



# PROJECT EXECUTION PLAN

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## Executive Summary

The Ocean Observatories Initiative (OOI) project is constructing an interactive, globally distributed, and integrated network of ocean nodes that create an observatory enabling transformational, complex, interdisciplinary ocean science.

The National Research Council (NRC) recommended that the OOI management structure should be one in which the day-to-day operation of different OOI elements is the responsibility of entities with appropriate scientific and technical expertise, while the role of the program management organization should be one of coordination, oversight, and fiscal and contract management. In 2004 NSF signed a cooperative agreement with the Joint Oceanographic Institutions (JOI), now the Consortium for Ocean Leadership, for the establishment of a project office to coordinate the OOI activities. This resulted in the creation of the current OOI Program Office. After a competitive bid process, Ocean Leadership signed subawards with four implementing organizations (IOs) to conduct the detailed design, engineering, construction, testing, and operation of the different OOI elements.

The *OOI Project Execution Plan (PEP)* describes how Ocean Leadership manages the OOI project. OOI construction is funded by the National Science Foundation (NSF) through its Major Research Equipment and Facilities Construction (MREFC) account. The Large Facilities Office at NSF has set out guidelines for the management of MREFC projects, and the PEP attempts to be responsive to the spirit of those guidelines.

In this spirit, Ocean Leadership conducts design reviews at appropriate times within each Implementing Organization's schedule of activities. The OOI Project Baseline has been established and is in Appendix A-4.

This version of the PEP reflects the changes that have occurred within the project since the start of construction, while maintaining the basic structure and scope approved by the National Science Board in May 2009. It will continue to be modified, under the change control process, as the project moves forward. The PEP incorporates a number of existing (or planned) supporting documents by reference. This allows the supporting documents to be updated without impacting the PEP. A list of program documents supporting this PEP is found in Appendix A-1.

## 1 Overview

The *Ocean Observatories Initiative (OOI) Project Execution Plan (PEP)* is viewed as a living document and is updated throughout the development and implementation phases of the OOI. This version of the document represents the project during construction execution in Year 2 of the five and one-half year schedule. Subsequent versions will be issued as the project reaches critical milestones or when external factors, such as final decisions on each year's federal budget, materialize. Substantive changes to the PEP, following major reviews or significant project changes are sent to the cognizant NSF program officer for written approval, following approved modifications via the OOI Change Control Board process.

The OOI Program will conduct transformational ocean science using an integrated ocean observatory with a network of interactive nodes studying interrelated ocean processes on coastal, regional, and global spatial scales and over a range of time scales, from microseconds to decades. NSF funds the planned facility through its MREFC account. The OOI is an outgrowth of scientific planning efforts by the national and international ocean research communities over the past two decades and is motivated in part by rapidly expanding development of computational, robotic, communications, and sensor capabilities.

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The OOI program is managed through the OOI Program Office housed within OL in Washington, D.C. Ocean Leadership is a not-for-profit corporation of member institutions (universities or other nonprofit institutions, organizations, or governmental entities involved in oceanographic sciences or related fields and that are organized for educational or scientific purposes). Ocean Leadership has contracted with four implementing organizations (IOs) for the development, construction, and operation of the OOI. The Woods Hole Oceanographic Institution (WHOI) is the IO for the coastal and global nodes, the University of Washington (UW) for the regional nodes, the University of California, San Diego (UCSD) for the cyberinfrastructure that connects the nodes together into an integrated observatory, and Rutgers, The State University of New Jersey for building related education and public engagement infrastructure. Figure 1 shows the responsibilities of OL and each IO in the execution of the OOI project. Each IO has developed a PEP covering its responsibilities. These subordinate PEP documents are consistent with this OOI PEP and are incorporated by reference in accordance with Appendix A-1.

OOI Organizational Chart

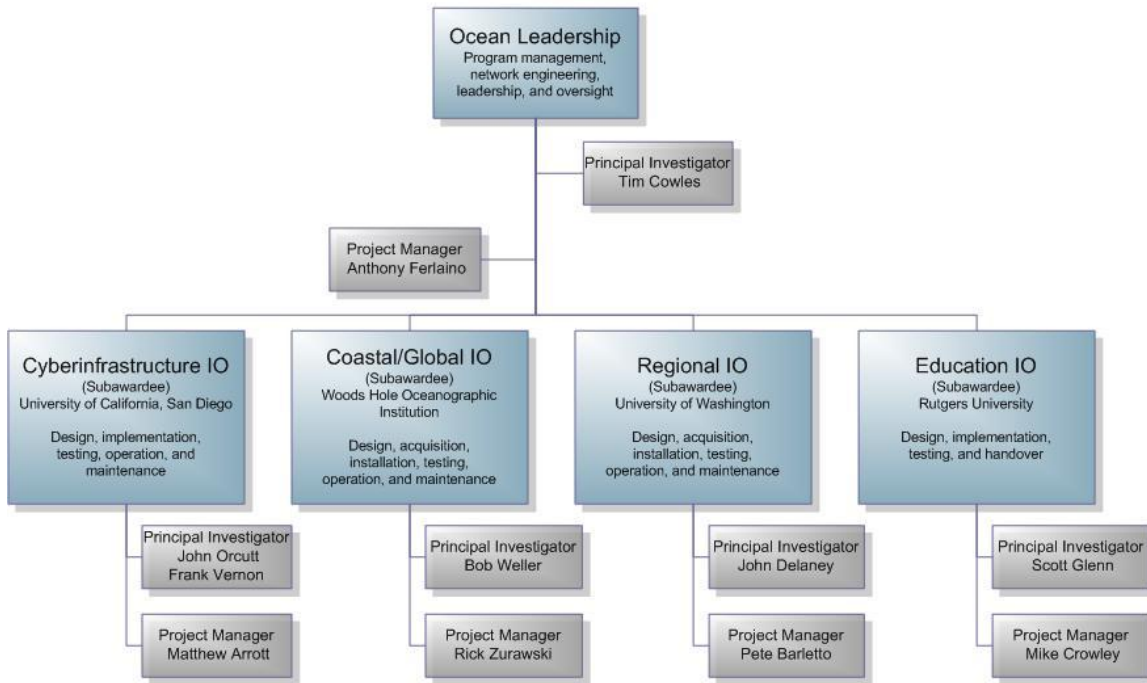


Figure 1 Responsibilities of Ocean Leadership and each Implementing Organization

The baseline technically driven funding profile and allocation was developed under NSF's guidance:

OOI Funding

IO / Project Year	PY 1	PY 2	PY 3	PY 4	PY 5	PY 6	Total
Project Office	8.5	6.6	5.9	5.4	5.1	-	31.5
Contingency	49.1	31.9	6.5	0.5	-	-	88.0
Cyber IO	8.8	7.9	7.4	5.8	4.3	-	34.1
Coastal/Global IO	19.0	19.2	43.4	13.9	6.3	-	101.9
Regional IO	40.6	44.8	18.9	20.4	2.6	-	127.4
Education IO	0.0	0.2	0.6	0.9	1.7	-	3.5
<b>Total OOI</b>	<b>126.1</b>	<b>110.7</b>	<b>82.8</b>	<b>46.8</b>	<b>20.0</b>	<b>-</b>	<b>386.4</b>

Note: Post award \$20 million funding was transferred from PY2 to PY3.

The funding profile and allocation above was derived from a technically driven implementation schedule and based upon a rolled-up costing of approximately 900 individual work packages. The funding profile in this chart includes approximately 30% contingency. The contingency value was calculated as part of the bottom-up cost estimate contained in the *OOI Cost Book* (20%) and the *OOI Risk Register* (10%), both held by Ocean Leadership. The Cost Book based contingency value is budgeted and managed at the OOI overall project level. The funding profile above includes funds required to commit contracts prior to the year in which payment is made. The technically driven implementation schedule is dependent on NSF funding continuity. In the funding profile table (previous page), PY6 consists of six months of construction schedule float ending in February 2015, with all funding provided by PY5.

The OOI website (<http://oceanobservatories.org>) serves as a baseline source of community information about the program. The website includes information and documents regarding the management, science planning, design refinement and other news related to the OOI.

### 1.1 Scientific Goals

The vast oceans, which cover two-thirds of our planet, largely determine the quality of life on Earth and are the last unexplored frontiers on our planet. The complex interacting environments and processes that operate within the world's oceans modulate both short-term and long-term variations in climate, harbor major energy and raw material resources, contain and support the largest biosphere on Earth, significantly influence rainfall and temperature patterns on land, and occasionally devastate heavily populated coastal regions with severe storms or tsunamis. Phenomena such as global climate change and El Niño events, and natural hazards such as hurricanes and tsunamis have enormous global economic and societal impact.

Many earth and ocean processes occur at temporal and spatial scales not effectively sampled using traditional ship-based or satellite-based observations. Such processes run the spectrum from episodic, short-lived events (earthquakes, submarine volcanic eruptions, severe storms), to longer-term changes or emergent phenomena (ocean circulation patterns, climate change, ocean acidity, ecosystem trends). The need for sustained ocean observations has long been recognized by the ocean science community and was re-affirmed in 2004 by the U.S. Commission on Ocean Policy in its report (<http://www.oceancommission.gov/>).

The overarching goal of NSF's OOI is to advance the investigation of complex earth and ocean processes by providing access to next-generation (i.e., transformational) technologies to support interactive and adaptive observatory science. The NSF's MREFC account supports the construction of an integrated observatory network to operate as a "permanent observational presence" in the ocean. The OOI Network will provide scientists with unique opportunities to conduct multi-disciplinary studies of linked atmosphere-ocean-earth processes over timescales of seconds to decades, and spatial scales of millimeters to thousands of kilometers.

The OOI will transform research of the oceans by establishing a network of interactive, globally distributed sensors with near real-time data access. Recent technological advances in sensors, computational speed, communication bandwidth, Internet resources, miniaturization, genomic analyses, high-definition imaging, robotics and data assimilation-modeling-visualization techniques are opening new possibilities for remote scientific inquiry and discovery. The OOI will enable innovative developments across all of these fields and will contribute to maintaining American leadership in scientific advancement as well as providing excellent educational opportunities. The OOI is the NSF's major contribution to the broader national and international efforts to establish the U.S. Integrated Ocean Observing System (IOOS) and the Global Earth Observation System of Systems (GEOSS), respectively.

The OOI is the result of almost twenty years of community planning. The scientific goals (i.e., the high-priority-research topics and questions) and types of infrastructure required to address those scientific goals are based on recommendations contained in more than thirty planning documents, including workshop reports, interagency reports, and two National Academy of Sciences publications. A more detailed description of OOI development and science goals is available in the OOI Science Prospectus titled *The Ocean Observatories Initiative Scientific Objectives and Network Design: A Closer Look*. As summarized in the OOI Science Prospectus and the earlier *Ocean Observatories Initiative Science Plan*, the scientific goals of the OOI are to provide the necessary infrastructure to enable profound advancements in the following research areas:

- Ocean-Atmosphere Exchange
- Climate Variability, Ocean Circulation, and Ecosystems
- Turbulent Mixing and Biophysical Interactions
- Coastal Ocean Dynamics and Ecosystems
- Fluid-Rock Interactions and the Subseafloor Biosphere
- Plate-Scale, Ocean Geodynamics

The design goals established in the National Research Council (NRC) report *Enabling Ocean Research in the 21<sup>st</sup> Century: Implementation of a Network of Ocean Observatories* are the guiding principles applied to the OOI Network design to ensure that OOI capabilities will address the science goals. Those guiding principles are: (1) continuous observations at high temporal resolution for decades; (2) spatial measurements on scales ranging from millimeter to kilometers; (3) the ability to collect data during storms and other severe conditions; (4) two-way data transmission and remote instrument control; (5) power delivery to sensors between the sea surface and the seafloor; (6) standard sensor interfaces; (7) autonomous underwater vehicles (AUV) docks for data download and battery recharge; (8) access to facilities to deploy, maintain, and calibrate sensors; (9) an effective data management system that provides open access to all; and (10) an engaging and effective education and outreach program that increases ocean literacy.

The series of planning activities leading up to release of the *OOI Conceptual Network Design* (CND) and the *OOI Preliminary Network Design* (PND) have involved the efforts of hundreds of ocean scientists, computer scientists, engineers, and educators spanning 130 research and education institutions. The *OOI Final Network Design* (FND) has been refined from the OOI PND to define, with higher confidence, the financial resources and schedule needed to accomplish the technical baseline. The technical baseline has been adjusted slightly to align, with higher confidence, with NSF's guidance on anticipated Operations and Maintenance funding. Other changes have been introduced to reduce risk and include technical information gained through several Requests for Proposal and Requests for Information. Changes were introduced to better align system capability with the lower level system requirements defined since Preliminary Design Review (PDR) in November 2007. Following Final Design Review (FDR), NSF requested specific changes to enhance the capability of the OOI to address the current need for better understanding of the ocean's role in the global carbon cycle and climate change, ocean acidification, ocean health and marine ecosystems. These changes in capability were approved by the NSB in May 2009.

The OOI facility incorporates marine infrastructure to observe the ocean over spatial and time scales relevant to a diverse and interconnected environment; it is organized operationally by subsystems. The major subsystems of the OOI Network are the Global Scale Nodes (GSN), the Regional Scale Nodes (RSN), the Coastal Scale Nodes (CSN), the integrating Cyberinfrastructure (CI), and the Education and Public Engagement (EPE) Infrastructure. Together these subsystems provide the unique capability to address high-level questions such as how the ocean responds to the two basic stressors on the planet – heat from above in the form of solar radiation, and heat from below in the form of geothermal heat. Another high-level question that will be addressed by the integrated capabilities of the OOI includes how climate change and

variability will influence diverse ocean ecosystems and how CO<sub>2</sub> uptake and ocean acidification are changing ocean properties.

The GSN supports air-sea, water-column, and seafloor sensors operating in remote, but scientifically important locations. The scientific goals are to provide observations of processes at critical high-latitude sites for which little or no time series data exist: air-sea interactions and gas exchange, the global carbon cycle, ocean acidification, and global geodynamics.

The RSN enables studies of water column, seafloor, and sub-seafloor processes using high-powered, high-bandwidth instrument arrays cabled to shore. The science drivers of the RSN are investigations into the structure of Earth's crust; seismicity, magmatism, and deformation across the Juan de Fuca Plate; water, heat, and chemistry fluxes of hydrothermal systems; benthic ecosystems; circulation and mixing at gyre boundaries; biogeochemistry and ecosystem dynamics.

