

Appendix F: OOI Organizational Charts

The OOI Data Policy is contained in Appendix A-1: OOI Data/Products Policy, of the OOI Data Management Plan (Document number: 1102-00000)

Appendix F: OOI Organizational Charts

The OOI Program Organization consists of a Program Management Office (PMO) at the Consortium for Ocean Leadership and four Implementing Organizations (IOs).

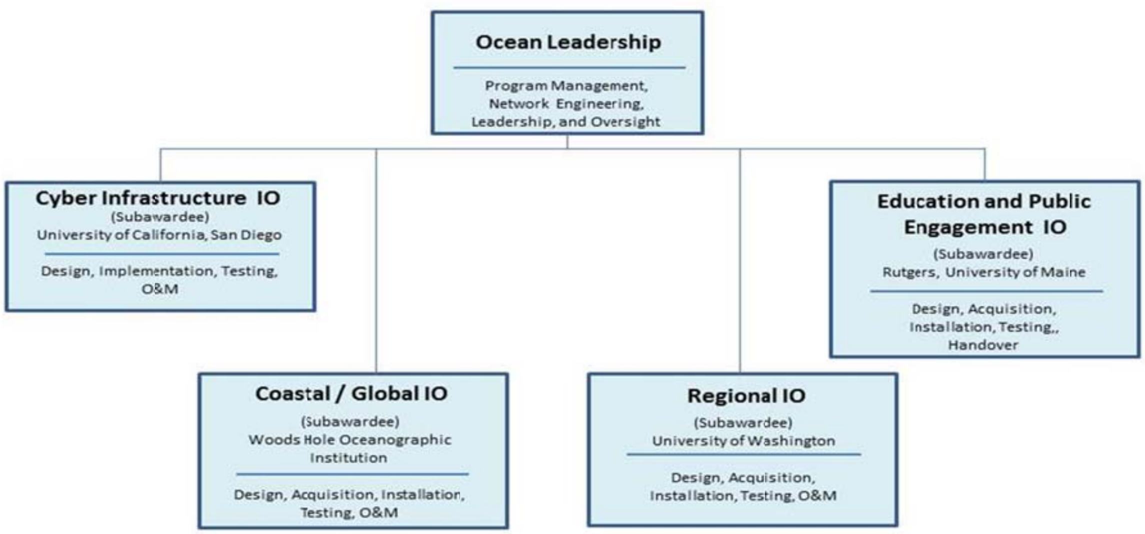
The Cyberinfrastructure IO consists of the University of California San Diego and sub awardees: Rutgers University, Jet Propulsion Laboratory, Monterey Bay Aquarium Research Institute, Massachusetts Institute of Technology, North Carolina State University, University of Chicago, and University of Illinois at Urbana-Champaign, University of Southern California and Woods Hole Oceanographic Institution.

The Coastal/Global IO consists of Woods Hole Oceanographic Institution and sub awardees: Oregon State University – College of Oceanic and Atmospheric Sciences, University of California San Diego – Scripps Institution of Oceanography, and Raytheon, Integrated Defense Systems.