The CSN supports long-term and high space-time resolution observations to understand the physics, chemistry, ecology, and climate science of key regions of the complex coastal ocean. The scientific goals include providing observations of phenomena such as: variability in complex eastern and western boundary current systems; coupling between coastal physics and biology, including nearshore fisheries and biological regime shifts; coastal carbon budgets; terrestrial-oceanic transport of carbon, nutrients, sediments, and fresh water; shelf, shelfbreak and slope exchanges; and coastal hazards such as storms, tsunamis, and hypoxia.

These three elements of the OOI marine infrastructure provide the unique new observations that when taken together with existing observations integrate to form the observing capability needed for the high-level science questions. For example, air-sea exchange at critical high latitude sites, where present current uncertainties in understanding are large and no sustained observatory capability exists, will be quantified by the GSN. Key western and eastern boundary current regimes that play a role in meridional (longitudinal) transports and are recipients of manifest climate signals from the poles and the equator will have comprehensive sampling be sampled by the CSN. The RSN will instrument the sea floor and observe its interaction with the slow, deep flow that completes the large-scale circulation pathways. Hypotheses about ecosystem change can be tested in contrasting regimes being sampled simultaneously: the high-latitude open ocean where strong climate signals are now seen, the benthic ocean that should be isolated from the immediacy of changes in surface fluxes, and the coastal ocean that displays the effects of shelf topography, exhibits strong water mass property gradients, and responds to the propagation of signals from polar and equatorial regimes as well as to basin scale processes.

The OOI's broadly distributed, multi-scale network of observing assets are bound together by an interactive CI backbone that will link the physical infrastructure elements, sensors, and data into a coherent system of systems. The CI will support the OOI science goals by providing a range of capabilities. The OOI CI will enable anyone—scientist, engineer, or educator—to have access to two-way interactivity, command and control, and resources (e.g., instruments, near-real-time data, historic data archives). The CI will allow mediation among different protocols, data streams, and derived data products. In accordance with the OOI data policy, calibrated and quality-controlled data will be made publicly available with minimal delay.

The OOI will also enable the effective translation of its capabilities and results into forms more readily usable by students, educators, workforce participants, and decision-makers via an education and public engagement (EPE) infrastructure. The EPE infrastructure will be designed in response to Education User Requirements that are closely related to standard ocean literacy principles. The requirements focus on the need for tools such as web-based interfaces, interactive visualization of data streams, simulations from simplified ocean models, merging with non-OOI databases, virtual participation in OOI science activities, a comprehensive database of education-relevant products with interfaces that are appropriate for cultural diversity, and social networking to enable collaborative workspaces.

The OOI promises to transform ocean sciences and open entirely new avenues of research, encourage the development and application of new sensors and technologies, provide new

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opportunities to convey the importance of the oceans to students and the general public, and provide essential information for decision-makers responsible for developing ocean policy.

## 1.2 Technical Description

The infrastructure provided to research scientists through the OOI includes the cables, buoys, deployment platforms, moorings and junction boxes, required power, and two-way data communication to support a wide variety of sensors at the sea surface, in the water column, and at or beneath the seafloor. A core suite of 49 sensor types chosen to best answer questions based on the science themes and distributed across the platforms is also included. The initiative also includes components such as unified project management, a CI for data capture, dissemination and archiving, and education and public awareness activities essential to the long-term success of ocean observatory science.

At completion, the OOI observatory system will have the capabilities to provide:

- Continuous observations over a range of time scales of seconds to decades
- Spatial measurements on scales ranging from millimeters to kilometers
- Sustained operations during storms and other severe conditions
- Real-time or near-real-time data as appropriate
- Two-way transmission of data and remote instrument control
- Power delivery to sensors between the sea surface and the seafloor
- The usage of gliders and autonomous underwater vehicles (AUVs) to expand the footprint of measurements at selected sites
- Facilities for instrument maintenance and calibration
- A data management system that makes data publicly available
- Infrastructure enabling effective education and public engagement activities
- Expansion of the system (space, power, bandwidth and technical support) to host new instruments and sensors.

The OOI facility will comprise networked marine infrastructure with integrating cyberinfrastructure and related education and public engagement infrastructure. The marine infrastructure will collect data over spatial and temporal scales relevant to a diverse and interconnected ocean environment through a loosely grouped set of costal, regional, and global scale nodes. These subsystems of the OOI provide platforms for multi-disciplinary observations and experiments:

1. CSN: New observing facilities in contrasting coastal boundary current regimes on the East and West Coasts of the U.S.
2. RSN: A regional electro-optical cabled network consisting of interconnected sites on the seafloor spanning multiple geological and oceanographic features and processes. The RSN is linked to the Coastal Endurance Array to provide power and bandwidth at two locations on that array.
3. GSN: Autonomous moored buoy platforms at four deep water, high-latitude locations are key to capturing large-scale ocean-atmosphere coupling where there has been little or no previous sustained coverage.

The subsystems are integrated through the CI, which provides connections to scientists and classroom, and allows the OOI to function as a single, secure, integrated network.

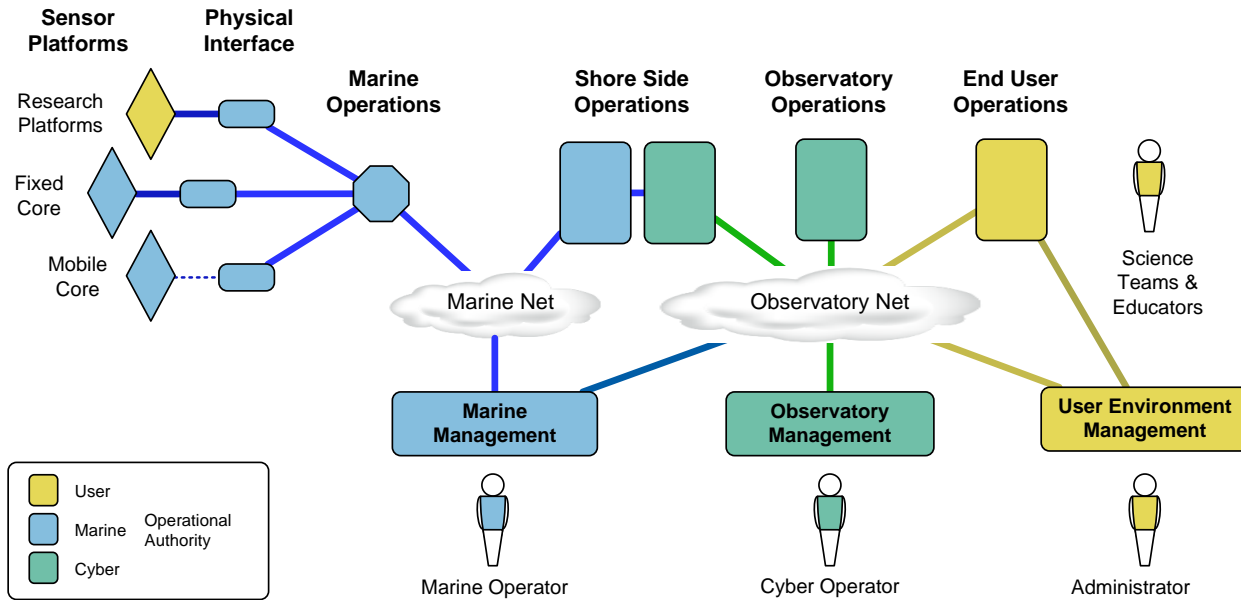


Figure 2. OOI Integrated Observatory.

Figure 2 shows the different operational domains that together form the OOI Integrated Observatory. The two marine observatories, RSN and CGSN, each represent one operational domain, both connected to the operational domain maintained by the CI IO, representing the Integrated Observatory to its users. The EPE infrastructure, once developed, will likely reside in the CI domain with interface agreements based on negotiation between the CI IO and the EPE IO. Most end users interacting with the integrated observatory, such as scientist and education teams, define their own operational domains. The lines and clouds in Figure 2 represent communication networks and the nodes represent physical sites with computation and storage resource, ranging from server clusters in data centers to embedded computing devices.

The OOI's marine infrastructure comprises mixed arrays of moorings and/or seafloor cables and will provide the capacity to make continuous observations at appropriate scales to investigate process studies of highest priority to the research community. These continuous observations will be augmented by the use of mobile platforms such as underwater gliders and AUVs to capture the spatial distribution of environmental variability around the fixed sites. The OOI construction investment will provide an initial set of core sensors tied to the science user requirements defined during the design process. Additional sensors will be added to the OOI observing platforms via experiments funded by the NSF or other research sponsors.

The CSN will provide sustained, adaptable access to investigate dynamic and heterogeneous processes in contrasting coastal systems. The infrastructure constructed will be a mix of "permanent" stations to document long-term variability and a "relocatable" mooring array targeted towards high frequency, spatially-variable environmental processes. The initial setting for the relocatable Pioneer Array is in the mid-Atlantic Bight off the southern coast of New England while the fixed coastal Endurance Array is off the Oregon and Washington coastline. The *OOI FND* provides additional details on the OOI's coastal-scale platforms. A combination of moorings and mobile platforms will be used; gliders will be deployed at Endurance and both gliders and AUVs at Pioneer.

The RSN will instrument two areas of the Juan de Fuca tectonic plate in the Northeast Pacific Ocean. The NEPTUNE (NorthEast Pacific Time-series Undersea Networked Experiments) Canada array is operating on the northern third of the same plate. Together these two systems will monitor the Juan de Fuca plate to allow the science community to conduct experiments.

Permanent electro-optical seafloor cables will connect instrumented seafloor nodes and will provide power (tens of kilowatts) and high bandwidth (data transfer rates of gigabits per second) for sensors, instruments, and underwater vehicles. This high power and bandwidth capability will allow experimental access from below, on the seafloor, within the water column, and across the air-sea interface. The FND provides additional details on the OOI's regional-scale assets.

The GSN comprise a set of highly capable interactive moored arrays combining different types of buoys focused on high latitude locations where surface and water column ocean data needs are greatest and air-sea interactions play a critical role in understanding ocean circulation. At three of the four sites GSN will provide a robust, self-powered, telemetering buoy providing ample data-return rates and improved power capacity. At the fourth site, the Gulf of Alaska, the surface buoy will be provided by the National Oceanographic and Atmospheric Administration (NOAA). Adjacent to each surface mooring, GSN will provide a hybrid profiler mooring. Each global scale node has a distributed footprint, occupying a triangular region, with two additional flanking moorings located about 50 km from the primary site and mobile assets (gliders) providing a broader context by resolving the mesoscale field in which the sites are embedded. The FND provides additional details on the OOI's global-scale assets.

The OOI CI will allow users, through its monitoring and control center element, to remotely control their instruments, to perform *in situ* experiments, to construct virtual observatories of suites of sensors specifically tailored to their scientific needs, and to access data in near-real time from anywhere in the system, thereby enabling adaptive sampling. The CI and information technology systems of the OOI, including the management of needs of the data users, data collectors and data system developers, will provide a common framework across the entirety of the OOI to ensure the OOI operates as a secure and integrated observatory. The CI acts as the network operations and control center for the OOI Network. The CI section of the FND provides additional detail on this OOI subsystem.

The EPE infrastructure will be designed in response to Education User Requirements. It is anticipated that the EPE infrastructure will provide tools for visualizations and simulations, enable virtual participation and mergers with other databases, and build a social networking capacity for EPE users.

The detailed FND describing each of the OOI subsystems is incorporated by reference into this PEP. These documents formed the basis for the baselines shown in Appendix A-4.

The OOI is designed to be a network that can be interconnected in various ways (through the CI) to provide different capabilities. The requirement that each set of nodes operates seamlessly within the network adds complexity above that encountered in a large-scale, interdependent system, but this yields an enhanced set of capabilities in spatial scale and sensor distribution not available without the integrated network. It is this capability that will allow many of the transformational experiments to be accomplished.

New sensors and nodes can be integrated into the expandable OOI Network; similarly, old experiments and sensors may be removed. This implies that the OOI will need to be designed to work in stages or phases following a set of strategies or policies in which decisions are made over time. This is accomplished in the five-year development of the CI system by having sequential releases that incrementally build the final capability.

## 2 Construction Approach

The NRC, in its report *Enabling Ocean Research in the 21<sup>st</sup> Century*, recommended that the approach to the OOI management structure should be one in which the day-to-day operation of different OOI elements is the responsibility of entities with appropriate scientific and technical expertise, while the role of the program management organization should be one of coordination, oversight, and fiscal and contract management. NSF signed a cooperative agreement with the Joint Oceanographic Institutions (JOI), now Ocean Leadership (OL), for the establishment of a project office to coordinate ocean observing activities in 2004; a new cooperative agreement was signed on September 1, 2009 for the 5 ½ year construction phase and two years of initial operations.

After a competitive bid process, OL made four subawards for development and implementation, one for the CI, two for the marine IOs, and one for EPE. The CI award was made to UCSD. One marine IO award was made to WHOI for the CGSN development and implementation. The other award for a marine IO was to the UW for the RSN infrastructure. The EPE IO was awarded to Rutgers University in March 2011.

OL coordinates the work of the IOs and provides a single point-of-contact to NSF. OL has implemented a system engineering and program management team with representatives from each subawardee. The OL project staff (Project Manager, System Engineer and Contracting Officer's Technical Representatives (COTRs)) use this team to coordinate the technical development, share best practices, and agree on interfaces, requirements, schedules and cost estimates. As the system develops, this team will be instrumental in resolving interface issues so that an integrated system is designed, constructed, and tested by learning from each group's experience.

### 2.1 Design and Development Strategy

OL's System Engineer worked with systems engineers at each of the IOs to define component requirements and interface requirements with the other IOs. *OOI Requirements* were updated and drove the final designs of the OOI elements developed by the IOs. All requirements were captured in a Dynamic Object Oriented Requirements System (DOORS) database and are under configuration control.

### 2.2 Construction and Installation Strategy

Each IO contracted with one or more entities for the construction and installation of its elements of the OOI, or constructs some elements of the system with internal capabilities. During the OOI planning phase detailed specifications were prepared and bids or information was received from industry to help validate the designs developed. In advance of construction, specific funding contracts have been awarded so that detailed engineering work on the particular components could be started. Each IO conducts periodic reviews with the suppliers and with Ocean Leadership for contact management and coordination. As construction begins, each physical OOI component will conduct integration testing prior to installation.

During the development of the final design, the sequencing of the acquisition of the major components was analyzed with the intent to reduce program risk. The planned profile is based on a technically limited approach to procuring the OOI. The critical path through the acquisition of the system is analyzed and described in a separate document, the Critical Path Analysis Report, and is re-evaluated for each major revision of the Integrated Master Schedule (IMS). Progress along this path is carefully monitored by the management systems and personnel.