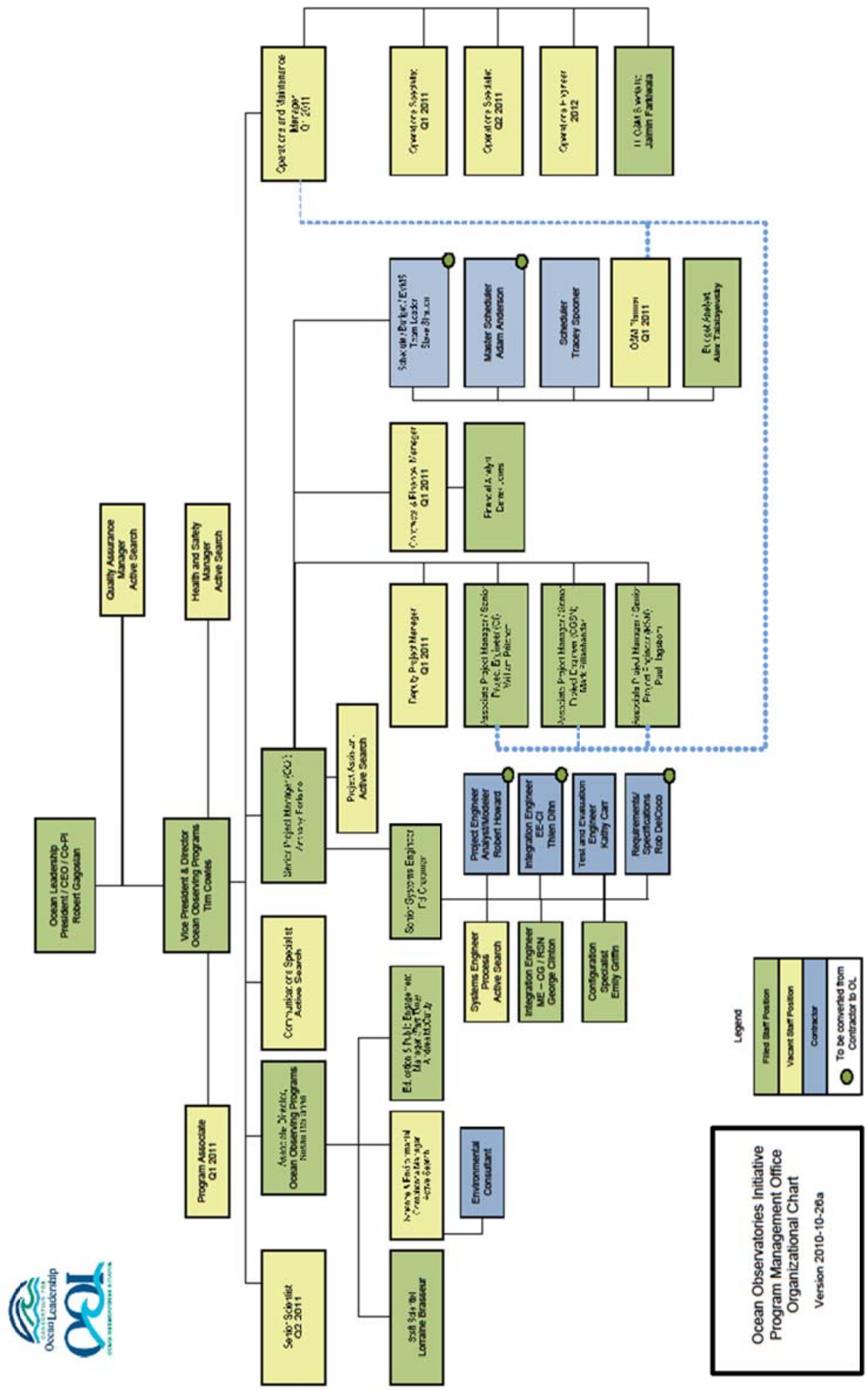
The University of Washington is the Regional IO.

The Education and Public Engagement IO – Consists of Rutgers, The State University of New Jersey (RSUNJ), with partners University of Maine (UM) and Raytheon Mission Operations and Services. Organizational charts for the OOI, PMO, and four IOs are depicted below.