## 2.3 Initial Operations Strategy and Commissioning

The OOI is a distributed network of marine nodes; some of which are cabled and some of which are tethered moorings that are autonomous, linking back to the network via wireless communications. The CI serves both to control the nodes and to capture the data returned from each sensor. The build plan for the system is set to deliver both infrastructure and sensors incrementally throughout the 5 1/2-year MREFC period. As each new component is installed and certified as operational, it will be transitioned to an initial operational status. The operation, maintenance and calibration of that component or infrastructure will then transition to operation and maintenance funding.

In the Commissioning Plan, there is a detailed explanation of Commissioning and Activation of components on the OOI. This document explains that commissioning is a multi-step process conducted to certify that a component is registered and meets the OOI interface standards. Land-based testing is done first to verify that the component meets the interface standards for deployment. Once deployed, another test is conducted which verifies that the sensor is operating properly. OOI will then assess that the component is operational and finish the commissioning process.

Each IO will be responsible for the commissioning of its element of the OOI, either directly or through its construction and installation contractor. Operation of the individual elements of the OOI will be the responsibility of the IOs for an initial period covered in their subawards.

An integrated system test will be conducted to ensure that all marine nodes connected through the CI can act as a single integrated system. CI functionality will also be verified at the system level. The OOI network will then transition to operations in accordance with the Transition to Operation plan, an appendix in the *OOI Operations and Maintenance Plan*. After successful completion of the operational readiness testing, the OOI will be presented to OL for acceptance. Operation from that point forward will be in accordance with the *OOI Operations and Maintenance Plan*.

## 3 Project Management

The OOI project management approach has been organized to conform to MREFC guidance contained in the various NSF management and oversight documents while providing a structure that will efficiently deliver the required elements of the OOI. The Program Director for Ocean Observing Activities at OL has overall responsibility for the oversight of the OOI project. In addition, OL has appointed COTRs who have overall responsibility for the oversight of each of the IOs.

### 3.1 Management and Oversight Structure

Construction of the OOI facility is managed through a cooperative agreement between the NSF and OL, a not-for-profit corporation of member institutions (universities or other nonprofit institutions, organizations, or governmental entities involved in oceanographic sciences or related fields and that are organized for educational or scientific purposes). OL was formed in 2007 by the merger of two longstanding ocean-focused not-for-profit corporations, Joint Oceanographic Institutions (JOI) and the Consortium for Oceanographic Research and Education. Ocean Leadership is a 501(c) 3 limited liability corporation constituted under the laws of the State of Delaware. OL membership includes both voting and non-voting members as well as non-voting associate members and affiliates. A Board of Trustees, which is elected by the voting members, has oversight responsibility for the corporation and its programmatic commitments.

OL's Program Director for Ocean Observing Activities is the Principal Investigator (PI) on the cooperative agreement. NSF has approval authority over candidates for this position, which has been filled by a doctoral-level scientist with research experience and experience in constructing and managing complex science facilities. The Program Director for Ocean Observing Activities holds primary responsibility for execution of the program and is considered a single point of authority by the NSF. The Program Director for Ocean Observing Activities directly or indirectly supervises all OOI Program Office personnel and holds or delegates technical approval authority on all subawards made from the OOI cooperative agreement.

The primary development and implementation of the OOI facility is being carried out by four competitively selected IOs, which are led by research or educational institutions. The existing IOs are responsible for the CI, RSN, CGSN, and EPE; they were awarded to the UCSD and partners, UW, WHOI and partners, and Rutgers, respectively. Authority and responsibility is transferred to the IO institutions via corporate subawards from OL, which flows down required clauses from the parent cooperative agreement and cooperative support agreements with NSF. The Program Director for Ocean Observing Activities and NSF have approval authority over candidates for the Principal Investigator (PI) and other key personnel of each IO subaward as stipulated in the cooperative agreement; the IO PIs hold responsibility and authority for work carried out under the subaward or convey it to their staff. They hold or delegate responsibility for technical approval of work carried out under acquisitions made from the IO subawards.

The OOI Program Office is responsible for integrating the work of the IOs and other subawardees developing the OOI facility, guiding and monitoring their progress and compliance with annual work plans and budgets, and assuring and issuing modifications to the IO subawards as necessary for the implementation of the program. The OOI Program Office is responsible for systems integration of the OOI facility, overall compliance with user requirements, adjudication between IOs, formal reporting to the NSF, and representing the program with a single voice to the NSF and the scientific community. The Program Director for Ocean Observing Activities and IO PIs form the management team of the program and generally makes decisions by consensus with input from the community advisory structure; however, the Program Director for Ocean Observing Activities has the authority and responsibility to make executive decisions in consultation with the NSF when necessary.

PMO and IO organizational charts are attached in Appendix A-5.

### 3.2 Community Advisory Structure

Ocean Leadership manages the planning and construction of the OOI with comprehensive science advice from an advisory structure broadly based in the oceanographic research community. The advisory structure will play a leading role in setting the strategic direction of the facility and will also help devise facility governance policies, participate in decisions on change control, serve as a consultative body of experts for specific questions as implementation proceeds, and provide guidance to ensure that the OOI facility is aligned with the research needs and interests of the science and education communities. The advisory structure will also develop partnerships with other organized ocean and earth science research programs, potential sponsoring agencies, and other entities.

Prior to the identification of IOs and the establishment of an adequate science and engineering management staff in the OOI Program Office, program planning was overseen by an initial advisory structure comprised of approximately 80 science community researchers representing the potential user groups of the eventual facility. This body of volunteers, supported by the OOI Program Office, was largely responsible for development of the CND and the successful completion of CDR. The Program Office worked with the top-level committee from the initial advisory structure, the Observatory Steering Committee, to advise and guide the preparation of the Preliminary Network Design carried out largely by the OOI IOs. In some cases, it was necessary to name interim membership to this committee due to conflicts of interest (overlap) with the staff of the Implementing Organizations.

Since the beginning of significant MREFC capital investment, the planning and development function has been carried out by a fiscally and contractually accountable project management structure. Guidance from an advisory structure appropriate for the construction phase will be sought and incorporated at multiple levels. The construction-phase advisory structure is led by a Program Advisory Committee (PAC). The PAC provides overall strategic planning and science leadership for the OOI facility, is the primary consultative group for the Program Director for Ocean Observing Activities and management team, and is one of the main conduits for community input into the implementation and management of the OOI facility. The PAC will assess community responsiveness to the transformative capabilities of the OOI facility and will provide strategic planning on science programs catalyzed by the OOI. The PAC is populated by individuals representing broad expertise in relevant ocean science disciplines and having significant leadership skills and management experience. The PAC met during the Pilot Period to receive updates on program execution, formulate guidance on the scientific direction of the facility, and consider specific advisory requests from program management. The PAC may also convene via web-enabled meeting utilities and has a designated work space within the project collaboration site, so that the committee can remain in touch with project developments and provide timely perspectives and advice to the Program Office.

PAC members also may serve as a resource pool for specific roles during MREFC execution. For example, PAC representation may be requested at higher level Change Control Boards described in the *OOI Configuration Management Plan*, and PAC members will be solicited for membership on the Observatory Advisory Team (OAT) described in the *OOI Operations and Maintenance Plan*.

The PAC formally reports to the Executive Committee of the Board of Trustees of Ocean Leadership. This reporting structure assures both that the ocean research and education community, as represented by the membership of the Consortium for Ocean Leadership, is kept informed of the planning and construction of this emerging new platform, and that the program's community advisors have access to the top level of the performing organization. The liaison function is maintained by inclusion of one Ocean Leadership trustee in the PAC membership. The initial membership of the PAC was invited from a list of candidate names provided by a nominating committee of community leaders in consultation with NSF's Ocean Sciences Division. The initial committee membership avoided qualified individuals whose main academic affiliation was with an IO institution, in order to assure unconflicted membership. The Chair was invited by the President and CEO of Ocean Leadership. The committee began its activities in September 2008 and has provided recommendations to the OOI leadership through direct meetings and teleconferences since that time. Current membership is given in Appendix A-3.

In consultation with and within available resources provided by Ocean Leadership's Program Director for Ocean Observing Activities, the PAC may form subcommittees or *ad hoc* advisory groups as appropriate during the construction of the OOI facility. This flexibility ensures that the advisory structure is adaptable to changing program needs, and that funds and human resources allocated for supporting the program's advisory functions are used effectively.

### 3.3 Interagency and International Partnerships

The construction of the OOI facility as described in the FND does not require interagency or international partnerships, and no formal fiscally-binding agreements are in place. OOI will, however, provide a foundation for the foundation of numerous, substantial partnerships and synergistic collaborations.

Within NSF programs, the Monterey Accelerated Research System (MARS) cable system was funded by the Ocean Sciences Division and designed and constructed by a consortium led by the Monterey Bay Aquarium Research Institute (MBARI). Using designs that were intended as prototypes for the OOI, MARS deployed an 8-port science node at 891 m depth on a 52 km submarine cable that has been populated with sensor experiments since late 2008. In addition to equipment and design testing, MARS serves as a test bed for operational procedures and policies and interacting with the user community.

Elsewhere within the Geosciences Directorate, data from the EarthScope project, which is devoted to understanding the deformation and evolution of the North American continent and underlying mantle, will dovetail with observations from OOI's RSN on the Juan de Fuca tectonic plate, which controls the deformation of the Pacific Northwest and the earthquake rupture along the Cascadia Subduction Zone. The Directorate for Biological Sciences' National Ecological Observing Network (NEON) will use distributed sensors to understand complex, diverse land habitats in the U.S. and will monitor baseline environmental parameters such as temperature, pollutant and trace concentrations, aerosols, and biological productivity on land and in the atmosphere that can tie in OOI's observations. The NSF Office of Cyberinfrastructure is committed to empowering all aspects of computation and networking necessary to implement many of the developing data-driven environmental programs, and is particularly interested in exploring commonalities among these three large distributed sensor network facilities. The OOI CI will facilitate these objectives by providing open access to all users to the OOI network's real-time data as well as data in third-party archives to support analyses and modeling.

The Massachusetts Technology Collaborative, an independent economic development organization chartered by the Commonwealth of Massachusetts, has provided \$2 million in state funding toward implementation of the OOI's Pioneer Array by the WHOI partnership. Future additional support is under consideration. Corporate partnerships will be sought at a variety of levels.

The mission agencies NOAA (National Oceanographic and Atmospheric Administration) and NASA (National Aeronautics and Space Administration) will also develop partnerships with the OOI in a number of ways. NOAA is the lead agency for the Integrated Ocean Observing System (IOOS), an operationally oriented approach to ocean observing intended to serve societal and national needs. The OOI, NSF's contribution to IOOS, will directly contribute to IOOS through the development of novel observing, data assimilation, and data management techniques as well as by advancing understanding of ocean phenomena upon which accurate predictions and forecasts important to society depend. Through NOAA support, the cyberinfrastructures for OOI and IOOS will converge to enhance interoperability of these two national systems. At this time, collaboration efforts are focused on 1) adoption of common middleware to aggregate datasets from remote sources and provide services for these datasets including search, format translation, graphing and time standardization; and 2) adoption of a common web server to provide metadata and data access for scientific datasets, building on established technologies and protocols.

NASA is committed to studying climate change and life on other planets. By illuminating unexplored ocean environments, the OOI will be involved in cutting-edge science on both fronts. NASA's satellite programs will be an important complement to all ocean observing systems, including the OOI Network. Satellite observations provide oceanographers with a unique pseudo-synoptic, global perspective of the ocean and will provide context for, and in some cases allow for, extrapolation of OOI Network observations. Observations from satellites remain primarily limited to measuring a limited suite of properties at the air-sea interface and in the uppermost ocean. The OOI Network will provide the larger suite of subsurface time series data that will benefit calibration efforts of satellite data streams and enable "in depth" studies of ecosystem processes. A partnership with NASA's Tracking Data Relay Satellite System is being sought through NSF for use in large-volume data collection from coastal and global buoys.

The U.S. Navy has contributed a great deal to the technologies and methodologies being integrated into the OOI. Examples include the development of mobile platforms (AUVs and gliders), research ships, and command/control of remote systems. The OOI, in turn, will provide data and knowledge essential to operations in the world ocean. The Navy's historical responsibility for ensuring freedom of the seas will depend increasingly upon access to oceanographic data, information, and global predictions. This has led to the development of the Littoral Battlespace Sensing, Fusion and Integration, Unmanned Undersea Vehicle program to transition observatory technologies into relocatable networks that will support the Pacific and Atlantic fleets.

Strong formal and informal international connections have evolved over the past decade, most demonstrably with Canada. The Canadian initiatives, NEPTUNE Canada and the associated VENUS (Victoria Experimental Network Under the Sea) program, have implemented cabled observatories on regional and coastal scales off North America. The OOI's RSN have been designed to complement the NEPTUNE Canada geometry in providing coverage of the Juan de Fuca plate, and the Program Office has regular technical and strategic coordination with the NEPTUNE Canada implementation group. In addition, the Consortium for Ocean Leadership and Ocean Networks Canada implemented a Memorandum of Understanding in March 2010.

The oceanographic observing legacy in the Gulf of Alaska is a rich one, with the historical lead in the area by the Canadians and long-term activity by NOAA's Pacific Marine Environmental Laboratory (PMEL). The Fisheries and Oceans Canada (DFO) Institute of Ocean Sciences (IOS) in British Columbia has made observations in the Gulf of Alaska at the Station Papa site for decades. At Station Papa, CGSN will collaborate with NOAA PMEL in the maintenance of the long-term Station Papa global site. NOAA PMEL will continue to deploy and maintain a surface mooring while CGSN deploys and maintains the hybrid profiler mooring (a mooring supporting a winched profiler to sample the upper ocean and a deep wire-crawler profiler to sample the deeper depths), the two flanking moorings, and the gliders tasked to the Papa site. Ongoing DFO IOS cruises to the site will provide additional ship-based sampling opportunities and are potentially a resource to assist in glider deployments. CGSN is working with NOAA PMEL and DFO IOS to catalyze and coordinate scientific sampling and programs at and around Station Papa in a continuing effort to sustain and expand observations and understanding in the region.

The Irminger Sea site also has a context of past and ongoing observations and is a location that has been used to track and identify long-term trends in ocean properties associated with climate variability and change. CGSN has engaged the EuroSITES (European ocean time series group) in discussions about their plans for continuing observations by Dutch (NIOZ, Nederlands Instituut voor Onderzoek der Zee) and German (IfMK, Institut für Meereskunde und der Universität Kiel) institutions in the Irminger Sea region. Most recently, U.S. and European oceanographers have come together to develop plans for the Overturning in the Subpolar North Atlantic Program (OSNAP), and CGSN is participating in these planning sessions to coordinate sampling at the OOI Irminger Sea site with OSNAP and to examine potential logistical synergies.

The two OOI global sites in the Southern Hemisphere provide the opportunity for scientific and logistical collaboration with Chilean and Argentine oceanographers and oceanographic institutions. The CGSN team is exploring collaborations and capacity building for ocean observing in both Chile and Argentina. In Chile, the Center for Oceanographic Research in the eastern South Pacific (COPAS), at the University of Concepcion, has expressed interest in establishing ocean observations inshore of the OOI Southern Ocean site. There is a COPAS proposal for a line of subsurface moorings inshore of the 55°S Southern Ocean site and related cruises would enhance and complement the observing capabilities and science there, providing an open ocean to coastal ocean connectivity similar to OOI infrastructure in the Northeastern Pacific Ocean. The potential for this was strengthened in January 2009 when WHOI renewed a MOU with the University of Concepcion and initial discussions on coordination of logistics, support facilities, and cross-training of personnel began during a visit by the CGSN PI to the University of Concepcion. At the same time, the Chilean Navy Hydrographic and Oceanographic Service (SHOA), who have collaborated with the CGSN PI on a long-term mooring off northern Chile, expressed interest in and support of the work at 55°S and asked for a return visit to brief the Director of SHOA. SHOA is taking a lead in the construction of a new Chilean research vessel. Cruise planning for the 55°S Southern Ocean site has focused on the use of the NSF Polar Programs staging facility in Punta Arenas.

A visit to an ocean observing workshop in Buenos Aires, Argentina in April 2010 by the OOI Program Director (Cowles) and the CGSN PI initiated discussions with colleagues in Argentina about a wide range of possible collaborations with Argentine ocean science agencies and the Argentine fisheries laboratory in Mar del Plata, Argentina. As in Chile, there is high interest in collaboration on sampling to link Argentine coastal observing efforts to the offshore Argentine Basin site. Development of plans for logistics for both sites and further discussion of scientific collaborations are planned in 2011 with both Chilean and Argentine institutions. Another link for

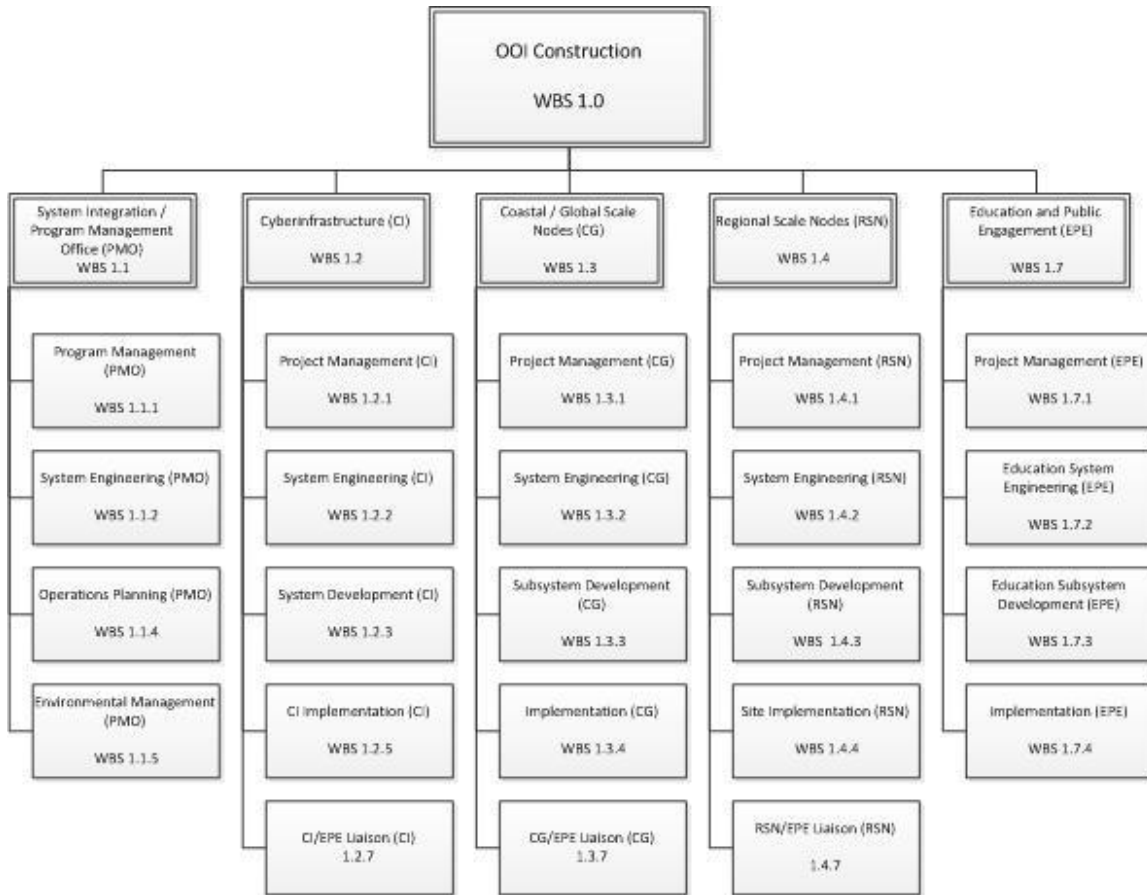
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scientific collaboration at the Argentine Basin is with the U.K. Geotraces program and the synergies between high resolution temporal sampling at the Argentine Basin site (42°S, 42°W) and the spatial sampling along the Geotraces A10 shipboard sampling line across the South Atlantic at 40°S.

At the multinational level, the Group on Earth Observations (GEO) includes 71 member countries, the European Commission, and 46 participating organizations working together to coordinate a Global Earth Observation System of Systems from existing or new Earth-observing systems. This global community is focused on a future wherein decisions and actions for the benefit of mankind are informed by coordinated, comprehensive, and sustained Earth observations and information. The OOI Network’s advanced capabilities can play a critical role in supplying data, information technology, and knowledge for this global effort.

**3.4 Work Breakdown Structure (MREFC Construction)**

The Work Breakdown Structure (WBS) provides the framework for the organization of the OOI project effort and defines the work as related to the project objectives, scope of work, and deliverables. It is an indented list of all the activities, products, components, software, and services to be furnished by Ocean Leadership and the IOs. It is used as a common base for all project planning, phasing, scheduling, budgeting, cost accounting, and reporting of performance during the life of the project.



*Figure 3. OOI Work Breakdown Structure at level 3*

The integrated baseline WBS has been developed with the IOs and includes more than 3,000 Summary, Control Account, Work Packages, and Tasks and is shown in Figure 3 at level 3. The top levels of the WBS are structured such that each IO's work activities can be reported both on a

stand-alone basis and as part of the overall integrated OOI Network. As the detail design engineering effort progresses additional tasks may be identified in the lower levels and the WBS updated. The April 2011 updated project schedule includes over 20,000 lines of schedule information including the integration of WBS branch 2.0 Operations and Maintenance. Any changes to the WBS are subject to the *OOI Configuration Management Plan (CMP)* and the *OOI Earned Value Management Plan*.

### 3.5 Cost and Schedule Management

Cost and schedule management is conducted using the OOI Earned Value Management System (EVMS). The key EVMS data components include:

- Work Breakdown Structure (WBS)
- Organizational Breakdown Structure (OBS)
- Control Accounts
- Work Packages
- Integrated Master Schedule (IMS)
- Direct & Indirect Rates
- Performance Measurement Baseline (PMB)
- Labor, Material & ODC Actual Costs

The source system for the WBS and the IMS is Microsoft Project. The IMS is comprised of the fully resource loaded OL and IO detailed schedules and the cross project interdependencies. The schedules also include the data necessary to integrate with Cobra, the EVM engine.

The source system for the PMB and all OOI direct and indirect budgeting rates is Cost Book, an OL in-house budgeting database tool. For each work package, Microsoft Project provides Cost Book the start date, duration and resource quantities so that Cost Book can apply budgetary rates and derive the fully burdened PMB at the work package level by resource.

The OOI EVMS Earned Value component is Deltek Cobra. Cobra takes receipt of the fully burdened PMB (Budgeted Cost of Work Scheduled) from Cost Book, monthly actual costs (Actual Cost of Work Performed) from the respective IO and OL accounting systems and monthly schedule status from Microsoft Project, from which Cobra calculates the Earned Value (Budgeted Cost of Work Performed). Cobra uses these components (BCWS, ACWP and BCWP) to calculate standard periodic and cumulative EV variances (e.g. Schedule Variance, Cost Variance) and performance indices (e.g., SPI, CPI, TCPI) which are used to track the progress of the program.

The OOI EVMS reporting and analysis tool is Deltek wInsight. It takes receipt of fully processed EV data from Cobra. wInsight presents EV performance indices in multiple graphical formats. It also compares variances to predefined thresholds and represents the results in simple red, yellow and green indicators. Standard ANSI cost performance reports such as the Format 1 and Format 5 which OOI submits to the NSF on a monthly basis are available from within wInsight.

## Project Execution Plan

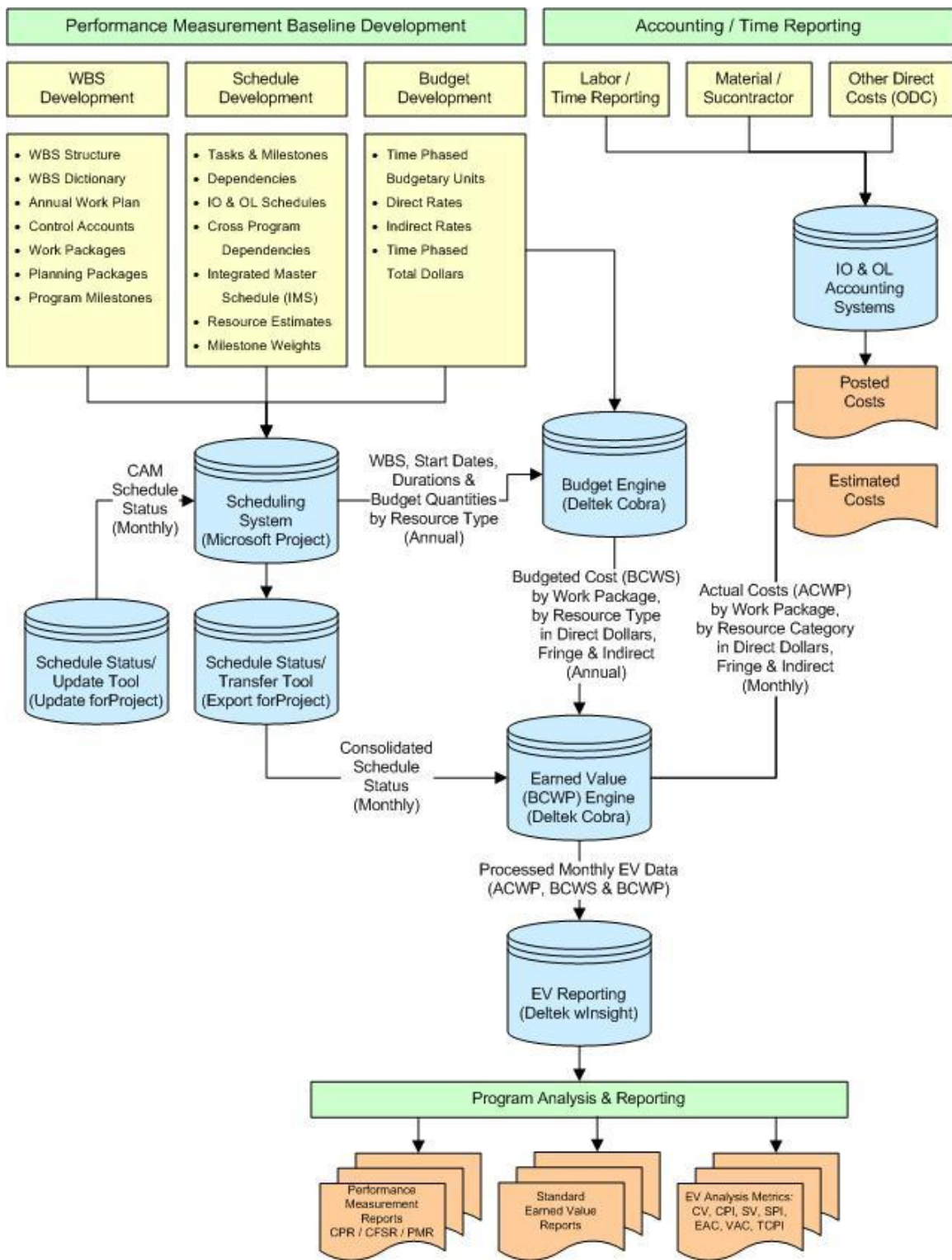


Figure 4, OOI Earned Value Management Infrastructure, describes the interaction of these tools and key EVMS data components.

### 3.6 Financial Management

Ocean Leadership has acquired and installed Navision business solutions as its formal project accounting system. This system allows Ocean Leadership to track labor hours and other costs by WBS and meets ANSI/EIA 748 requirements. The system is compatible with the EVMS system that has been selected and standard processes are in place for solid financial controls.

IOs are required to have financial systems that meet Generally Accepted Accounting Principles (GAAP) standards and financial processes in place to meet Office of Management and Budget Circulars A-133 and A-122 guidance and be subject to annual audits. Each of the IOs has accounting systems that range from robust to adequate in reporting capabilities. The systems are GAAP compliant and provide basic labor and expenditures tracking for the program. These systems provide the formal invoicing of the cost incurred by the IOs, which Ocean Leadership combines with its expenses and then submits to NSF.

Procedures and processes have been implemented at each institution to ensure proper tracking of labor, sub-contract, material costs, and assets by WBS. Periodic Financial Status Reports, Close-out Reports, and invoices are used to monitor and analyze progress and provide a basis for reconciling EVMS reports to actual costs.

### 3.7 Configuration Management and Change Control

The *OOI Configuration Management Plan* (CMP) has been developed to formally establish the activities, responsibilities, processes and methods used to maintain the configuration of the OOI facility and to manage changes to the scope and design of the facility (CMP, incorporated by reference). The plan provides the background information and outlines the approach to be followed to control the use and modification of the Technical Data Package (TDP) required for the design, manufacture, and deployment of the OOI facility. The plan provides details as to how program documents shall be prepared, configuration management requirements for use, required TDP quality assurance procedures and the operation of the design Change Control Boards.