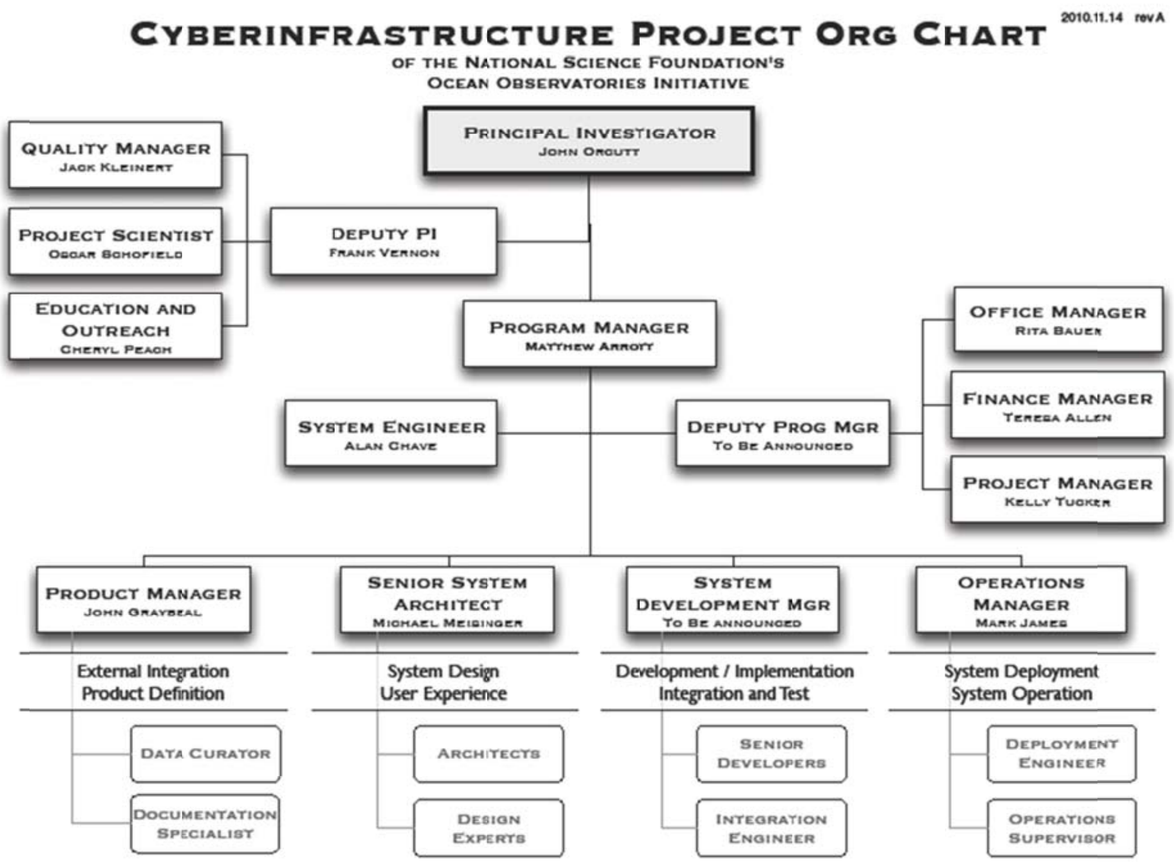
OOI Organizational Chart



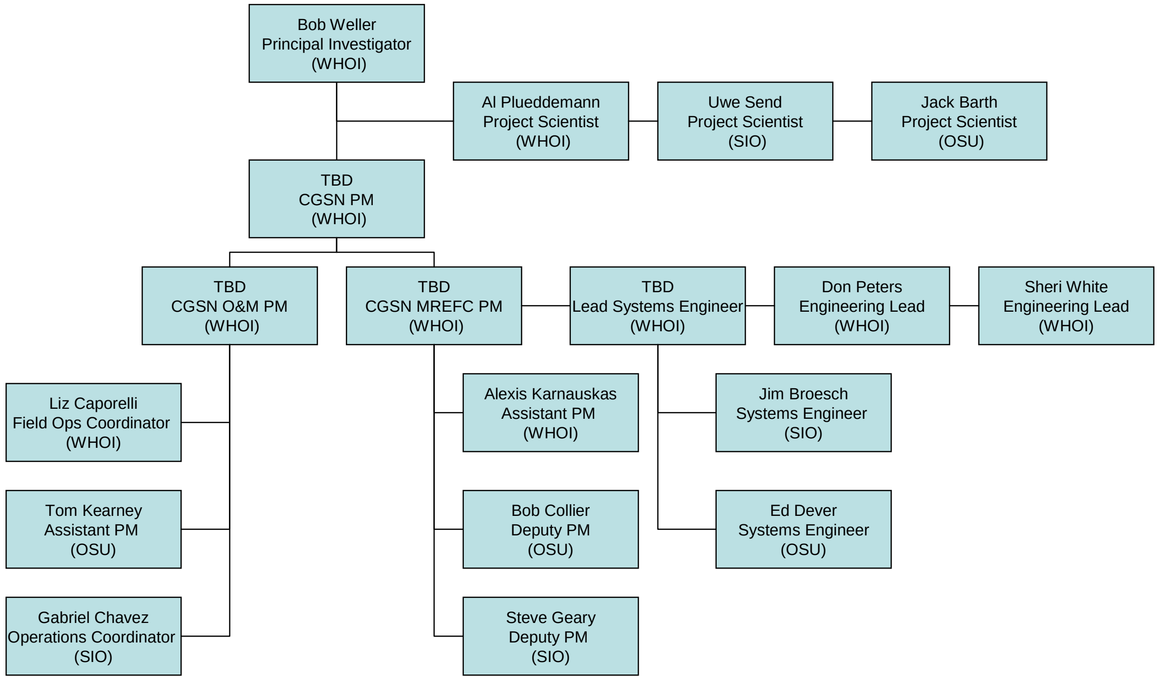
Program Management Office Organizational Chart