The CMP addresses which key documents are under configuration control, what drawing standards, file formats, and applications are used, naming and numbering conventions, and conventions for hardware documentation. The CMP defines baselines and change classes, and outlines how engineering changes are requested, assessed, and considered. The CMP establishes change control boards at the IO level, system level, and program level, and defines which board level considers what type of change depending on its impact. The CMP defines membership of the change control boards and defines which changes must be forwarded to the NSF for approval.

The Document Management System (DMS) is described in the plan and an overview of the application and the roles of users and managers is also provided. All of the collaboration tools and configuration management tools and applications are described, and the plan details how they are used in the OOI. These tools have advanced features which provide configured enforcement of configuration control policies and procedures as well as provide modification tracking, tracing and security of changes to any controlled information.

#### 3.7.1 Requirements Management

The Executive Steering Committee, later known as the Observatories Steering Committee, developed an *OOI Science Plan* in May 2005. The plan was further refined and documented in *OOI Scientific Objectives and Network Design: A Closer Look in 2007*. From this and the outputs of the past decade's numerous community workshops, the OOI Program Office has developed the OOI requirements set. This set of requirements was manifest in three documents at the preliminary design level, the *OOI Science User Requirements* (SUR), the *OOI Systems Requirements Document* (SRD) and the *Interface Requirements Agreement* (IRA). At PDR the requirements from those sets were migrated to the Dynamic Object Oriented Requirements System (DOORS) to provide configuration control and requirements management. This set of requirements was developed to guide the IOs in the development of their preliminary designs.

This includes some higher-level system requirements as well as a set of requirements for the CI. The SUR represent ten exemplar science questions representative of the science themes that the OOI is being built to address. These themes are a distillation of the science that the oceanographic community, through a series of meetings and workshops, has recommended that a networked ocean observatory have the ability to address. An important requirement driving the OOI design is that the power and bandwidth provided in each element of the infrastructure be expandable/extendable so that during the 25-year planned life of the system additional science questions can be addressed.

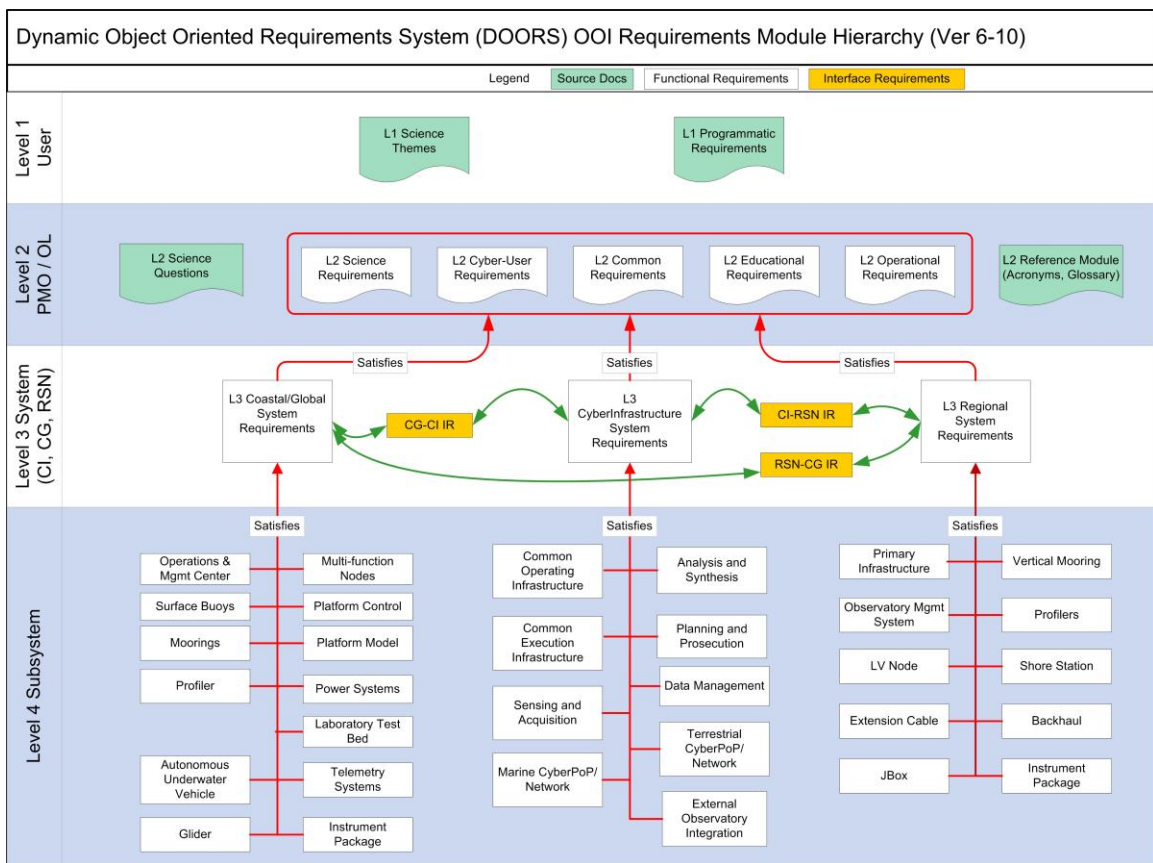
As the program matured and additional systems engineering was performed, the requirements process was fully engaged and full requirements hierarchy was developed, and the elicitation and derivation of a full final set of high-level requirements was undertaken and completed for the final design. The science and engineering teams developed full traceability in the requirements structure from the science plan through the traceability matrices down to the measurements required of the OOI. These requirements are grouped into the OOI Science Requirements set.

An important element of system-level stakeholder engagement is the process of eliciting user requirements from representatives of the science and education user communities through formal workshops, technical interchange meetings, or systems engineering work sessions. Stakeholders who have an interest or stake in the outcome of the project have been identified and their needs are the driving force behind the OOI Cyber User Requirements. The primary stakeholders are scientists, modelers, and educators that use the system for a variety of reasons. A series of formal workshops have been conducted to elicit stakeholder requirements.

In order to achieve this goal, IO engineers, scientists and workshop participants constructed a wide range of use scenarios (i.e., operational concepts) and concepts of operations incorporating representative suites of sensors and platforms in close collaboration with a representative group of domain users. Each of the Formal Workshops was crafted to have a particular technical emphasis, and the Cyber User Requirements, System Requirements and Education and Public Engagement Requirements were the products of this branch of the requirements development process. The preliminary SRD was the basis for the system requirements both in the CI and Marine IO domains.

The detailed System requirements have been derived and documented by each IO's system engineers in collaboration with Ocean Leadership's System Engineer. The full set of requirements, including subsystems, now resides in the DOORS database as a unified set.

## Project Execution Plan



*Figure 5. OOI Requirements Module Hierarchy*

A current pictorial view of the OOI DOORS Requirements Module structure and linkage paths is maintained in 1120-00000 Requirements Module Hierarchy. The Level 2, Level 3, and Level 4 requirements in DOORS are the basis for the OOI design and serve as the reference to validate and verify the design through the test and commissioning process.

OOI follows a standard systems-engineering approach for setting requirements at successive levels of detail, maintaining traceable relationships between them, and testing them appropriately. The relationships between science requirements, system requirements (at all levels), and conformance tests, as well as the systems engineering and configuration management policies are maintained and enforced using the DOORS application.

### 3.7.2 Interface Management

The OOI design is an integrated, interactive system of systems with major systems covering coastal, regional, and global spatial scales connected via an integrated cyberinfrastructure. The systems will also be linked by common instrument interface types and infrastructure components. The interfaces between systems and users have been grouped into four categories covering three types of interfaces. The interfaces are described in general terms as physical, logical or programmatic. Any of the systems or users may interact through the three types. The groupings of users and systems follow the matrix below:

- CI to CG
- CI to RSN
- CI to EPE
- CG to RSN

The CI "User" requirements were developed with the science and education communities through a series of user workshops convened to ensure utility and relevance of its services. The interface

to the community is implicit in the requirements and no "agreement" document was created.

User involvement in the development of CI services is assured through the development strategy selected for the CI system. The CI Project Execution Plan, Section 2.2 (CI PEP, Document # 2010-00001, incorporated by reference) documents the Project Life Cycle and the Spiral Development Model. This method was selected to provide the strongest emphasis on risk identification in the early stages of development for projects where the user needs and enterprise requirements are not fully known at the start of the project and must evolve as the community better understands the capabilities of the maturing system.

The spiral development process uncovers functional, performance, and interface defects early in the life cycle where they can be removed in a cost effective manner. There will be four major CI releases of incrementally increasing capability. Each release is the end product of a development spiral. Each spiral covers the activities of inception, elaboration, construction and transition. The CI PEP states that the key activities during the inception phase are requirements discovery and conceptual architecture definition based on negotiation with and among stakeholders. This culminates in the Life Cycle Objectives anchor point milestone that produces stakeholder commitment to building the architecture. Stakeholders will also be involved in the subsequent Life Cycle Architecture and Initial Operating Capabilities reviews. At least four times during the construction of the OOI there will be official consideration of end user feedback in the context of a major milestone review.

Systems engineers from each IO meet regularly with the OOI System Engineer to integrate the subsystems, and develop and document appropriate interface specifications between OOI elements. The preliminary engineering design effort produced a comprehensive set of subsystem interface requirements, identified a core set of instruments and interface(s), and levied appropriate requirements on instrument designs to ensure non-interference with the infrastructure as well as other instruments. The *OOI Interface Requirements Agreements* (IRA) were developed for Preliminary Design stage and were applicable to all OOI system and subsystem hardware, software technical data, designs, and software code, and hardware developed or delivered as part of the OOI MREFC project. The IRA defined the roles, responsibilities, and authority of IOs in planning, design, development, and implementation phases relative to the interaction of subsystems and delineation of responsibilities and obligations.

These preliminary level agreements were captured in the IRA document and were the basis for developing the final design, including the detail design engineering and technical data package. As the requirements maturation and derivation was performed along with the detailed design engineering, the physical and logical "technical" requirements were migrated into the DOORS database so they could be properly linked and allocated with full requirements set. The remaining items were programmatic and are specifically statements of responsibility between the implementing organizations relative to cost and schedule. These "responsibilities" have been integrated into the requirements database as well, and can be exported as Interface Requirements sets.

The product of these requirements and agreements are now imbedded in the foundation of the WBS, Schedule, Cost Book and TDP, providing logical and physical structure to the design, as well as programmatic responsibility. These controlled documents fall under the systems engineering and configuration management policies and are maintained and enforced under the program. The requirements have been and are used to develop Interface Control Documents (ICDs) as part of the Technical Data Package. The ICD development process is detailed in the *OOI Systems Engineering Management Plan* (SEMP), document number 1100-00000.

### 3.8 Quality Assurance and Quality Control

OOI Quality Assurance is documented in the *OOI Quality Assurance and Quality Control Plan*. The responsibility and guidance for the overall quality assurance of the OOI is coordinated through the QA Manager for Ocean Observing Activities at OL reports directly to the OL President. Each of the IOs has submitted its own QA Plan and will implement quality assurance and quality control for hardware, software and telecommunications systems that comprise the OOI. The Project Management Office COTRs coordinate with the OOI QA Manager to oversee QA activities within the IO facilities and their subcontractor organizations where the OOI hardware and software components, systems and subsystems will be received, built, inspected, integrated, tested and accepted before deployment. The OOI Quality Assurance Manager or the COTRs may choose to audit selected major suppliers.

The OL Quality Plan specifies the OL QA organization, its goals and objectives and procedures for key aspects of the OOI Quality Program including QA during system design, construction, testing and for recording inspections and tests, customer satisfaction processes and for QA audits. Detailed QA procedures and procedures to be evaluated include the following:

- Quality management system implementation
- Documentation
- Management commitment
- Customer focus
- Responsibility and authority
- Management review
- Engineering Documentation Control
- Engineering Change Order Approval
- Design and Assembly Documentation Requirements
- Manufacturing Practices Specifications
- Material Tracking Procedures
- Testing and Acceptance Requirements
- Software Revision Control and Documentation Procedures
- Identification and traceability
- Inspection at subcontractor facilities
- Purchasing processes
- Verification of purchased products
- Control of non-conforming product
- Data analysis
- Continual improvement
- Corrective action

Ocean Leadership has hired a Quality Assurance Manager to assist with and perform Quality Management functions on the OOI project. The Quality Assurance Manager provides guidance to the COTRs, schedules and conducts quality audits of IO and subcontractor facilities, assists with evaluation of the IO Quality Plans and procedures and provides quality performance metrics to OL staff on a routine basis.

### 3.9 Risk and Opportunity Management

A formal risk and opportunity management process has been implemented for the OOI. This process is described in the *OOI Risk and Opportunity Management Plan*, which is incorporated into this PEP by reference. The ROMP follows an accepted standard risk and opportunity management approach of planning, identifying potential risks and opportunities, assessment, analysis and developing mitigation, enhancement strategies or other handling techniques. Risk and opportunity management is also imbedded in the *Cost Estimating Plan* (CEP) and *Systems Engineering Management Plan* (SEMP) and integrated in engineering design process. The OOI risk and opportunity management plan provides substance for and formalizes the Risk and

Opportunity Management Process, in the International Council on Systems Engineering (INCOSE) Systems Engineering Handbook, Version 3.0, June 2006, which in turn formalizes an adoption of the ISO/IEC/IEEE 16085 Risk Management standard.

Risk is an undesirable situation or circumstance, generally associated with uncertainties, that has both a likelihood of occurring and a potential detrimental consequence to the project. On the other hand, opportunities are desirable situations or circumstances, also with a likelihood of occurring and a potential benefit to the project. Risk and opportunity management is an organized process to effectively reduce such risks and/or enhance opportunities to achieve project goals. The risk and opportunity management process includes planning, identification, assessment, analysis, and handling of potential risks and opportunities, implementation of risk or opportunity handling options, and a monitoring effort to track the effectiveness of the risk and opportunity management process. The goal of risk and opportunity management is to define methods or identify alternatives that mitigate or minimize risks to an acceptable level and enhance the possibility of taking advantage of opportunities.

Risk and opportunity management consists of five separate, but interrelated activities:

- Planning
- Identification
- Assessment
- Analysis
- Handling

In one sense, everyone involved in the OOI project contributes to risk and opportunity management; i.e., all project participants are responsible for exposing risk items within their purview so that the negative impact of such risks can be minimized and positive impacts can be captured, but the organization that deals with risk on a regular basis are the Risk and Opportunity Management Boards (ROMBs) and a group of Risk Facilitators.

There is a ROMB at the Project Management Office level and a ROMB for three of the Implementing Organizations (IOs) on the OOI project. The ROMBs are led by the Senior Project Manager for the base organization, as the Chair of the ROMB, but a Risk Facilitator coordinates all activities. Mandatory and adjunct members of the ROMBs may voice their opinions and provide advice, but the Chair is responsible for any and all final decisions. The Risk Facilitators serve as the secretaries of the ROMBs with responsibility for hands-on maintenance of the Risk Register (database), generating the necessary reports to support ROMB meetings, tracking the current status of each risk item, and tracking the status of risk handling activities against specific risk items.

The OOI (System) level ROMB is attended by each of the IO Risk Facilitators to ensure that any risks that the IOs need PMO direction, support or contingency funding for are presented with all necessary information to the top level ROMB. Regular membership on each of the ROMBs embraces the various managers and leads within OL and each IO, including IO Technical Leadership Teams, IO Chief Systems Engineer, IO Chief Architect, System Development Managers, Lead Software Engineers, Lead Test Engineers, Quality Managers, Configuration Managers, and Integrated Product Team (IPT) Leads. Also, there will be occasions when additional technical experts and members of the PMO or IO technical staff may be asked to attend ROMB meetings, or become ad-hoc members, to effectively evaluate or address risk issues.

There are four risk/opportunity handling techniques, or options as part of the standard process and in the OOI *Risk and Opportunity Management Plan*. Risk control or mitigation actively manages the risk in a manner that reduces the likelihood of its occurrence and/or minimizes the risk's effect on the project; or for an opportunity, control or enhancement actively manages efforts to increase its likelihood of realization or enhance its effect on the project. Risk avoidance eliminates the sources of high risk and replaces them with lower-risk solutions. Risk/opportunity transfer is the reallocation of risk/opportunity from one part of the system to another or the

reallocation of risks/opportunities between the NSF, OL, IOs or subcontractors. Risk/opportunity assumption or as-is acceptance is the acknowledgment of the existence of a particular risk/opportunity situation and a conscious decision to accept the associated level of risk/opportunity without engaging in any additional control efforts.

### 3.10 Environmental Health and Safety

Environmental Health and Safety (EH&S) is a critical concern for the OOI. The OL approach to EH&S has been documented in a comprehensive *OOI Environmental Health and Safety Plan* (incorporated by reference). The EH&S Plan establishes a systematic health and safety program to provide a means to identify and eliminate or control identified health and safety risks. It also assures that the environment is considered in the design, operations and maintenance of the OOI systems and subsystems. The Plan encourages the health and safety of personnel throughout activities associated with the design, development and operation of the OOI.

In turn, each IO has submitted its own EH&S Plan which complements the OOI EH&S Plan. These comprehensive, institutional based EH&S Plans focus on duties and responsibilities of personnel, specific safety procedures and reporting procedures in the event of an accident or incident. The IO EH&S Plans have placed particular emphasis on ship-board safety and on routine safety training of personnel working the OOI. Rapid reporting of safety accidents/incidents and correction of the cause of the accident/incident is also a priority.

The OOI Program Office and each IO complies with all applicable Federal, state, institutional and University-National Oceanographic Laboratory System (UNOLS) environmental, health and safety (EH&S) policies, procedures and requirements. Each IO is implementing EH&S procedures for personnel involved in the deployment, operation and routine maintenance of the observatory. All personnel who work on the OOI will be provided EH&S training and will be required to understand and adopt these policies, procedures and requirements.

To establish a systematic approach to EH&S for the OOI, OL has hired a full-time EH&S Manager. The EH&S manager is a key member of the OL staff and reports directly to the OOI Program Director. The EH&S manager chairs the OOI Safety Steering Committee. The EH&S manager conducts environmental, health and safety audits of OOI installations including production facilities, operations centers, shore stations, and shore facilities.

### 3.11 Permits and Environmental Compliance

#### 3.11.1 Environmental Compliance

The National Environmental Policy Act (NEPA) of 1969 (42 United States Code [USC] §4332) requires that Federal agencies consider the potential impacts of major Federal actions on the human and natural environment. NSF, as the lead agency, has funded Ocean Leadership to develop environmental assessments at the initial programmatic stage, and then at the final design or site-specific stage, to address the installation and operation of the OOI Network to meet NSF's legal responsibilities for compliance with NEPA, the Council of Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] §§ 1500-1508), and NSF regulations for implementing NEPA found in 45 Code of Federal Regulations (CFR) Part 640.

In advance of Final Design Review, the potential impacts on the human and natural environment associated with the proposed installation and operation of the OOI were assessed in the *Final Programmatic Environmental Assessment for the National Science Foundation-Funded Ocean Observatories Initiative* (NSF, 2008a) which was issued in June 2008 after a 30-day public comment period. The Final Programmatic Environmental Assessment (PEA) concluded with a Finding of No Significant Impact (FONSI) on February 4, 2009 (NSF, 2009a). Shortly after Final Design Review, NSF proposed modifications to the OOI design; the potential impacts of those modifications were assessed in a *Supplemental Environmental Report (SER) for the Ocean Observatories Initiative* (NSF 2009b) issued April, 2009.

With construction start, the OOI moved from the programmatic analysis to the site-specific analysis stage. The purpose of the Site-specific Environmental Assessment (SSEA) is to update information previously described in the PEA and SER with more detailed descriptions of the proposed infrastructure, noting any changes to the location of the infrastructure and the technology to be deployed, as well as addressing any new findings regarding potential impacts. This document tiers off from the previously prepared PEA, associated FONSI, and SER. It focuses only on those activities and the associated potential impacts, including cumulative impacts, resulting from the site-specific installation and operation and maintenance (O&M) of OOI assets not previously assessed in the PEA and SER.

The *Final Site-Specific Environmental Assessment for the National Science Foundation-Funded Ocean Observatories Initiative* (NSF, 2011) was issued on January 31, 2011, after a 45-day comment period and concluded with a Finding of No Significant Impact/Decision Document issued on January 31, 2011 (NSF, 2011). These documents can be accessed via the NSF Environmental Compliance page on the OOI web site (<http://www.oceanobservatories.org/about/environmental-compliance/>), which provides links to the NSF Ocean Sciences Division Environmental Compliance webpage.

The OOI Environmental Compliance and Permit Plan (DCN 1001-00001) describes the project's approach to and management of the requirements for complying with the NEPA and securing the necessary permits and authorizations to implement and operate the OOI network. The plan addresses both the NEPA environmental compliance process and the permit process for installation and operation of the OOI infrastructure. The plan defines roles and responsibilities of Ocean Leadership, the marine IOs, their environmental consultants, and the NSF in environmental compliance and for securing the necessary permits and authorizations to install and operate OOI infrastructure.

### 3.11.2 Permitting Responsibility

Various permits, certifications, and authorizations are required by federal, state, and local agencies with jurisdiction in the high seas or coastal waters where the OOI infrastructure will be installed. The IOs are responsible for securing the required permits, licenses, or authorizations for installation and operation of the OOI Network on behalf of Ocean Leadership (as the designated owner/operator). All applications for permits, licenses, or authorization will be reviewed by Ocean Leadership before submission to regulatory agencies. The IOs are also responsible for permits or authorizations for temporary test deployments or survey work; Ocean Leadership will provide review and oversight for test permits. The designations for the named applicant and authorized agent on permit applications are defined in the OOI Environmental Compliance and Permit Plan.

The list of necessary permits, licenses, authorizations, and other environmental compliance notifications, by installation site, is found in the OOI Permit List (incorporated by reference). This list is updated regularly.

## 3.12 Testing and Acceptance

OOI shall conduct testing and product evaluation activities throughout the design, development, integration, deployment, and operations phases of the OOI life cycle. Testing and product evaluation takes place against both developmental/prototype and production articles at all levels of integration, and serves to verify and validate all OOI system of systems, system, and subsystem requirements.

Maximum use of OOI System Development Environment (SDE) Configuration Management tools and OOI SDE Collaboration tools, such as OOI DOORS, ITM/JIRA, and OOI Subversion will be made to monitor and record testing and evaluation results, including: corrective actions taken; lessons learned; outcomes achieved; tradeoff, effectiveness, and risk analyses completed with resulting key decisions.

A Test Plan and Test Procedures will be developed for each formal test within OOI. The systems engineers at each IO, with review and approval of the OOI Chief Systems Engineer, will be

responsible for verification and validation of all science, engineering design, performance, and interface requirements. Each requirement will be verified and traced to the verification event, through the DOORS database of requirements. Test Reports will be created to document and analyze test results.

Detailed explanations of the OOI testing, acceptance, and commissioning processes may be found in each IO's PEP, as well as in the *OOI Commissioning Plan*, *OOI Quality Assurance and Quality Control Plan*, *OOI Test and Evaluation Strategy*, and *OOI Systems Engineering Management Plan (SEMP)*. The general approach to testing and acceptance is that the IOs will perform testing on developmental and production articles in an iterative and incremental fashion through all levels of product integration up to and including the hardware platform or software release. Hardware platforms and software releases will then be deployed and turned over to the PMO for Acceptance Testing. PMO Acceptance testing will include validation of end user requirements through execution of use case scenarios. After Acceptance Testing is passed, the PMO will take ownership of the deployed hardware platform or software release. Commissioning Evaluation is the final integration and operational readiness test of the progression, performed at the Array level for marine infrastructure, the Release level for software, and the building level for shore-side facilities. Commissioning Evaluation will be conducted by the PMO, and will verify, through testing and audits, that the product to be commissioned is ready for use in routine operations, that standard operating procedures and logistics are finalized and documented, and that operations staff has been trained. At Commissioning, the product will move from Engineering control and responsibility, to the control and responsibility of Operations and Maintenance at the relevant IO.

### 3.13 Annual Work Plans

Ocean Leadership prepares two types of annual work plans for its activities associated with the OOI. The first addresses the MREFC activities scheduled during the next project year and the second addresses the plan for operations and maintenance (O&M) activities that are scheduled in the next project year.

Ocean Leadership and the IOs prepare the construction annual work plan to provide a clear accounting of the part of the OOI MREFC project that is being executed during the particular project year. This will be based upon the work to be accomplished that is documented in the resource-loaded schedule that is maintained in Project Server. The annual plan will also track the progress of the project as it progresses through the five and a half year construction.

Ocean Leadership and the IOs also plan the use of initial operations of the OOI as component parts of the system are accepted and begin initial operations during the five and a half year construction period. This annual plan shows what the NSF Research and Related Activities (R&RA) funding provides for, in terms of operating the control centers, establishing the maintenance processes, providing a initial planning and technical support to the user community, and establishing the rotating pool of spares and repair parts necessary to maintain the OOI system.

### 3.14 Document Control and Reporting

The Configuration Manager is responsible for tracking and maintenance of the document list (accession list) with version numbers and dates. Authors of preliminary documents are responsible for updating the date on the document list and document within a day of the change and must provide an electronic file and .PDF file for the electronic repository upon issuance. Before release, the controls on preliminary documents are minimal and intended to facilitate the review of early drafts and numerous changes in a short period of time.

The Alfresco Document Management software is the basis for the OOI Document Management System (DMS) portion of the Collaboration Tools. Document Management software enables a unified, extendable digital solution of how documents are created, stored, filed, retrieved, secured, recovered, retained, archived, distributed and authenticated; all of which span near-unlimited locations (only limited by connectivity).

The central repository aspect of the OOI DMS efficiently stores libraries of documentation, as well as past revisions and versions. This central repository not only allows for disparate groups and individuals to gain access to the proper documentation, but also provides a single source of access to all of the documentation they require. It also enables various policies that documents within the repository are subject to, including but not limited to organizational security, disaster recovery, retention, and archive policies.

Version controls within the Document Management software give strong support to the change process within the project. This allows for previous version of documents to be archived, thus not only preserving previous versions, but also enables better program oversight as documentation can be monitored within iterative states.

Document Management software also enables a true sense of workflow associated with each critical document within a project and/or organization, thereby allowing documents to be controlled in a fashion where creation, editing, and deletion is tracked, monitored and managed. Workflow is defined more narrowly as the automated movement of documents or items through a sequence of actions or tasks that are related to a business process. Workflows are used to consistently manage common business processes within an organization by enabling the organization to attach business logic to documents or items in a DMS or library. Business logic is essentially a set of instructions that specifies and controls the actions that happen to a document or item.

Alfresco uses roles to determine what a user can and cannot do in a space. These roles are associated with permissions, which as a general rule are as follows: Users have all rights in their own space, while Administrators have all rights in all spaces. This way, only those with the proper authority to create, edit, or delete content and information are able to do so.

Ocean Leadership coordinates monthly reports to NSF on the OOI project based on the reporting requirements set forth in the Cooperative Agreement and Cooperative Support Agreements. The reports include a section that analyzes the cost and schedule variances from the EVMS. Annual reports are produced in phase with the project year.

### 3.15 Contingency Management

The contingency budget is determined as part of a bottom-up cost estimate and a programmatic top down risk evaluation. These two segments combine to provide the value of the contingency pool appropriate to the project. Actual contingency funding is held by Ocean Leadership and allocated to best support total project priorities. The formal change control process is used to allocate contingency to specific change requests and their related scope and activities.

OOI will conduct detailed planning as a rolling wave activity associated with each annual funding increment. This enables the project to adjust to actual funding levels, prior year accomplishments and lessons learned, and the availability of more mature/definitive pricing than was available during the initial cost estimation process. Detailed planning typically results in approximately a 10% budget increase for the execution year. An additional 5% increase can be expected during the execution year as a result of technical and schedule divergence from plan. This 15% is roughly equivalent to the contingency estimates from the risk model above. At least 10% should be available to the project during the detailed planning process, and the remaining 5% of contingency funding should be available at the beginning of the execution year.

OOI development relies heavily on existing technologies and modified off-the-shelf products. The one notable exception is software development, where interfaces are numerous, operational possibilities are complex, and development effort is notoriously difficult to predict. These risks are partially mitigated by the spiral software development process planned for OOI, which supports

rapid development and operational exposure for incremental functionality with subsequent fault elimination and software maturation. These risks are further mitigated by budgeting for an additional six months of schedule float for the Cyberinfrastructure development. The associated cost is included in the proposed budget and considered in determining the OOI period of performance, but it is also recognized and captured as a component of total project contingency. Additionally, the OOI project is vulnerable to rapidly escalating commodity prices, particularly the price of copper in the network cables. We have assumed these prices will increase at 10% per year and that the contingency funding required to cover this increase will be needed prior to execution of each option year.