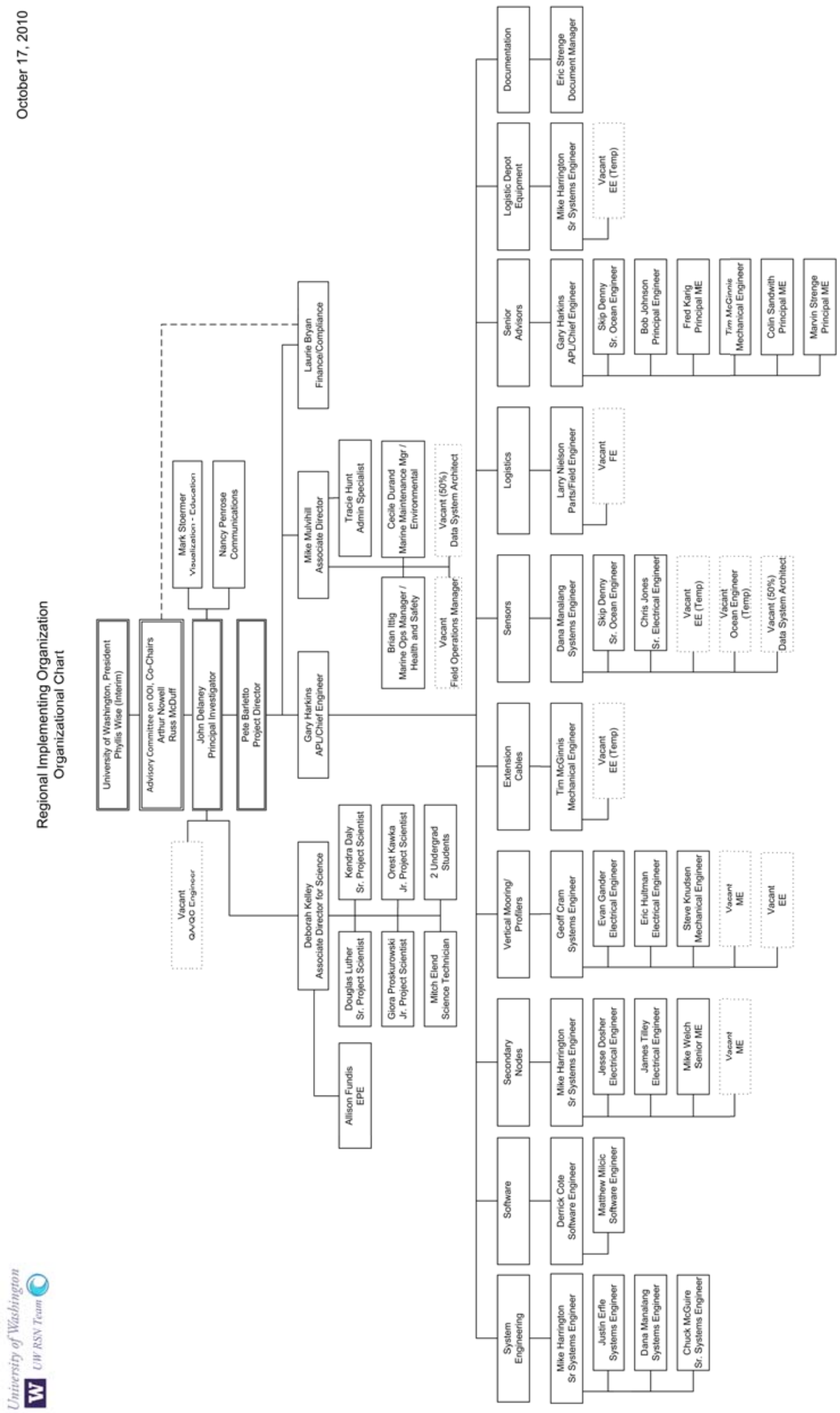
Cyberinfrastructure Implementing Organization Organizational Chart