Deployment costs are dominated by labor and ship time. Labor increases should fall within planned escalation, but the cost of ship time is heavily dependent on fuel prices, overall ship usage and assigned ports, and exchange rates. Alternate port assignments are the largest unknown factor within the work package and can change the cost of an installation or maintenance cruise by 50% or more. We have assigned an additional 4.2% (8% total) of inflation escalation for ship operations each year to mitigate fluctuating fuel prices. Furthermore, the deployment window each year is limited and highly susceptible to adverse weather conditions. It is extremely unlikely that weather will permit the achievement of annual deployment objectives for every planned deployment season. An additional half-deployment season has been scheduled at the end of the project to mitigate likely weather impacts. Again, the associated cost is included in the proposed budget and considered in determining the OOI period of performance, but it is also recognized and captured as a component of total project contingency.

The total contingency budget, including risk model assignments and the special case considerations described above, and products of the Cost Book and Risk Register is approximately 30% of the Total Project Cost. The program office will manage contingency to retain a contingency budget of 25-30% of the Estimate to Complete throughout the construction project.

### 3.16 IO Selection, Performance Management, and Acquisition Planning

#### 3.16.1 Selection of IOs: Marine Infrastructures, Cyberinfrastructure, and Education and Public Engagement Infrastructures

Ocean Leadership utilized a formal source selection process similar to the federal process followed for competitive, high-level awards. Each IO procurement started with a Notice of Intent, which provided information to potential bidders about the scope of work and estimated date for solicitation release; interested parties were requested to reply with a non-binding letter of intent to bid. Formal solicitations were then released, allowing an average of 120 calendar days to prepare proposals. An amendment to the solicitation provided answers to all potential bidders on all questions that were received. The solicitation detailed clearly the basis for source selection (i.e., greatest value assessment) and delineated the information required for this assessment. Proposals, which were in two volumes, Technical and Cost/Past Performance, were rated by two different panels. These panels had outside representatives from the science community as well as industry experts. Chairs of each panel briefed the source selection committee who in turn made the selection recommendation to the source selection official. Prior to entering into final negotiations, a complete package of the solicitation, scoring, and best value analysis was provided to NSF for concurrence. In some cases oral presentations preceded negotiations. Resulting subawards incorporate all the NSF flowdown provisions, and the award documents were provided to NSF.

#### 3.16.2 Management of IO Subaward Performance

Each subaward contains a "Reporting Requirements" clause which lists all deliverables, the due date for each deliverable and a reference to the task/sub-task area of the Statement of Work.

Ocean Leadership COTRs are identified in the subaward along with clear parameters as to when their technical direction is valid within the scope of the contract. COTRs provide a general technical liaison with the IO and monitor the timeliness of deliverables.

Monthly invoices are reviewed to assess costs incurred in relationship to subaward milestones. The subawards provide Ocean Leadership with the right to withhold additional funding if contract deliverables are deficient in quality and/or untimely. Each subaward requires the IO to notify Ocean Leadership in writing when 75% of the incremental funding has been expended and provide an estimate of additional funding needed to continue performance for the next 120 calendar days. COTRs review variance between planned value and earned value with IOs at a work package level as part of the implementation of Earned Value Management.

IOs are required to meet regularly with suppliers and vendors to review status, issues, action items, payment forecasts, and schedules. The results of these reviews are discussed at weekly conference calls with the COTR.

### 3.16.3 Acquisition Planning for New Subawards

Solicitations for new hardware and software are conducted in accordance with each IO's approved purchasing policies/procedures. These purchasing procedures have been reviewed by independent auditors as well as by each IO's cognizant federal agency. (For WHOI it is Defense Contract Audit Agency/Office of Naval Research; for UCSD it is U.S. Department of Health and Human Services; for UW it is U.S. Department of Health and Human Services; for Rutgers it is U.S. Department of Education). Review and approval of new awards shall adhere to the NSF cooperative agreement flowdown clause entitled "Subaward Requirements," which authorizes Ocean Leadership and each IO to enter into proposed contractual arrangements and to fund such arrangements up to the amount indicated in their respective budgets. Ocean Leadership is required to obtain NSF approval prior to awarding any new subaward or subcontract that exceeds \$250,000 award value. This clause is incorporated into the IO subawards; therefore NSF and Ocean Leadership reviews for approval new IO subawards above \$250,000 before the IOs are authorized to sign them. The NSF has provided Ocean Leadership advance authorization for prime and partner subawards as identified in the Cooperative Agreement (CA), and those listed in the CA are exempt from the threshold above.

To provide NSF with insight into all planned awards greater than \$250,000 in each project year, Ocean Leadership and the IOs have developed an Advanced Acquisition Plan for OOI Acquisitions, which is included in the OOI Annual Work Plan. The worksheet identifies anticipated new high-value awards or acquisitions across the program. The Advanced Acquisition Plan specifies whether the anticipated acquisitions are sole-source versus competitive, the purpose, the quantity procured, the estimated award value, the award lead-times, the anticipated contract type and other information required by the Cooperative Agreement. With other coordination measures, this planning process assists the OOI Program Office in integrating acquisitions across the IOs when technically appropriate.

## 3.17 Property Management

The OOI Property Management Plan (PMP) establishes an effective property control system for use by the OL in the management of the OOI hardware, software, and associated OOI equipment purchased with OOI funding under the cooperative agreement, including subawards and subcontracts. The PMP is implemented by OL under the direction of the OL Director of Contracts and Grants. It is used to audit IOs in the management of their property systems. Each IO has property plans and procedures for receiving and controlling property purchased with OOI funding. It is essential to promptly report incidents of loss, damage, or destruction of the OOI property. It is also essential to perform internal property self audits, and to initiate corrective actions when deficiencies are disclosed.

The IOs maintain formal written policies, plans and procedures that provide an effective property control system for each OOI asset for which they are responsible in accordance with the terms and conditions of their contracts. These plans and procedures will be provided to the OL Director of Contracts and Grants, to the OL Contracting Officer's Technical Representatives (COTR), and to the OL Property Administrator responsible for the custody of OOI equipment. If an incident of loss, damage or destruction (LDD) occurs, the OL Director of Contracts and Grants and the Ocean Leadership Property Administrator is promptly notified. Property self-audits by the IOs will

be performed at least annually and corrective actions will be taken in the event of any deficiencies. Property audits by the OL Property Administrator will be performed on an annual basis.

Each of the IOs and their subcontractors/subawardees will maintain an effective system to control and manage OOI equipment. The system will consist of procedures that define processes for the acquisition, receipt, identification, record keeping, movement, storage, physical inventory, reporting, utilization, subcontractor/subawardee control, disposition, loss and contract close-out of OOI-owned hardware, software, and other equipment in accordance with the Code of Federal Regulations (2 CFR 215), the NSF Financial and Administrative Terms and Conditions (FATC), NSF Award and Administration Guidelines and other applicable NSF regulations. Each IOs will ensure that its OOI property management system is in place from the time of equipment (or property) receipt to the time of return, deployment, or disposition of the property. Accountability will be compatible with Ocean Leadership contracts and with 2 CFR, 215.33(a)(1) and other NSF regulations/requirements.

An OOI Property Management Database will be developed and maintained by the Project Management Office. Electronic transfers of information will be provided by the IOs on a monthly basis from the IO records systems and the combined project data and information made available via a web application. The system will provide analysis and reporting capability to the project during execution and also serve as the initial data store maintenance information pending the development of the OOI Cyberinfrastructure.

## 4 Security

Security is 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.

### 4.1 Physical Security

Ensuring the physical security of the OOI is primarily be the responsibility of the IOs. On-shore facilities are locked and protected from illegal entry and access. The nature of the facility may warrant significant measures like security systems or guards. Each IO plans and implements appropriate security throughout the design, implementation, installation, and operational phases of the OOI.

Physical security of the marine observatories is the responsibility of the respective IO. Each IO considers physical security in the design phase and implement solutions that reduces or eliminates risk through the choice of buoy design, landing sites, burial methods, and route selection. In addition, the IOs may recommend that the OOI participate in community preventative measures by publishing route position lists and communicating with fishermen and mariners.

### 4.2 Cyberinfrastructure Security

The OOI Cybersecurity Plan describes the specific measures to undertaken by the OOI to ensure the system remains operational, there is no interruption in data access, and the data is accurate within established quality assurance/quality control parameters. 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.

Per the Cybersecurity Plan, the CI IO will also have responsibility to ensure that the OOI data and programs are not susceptible to cyber attacks in the form of viruses, malware, and denial of service attacks, 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) with the users via the public Internet/Internet2 and the other for the CI interactions with instruments (Service and Marine VLAN) 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.

### 4.3 Operational Security

Security for the OOI during its operational phase takes several forms: national security, individual PI data security, data validity, protection of operational systems during software upgrades or turn-up of new observatory elements, and installation of new sensors on existing infrastructure.

Acquisition and public distribution of acoustic and other geophysical data in some regions along the U.S. coastlines poses a significant national security risk. Deploying sensitive arrays in some areas will lead to the need to restrict data access, prevent data acquisition at random intervals, or restrict publication of results. Ocean Leadership and NSF continue to hold discussions with the U.S. Navy about this issue. A US Navy/OOI Cybersecurity Subcommittee has been established to develop the requirements, design, and operating procedures associated with the technical solution providing this restricted data access. The OOI will conform to any additional conditions levied by these groups and, if required, will monitor its registered users against a terrorist watch list.

Individual PIs who have developed a data source that becomes part of the OOI network will be required to make data publicly available in accordance with the OOI data policy

The Operations Plan envisions that the Facility Governance Group will define various user classes and permissions for the OOI. Each class of user will have certain rights and responsibilities ensuring that critical data streams are not interrupted by a casual user.

Data users also want to be sure that the data that the OOI is providing is accurate. The OOI Network data policy requires data providers to provide information regarding the provenance, description, quality, maturity level, and collection context of their data. This additional information that is associated with the data will help the users understand the quality level of the data. It is expected that each and every instrument or sensor on the OOI Network will have a user that is entrusted with this responsibility.

An important feature of the OOI is the ability for scientists to interact with their instruments in near-real time to respond to significant events. The OOI an IO Network Operations centers must coordinate these requests per the established marine operator policies, especially when such a request might overload the node and require other instruments to be turned down or turned off. The OOI operating center(s) will develop a process that will regulate this feature to avoid data or power contention.

The OOI will have a number of experiments running on the system simultaneously. During system upgrades and maintenance, it may be necessary to remove power on the system for a brief period. The OOI Network Operations center 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 Network Operations center and will be tested to ensure backward compatibility.

Finally, the OOI must approve any new sensors for use according to a formal process that will be developed by the Observatory Operations Team (OOT). OOI, as part of operational security, will confirm that any sensors planned to be placed on the OOI have been approved by the necessary entity(s).

## 5 Operations and Maintenance

### 5.1 Operations and Maintenance Planning

Initial Operations and Maintenance in the OOI Project Office started in Project Year 1. A full time contractor O&M Manager (OMM) is responsible for O&M planning and project execution. The OMM assists with the selection of insurance brokers to protect OL interests in the ownership of OOI assets. The OMM performs logistics analysis of OOI systems and equipment, performs maintenance planning and staffing analysis and oversees the initial O&M planning of the IOs. It is envisioned that during Project Years 2 through 5, there will be a gradual transition of staff (when appropriate) from their MREFC functions during construction to the O&M program. This gradual transition is described in the *OOI Operations and Maintenance Plan* (incorporated by reference) which establishes a framework and shared vision in which OL and the IOs can establish requirements for governance, daily operations, maintenance, administration, policies and procedures. This plan establishes two groups, the Observatory Advisory Team (OAT) and the Observatory Operations Team (OOT). The responsibilities of OL, the OAT, the OOT, and each of the IOs are shown in Figure 5.

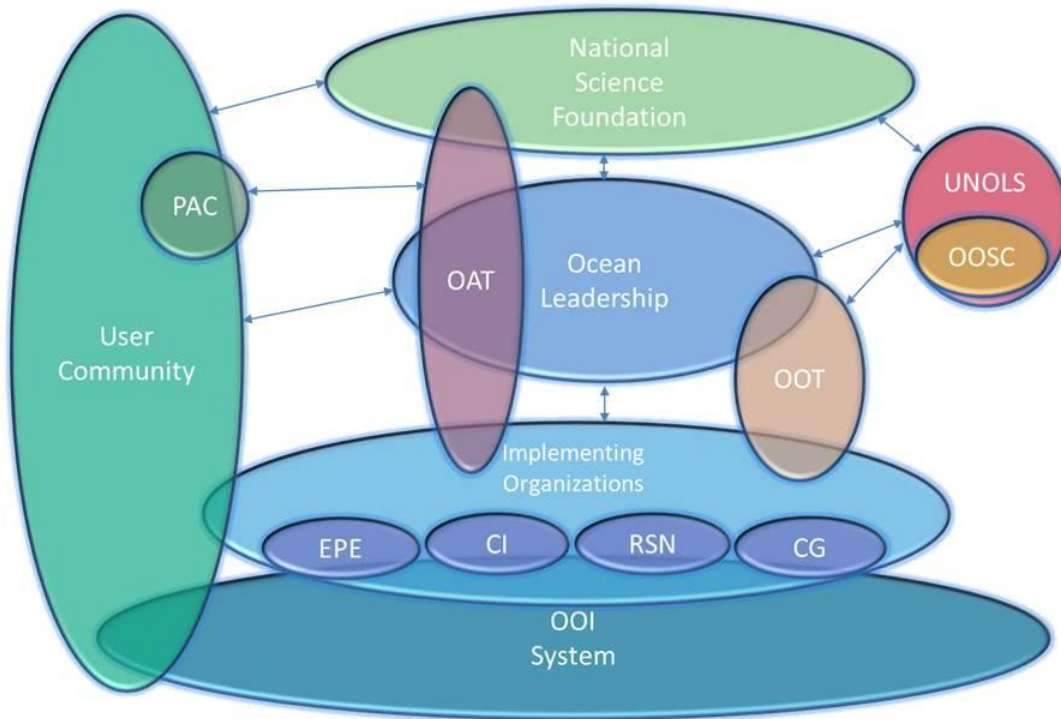


Figure 6. OOI Operations and Maintenance relationship structure

Concurrently, the IOs began their OOI O&M efforts in Project Year 1 by each hiring a full time O&M Manager or providing dedicated resources. The individual IO O&M Plans (incorporated by reference, Appendix A-1) describe in detail each IOs approach toward implementation of O&M on

the Program. They also describe how the IOs will base their O&M strategies on the Telecommunication Operations Map (TOM) that was developed by the TeleManagement Forum, a telecommunications industry group to address issues related to the inter-workings of telecommunications networks.

In Project Year 1, the Marine IOs OMMs will participate in lease/purchase decisions for Shore Stations facilities and equipment, will locate warehouse space to store operational spares and equipment and will start staff planning and space planning for data centers. The CI OMM in Project Year 1 will plan for establishing manned Operations Management Center (OMCs) at six separate locations and unmanned Observatory Execution Facilities at ten other locations. The three IOs also envision that during Project Years 2 through 5 (when appropriate) there will be a gradual transition of staff from MREFC functions to O&M program functions.