Coastal/Global Scale Nodes Implementing Organization Organizational Chart



Regional Scale Nodes Implementing Organization Organizational Chart



Education and Public Engagement Implementing Organization Organizational Chart

Appendix G: Acronyms

AAG	Astronomy and Astrophysics Research Grants
APL	Applied Physics Laboratory
AWP	Annual Work Plan
BIA	Backbone Interface Assembly
BOM	Bill of Materials
CGSN	Coastal/Global Scale Nodes
CCB	Change Control Board
CDR	Critical Design Review
CE	Chief Engineer
CEO	Chief Executive Officer
CFR	Code of Federal Regulations
CI	Cyberinfrastructure
CMP	Configuration Management Plan
COC	Certificate of Calibration
COL	Consortium for Ocean Leadership
COTR	Contracting Office’s Technical Representative
COTS	Commercial Off The Shelf
CPOP	Cyber Point of Presence
CRM	Customer Relationship Management
CSA	Cooperative Support Agreement
CTD	Conductivity, Temperature, Depth
DCL	Data Concentrator Logger
DMOQ	Direct Measurements of Quality
DOORS	Dynamic Object Oriented Requirements System
EDM	Engineering Development Models
EH&S	Environmental Health and Safety
EMI/EMC	Electromagnetic Interference/Electromagnetic Compatibility
EO	Electro-Optical
EOM	Electro-Optical-Mechanical
EPE	Education and Public Engagement
eTOM	Enhanced Telecom Operations Map
EVMS	Earned Value Management System
FAC	Facility Advisory Committee
FMEA	Failure Mode Effects Analysis
FT	Factory Test
FTE	Full Time Employee
HVAC	Heating, Ventilating, and Air Conditioning
ICPC	International Cable Protection Committee
IDG	Instrument Development Group
IGERT	Integrative Graduate Education and Research Traineeship
IMS	Integrated Master Schedule
IO	Implementing Organization
IODP	International Ocean Drilling Program
ION	Integrated Observatory Network
IOOS	Integrated Ocean Observing System
IT	Information Technology
ITU	International Telecommunications Union

ITU-T	ITU Telecommunication Standardization
J-Box	Junction box
JOI	Joint Oceanographic Institutions
LCC	Life Cycle Cost
LV	Low Voltage Node
MarFac	Marine Facility
MARS	Monterey Accelerated Research System
MFN	Multi Function Node
MP-JBox	Medium Power Junction Box
MREFC	Major Research Equipment and Facilities Construction
MRP	Materials Resource Planning
MOSA	Major Overhaul Stabilization Account
MRI	Major Research Instrumentation
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NAZ	North America Zone
NEPTUNE	North-East Pacific Time-Series Undersea Networked Experiments
NGO	Non-government Organization
NIST	National Institute of Standards and Technology
NMS	Network Management System
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
O&M	Operations and Maintenance
OA&M	Operation, Administration, & Maintenance
OAT	Observatory Advisory Team
ODF	Oceanographic Data Facility
ODP	Ocean Drilling Program
OEM	Original Equipment Manufacturer
OL	Ocean Leadership
OM	Operations Manager
OMB	Office of Management and Budget
OMC	Operations and Management Center
OMM	Operations and Maintenance Manager
OMS	Observatory Management System
OOC	Observatory Operations Center (RSN)
OOC	Ocean Observatories Center (CGSN – OSU)
OOI	Ocean Observatories Initiative
OOT	Observatory Operations Team
OSU	Oregon State University
OTIC	Ocean Technology and Interdisciplinary Coordination
PAC	Program Advisory Committee
PEP	Project Execution Planning
PI	Principal Investigator
PIT	Pre-installation Integration Test
PM	Project Manager
PMEL	Pacific Marine Environmental Laboratory
PoP	Point of Presence
PS	Project Scientist
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control

QC	Quality Control
RF	Radio Frequency
ROPOS	Remotely Operated Platform for Ocean Science
ROV	Remotely Operated Vehicle
RSN	Regional Scale Nodes
S&R	Shipping and Receiving
SE	Systems Engineer
SIA	Science Interface Assembly
SIO	Scripps Institution of Oceanography
SLA	Service Level Agreement
SOW	Statement of Work
SP	Service Provider
SSL	Secure Sockets Layer
STS	Shipboard Technical Support
TDP	Technical Data Plan
TESAC	Technical, Environmental and Security Assessment Committee
TOM	Telecom Operations Map (TM Forum)
UCSD	University of California San Diego
UNOLS	University-National Oceanographic Laboratory System
UOP	Upper Ocean Processes
UPS	Uninterrupted Power Supply
UUT	Unit-Under-Test
UW	University of Washington
VLAN	Virtual Local Area Network
WAN	Wide Area Network
WBS	Work Breakdown Structure
WG	Working Group
WHOI	Woods Hole Oceanographic Institution
WLAN	Wireless Local Area Network