## 5.2 Science Planning

The *OOI Science Plan* and related OOI research planning documents describe in detail the science themes leading to the OOI Network Design. The science themes informing the OOI network design will be rich areas of active oceanographic investigation for decades to come. Conducting the eventual science activities carried out with the OOI integrated observatory network will require a collaboration among the NSF's Ocean Sciences Division, Ocean Leadership's OOI Program Office, the project scientists associated with the IOs, and the OOI advisory structure.

There will be several modes in which potential investigators will use the completed OOI facility. Considering all possible use case scenarios, at one extreme are researchers who will use only data or data products from the core sensors (for example, for incorporation into models). In this case, the planning or technical support needed from the OOI operational entity will be mainly informational (e.g., instrument calibration, description of the mode of deployment, etc). At the other extreme are researchers who propose to deploy instrumentation or experiments on the OOI physical infrastructure. These users will require more intensive planning and technical support, such as feasibility assessments, requirements for power and data rate bandwidth, installation schedule, risk and risk mitigation, etc. Somewhere in the middle are researchers who propose to manipulate OOI observing assets and sampling protocols or conduct field campaigns centered at, or in the vicinity of, OOI infrastructure.

The NSF and the project team have drafted a description of the process for proposal and experiment planning and associated technical support required by different categories of users (see *OOI Operations and Maintenance Plan*, Section 7, OOI Proposal Management). Proposals submitted to NSF for research funding involving OOI data and/or requesting direct interaction with the infrastructure will follow a process involving varying levels of requirements and review. The process will be based on four principal proposal attributes, one or more of which may be true for a given proposal: 1) analysis using data from OOI core sensors, 2) alteration of the OOI core sensor baseline measurement protocol, 3) participation in OOI seagoing operations, and 4) addition of instrumentation to the OOI infrastructure. All proposals submitted to NSF will be subject to NSF's standard merit review process. Investigators who request alterations in core sensor sampling protocol and/or propose to add instrumentation to the OOI Network will need to submit planning letters for assessment of technical feasibility in advance of submission to the funding agency. Potential investigators will be provided guidance and information regarding feasibility assessments, facility usage, budgeting, technical and cyberinfrastructure requirements, education and public engagement, and security requirements. Assistance in proposal planning and scheduling will be provided through involvement of the OOI personnel, the NSF, the University-National Oceanographic Laboratory System (UNOLS), and the U.S. Navy. When the process has been sufficiently elaborated and approved by the NSF, information about the OOI proposal process will be available on the OOI website. A conceptual description of the proposal process has been discussed at upcoming OOI Community Workshops to be held throughout the construction phase. The Program Advisory Committee will take an active role in the science planning discussions and help identify the path to develop optimal user support models.

Initial science planning activities will involve interaction with the prospective OOI user community through a variety of meetings and workshops. The Program Management Office convened two regional community meetings during Project Year 1 to introduce the OOI Network, i.e., its observation capabilities, sensors and instrumentation, concept of operations and investigator access to the network, data, and information. These introductory meetings will continue throughout the early construction phase with agendas that will then expand to include science planning as the infrastructure advances towards operational readiness. Because future funding for individual researchers to use the OOI platform may come from a range of agencies (e.g., NSF, NOAA, ONR, DOE), it is essential that these meetings have active participation by agency program directors.

Workshops and community meetings are planned throughout the MREFC project period of performance. Specific plans for these workshops will be developed with advice from the Program Advisory Committee and NSF/OCE. These events may also include targeted workshops that focus on identifying new research avenues, computational, modeling or visualization tools for analysis of the OOI data streams, or development of new sensors/instruments. These workshops and meetings could also serve within NSF funding guidelines, to form topical working groups of investigators to plan specific experiments in focused areas of the science themes.

## 6 Reviews

Multiple review mechanisms are in place during construction of the OOI facility to ensure effective management, performance, and compliance with requirements. The sponsoring agency, NSF, conducts reviews in accordance with the MREFC process. As with other large facility programs, NSF organizes annual program reviews with external panels to address management performance and progress against any changes to the capability, cost, and schedule baselines. Additionally, NSF will establish an external scientific oversight committee to assess program progress against science goals periodically, evaluate the impact of proposed changes in infrastructure on the achievement of program goals, and recommend change in direction and reallocation of resources as appropriate. This committee will comprise informed but non-conflicted members of the ocean science, engineering, and education communities and thereby will also encourage continued support of the program by the oceanographic community.

Engineering reviews (formal and informal) are conducted at key junctures. For larger complex configuration items, this may be a progressive or incremental review, culminating in system-level reviews that essentially validate the completeness of preceding configuration-item-level technical reviews and ensures adequate interfaces between all configuration items. The engineering technical reviews are discussed further in the SEMP. Technical reviews generally look to identify the review objectives and requirements cited in the respective plan, as well as considerations given to OOI policies, procedures, and agreements, as applicable. They also help determine progress toward satisfying the technical review entry requirements and help prepare the materials constituting technical review package and presentation package.

Regular, issue-specific technical and cost reviews are also conducted by the OOI Program Office on an as-needed basis using expertise from within and outside the project team. Peer review involving cross-cutting teams from all IOs is used as a routine measure to vet proposed technical solutions and is one method to achieve standardization of solutions across the facility. The program's science advisory structure and wider user community provides a pool of domain experts who can be brought in as issue-specific reviewers on a flexible basis. Finally, the change control process allows for an element of technical review as proposed changes are considered among and across implementing organizations.

OOI has successfully completed multiple internal and external science, technical and programmatic reviews including the NSF Conceptual Design Review (August 2006), Preliminary Design Review (December 2007), and Final Design Review (November 2008). In addition, OL has conducted individual IO *ifdrs* for CI, CGSN and RSN as well as a *System Level ifdr*.

## **Project Execution Plan**

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As outlined in Section 1, the Consortium for Ocean Leadership has management, coordination, and integration responsibility for the OOI through the cooperative agreement with NSF. The Board of Trustees of OL has oversight responsibility for the corporation and its performance against programmatic commitments, and can elect to provide another level of review or add external subject matter experts to the review structure outlined in this document.

## **Appendix A-1: Documents Incorporated by Reference**

Listed in order of reference.

<b>Document Title</b>	<b>Document File Name</b>
Ocean Observatories Initiative Science Plan (May 2005)	<a href="http://www.oceanleadership.org/files/OOI_Science_Plan.pdf">http://www.oceanleadership.org/files/OOI_Science_Plan.pdf</a>
CGSN Project Execution Plan	3101-00001_Project_Execution_Plan
CI Project Execution Plan	2010-00001_PEP_CI
RSN Project Execution Plan	4021-00001_PEP_RSN
OOI Pilot Plan	
OOI Scientific Objectives and Network Design: A Closer Look	<a href="http://www.oceanleadership.org/files/Science_Prospectus_2007-10-10_lowres_0.pdf">http://www.oceanleadership.org/files/Science_Prospectus_2007-10-10_lowres_0.pdf</a>
Blue Ribbon Review of OOI Scientific Objectives and Network Design: A Closer Look	
OOI Final Network Design	1101-00000_FND_OOI
OOI Operations and Maintenance Plan	1010-00000_OM_Plan
OOI Commissioning Plan	1004-00000_Commissioning_Plan_OOI
OOI WBS Dictionary	1041-00000_WBS_Dictionary_OOI
OOI Configuration Management Plan	1000-00000_CMP_OOI
OOI Earned Value Management System Plan	1005-00000_EVM_Plan_OOI
OOI Interface Agreements (CI-CG)	1132-00000_IA_CI-CG
OOI Interface Agreements (CI-RSN)	1131-00000_IA_CI-RSN
OOI Interface Agreements (CG-RSN)	1133-00000_IA_CG-RSN
OOI Quality Assurance and Quality Control Plan	1003-00000_QA_QC_Plan_OOI
OOI Risk Management Plan	1007-00000_Risk_Management_Plan_OOI
OOI Cost Estimating Plan	1002-00000_CEP_OOI
OOI Systems Engineering Management Plan	1100-00000_SEMP_OOI
OOI Environmental Health and Safety Plan	1006-00000_EHSP_OOI
Final Programmatic Environmental Assessment (NSF OOI)	<a href="http://www.nsf.gov/geo/oce/pubs/OOI_Final_PEA_Jun08.pdf">http://www.nsf.gov/geo/oce/pubs/OOI_Final_PEA_Jun08.pdf</a>
OOI Integrated Master Schedule	1040-00000_IMS_OOI
OOI Environmental Compliance and Permit Plan	1001-00001_Permit_List_OOI
OOI Acquisition Plan	1008-00000_Acquisition_Plan_OOI
OOI Property Management Plan	1011-00000_Property_Management_Plan_OOI

**Appendix A-2: Acronym List**

ACWP	Actual Cost of Work Performed
AUV	Autonomous Underwater Vehicle
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
CDR	Conceptual Design Review
CGSN	Coastal/Global Scale Nodes
CI	Cyberinfrastructure
CMP	Configuration Management Plan
CND	Conceptual Network Design
COTR	Contracting Officer's Technical Representative
COTS	Commercial Off-the-Shelf
CPO	Capital Projects Office
CSN	Coastal Scale Nodes
CyberPOP	Cyberinfrastructure Point of Presence
DMS	Document Management System
DOORS	Dynamic Object Oriented Requirements System
EIS	Environmental Impact Statement
EH&S	Environmental Health & Safety
EPE	Education and Public Engagement
ESONET	European Seafloor Observatory Network
EVMS	Earned Value Management System
FATC	Financial and Administrative Terms and Conditions
FDR	Final Design Review
FND	Final Network Design
FONSI	Finding of No Significant Impact
FY	Fiscal Year
GAAP	Generally Accepted Accounting Principles
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GSN	Global Scale Nodes
ifdr	Internal Final Design Review
IMS	Integrated Master Schedule
IO	Implementing Organization
IOC	International Oceanographic Commission
IOOS	Integrated Ocean Observing System
IPT	Integrated Product Team
JCOMM	Joint Commission on Oceanography and Marine Meteorology
JOI	Joint Oceanographic Institutions
MARS	Monterey Accelerated Research System
MBARI	Monterey Bay Aquarium Research Institute
MOU	Memorandum of Understanding
MREFC	Major Research Equipment and Facilities Construction
NASA	National Aeronautics and Space Administration
NEON	National Ecological Observatory Network
NEPA	National Environmental Policy Act
NEPTUNE	NorthEast Pacific Time-series Undersea Networked Experiments
NOAA	National Oceanographic and Atmospheric Administration
NRC	National Research Council
NSB	National Science Board
NSF	National Science Foundation

**Project Execution Plan**

OAT	Observatory Advisory Team
OBS	Organizational Breakdown Structure
OFEG	Observing Facilities Exchange Group
O&M	Operations and Maintenance
OMM	Operations and Maintenance Manager
OOI	Ocean Observatories Initiative
OOT	Observatory Operations Team
OSC	Observatory Steering Committee
OSU	Oregon State University
PAC	Program Advisory Committee
PDR	Preliminary Design Review
PEA	Programmatic Environmental Assessment
PEP	Project Execution Plan
PI	Principal Investigator
PMB	Performance Measurement Baseline
PMEL	Pacific Marine Environmental Laboratory
PMP	Property Management Plan
PND	Preliminary Network Design
POGO	Partnership for Ocean Global Observations
PY	Project Year
QA	Quality Assurance
RFP	Request for Proposal
RFQ	Request for Qualification
ROMB	Risk and Opportunity Management Board
R&RA	Research and Related Activities
RSN	Regional Scale Nodes
SIO	Scripps Institution of Oceanography
SRD	System Requirements Document
SUR	Science User Requirements
TDP	Technical Data Package
UCSD	University of California, San Diego
UNOLS	University-National Oceanographic Laboratory System
UW	University of Washington
VENUS	Victoria Experimental Network Under the Sea
WBS	Work Breakdown Structure
WHOI	Woods Hole Oceanographic Institution
WMO	World Meteorology Organization

### Appendix A-3: Current Membership, Program Advisory Committee

William Boicourt	University of Maryland
Francisco Chavez	Monterey Bay Aquarium Research Institute
Paula Coble	University of South Florida
Percy Donaghay	University of Rhode Island
Robert Duce	Texas A&M University
James Edson ^	University of Connecticut
Ian Foster	Argonne National Laboratory/University of Chicago
Jeff Hare	National Oceanographic and Atmospheric Administration
Larry Mayer *	University of New Hampshire
Mike Purdy	Lamont-Doherty Earth Observatory
Verena Tunnicliffe	University of Victoria
* Ocean Leadership Board of Trustees representative	
^ Chair	

## Appendix A-4: Technical Summary

### Physical Infrastructure Description

#### Locations

##### Regional Scale Nodes:

- Node 1 Hydrate Ridge – Juan de Fuca tectonic plate, off Oregon, Position 44° 30' N 125° 24' W
- Node 3 Axial Seamount – Juan de Fuca tectonic plate, off Oregon, Position 45° 51' N 129° 43' W
- Node 5 Mid-Plate – Juan de Fuca tectonic plate, off Oregon, Position 45° 27' N 126° 22' W

##### Global Scale Nodes:

- Node 6 Station Papa – Northeast Pacific Ocean, Position 50°N 145°W
- Node 7 Irminger Sea – Irminger Sea, Position 60°N 39°W
- Node 8 Southern Ocean – Southern Ocean, Position 55°S 90°W
- Node 12 Argentine Basin – Argentine Basin, Position 42°S 42°W

##### Coastal Scale Nodes:

- Node 10 Pioneer Array – Mid-Atlantic Bight 40° 03' N 70° 45' W
- Node 11 Endurance Array – Pacific coast off Oregon 44° 39' N 126° 00' W
- Pacific coast off Washington 46° 55' N 124° 57' W

### Components

#### Regional Scale Nodes (104 total sensors):

##### Node 1 Hydrate Ridge

- Seafloor: Primary and Secondary 16 sensors total
- Profiler – Winched 12 sensors
- Profiler – Wire crawler 5 sensors
- Midwater Platform @ 200m 8 sensors
- Bottom Instrument Package 6 sensors

##### Node 3 Axial Seamount

- Seafloor: Primary and Secondary 26 sensors total
- Profiler – Winched 12 sensors
- Profiler – Wire crawler 5 sensors
- Midwater Platform @ 200m 8 sensors
- Bottom Instrument Package 6 sensors

##### Node 5 Mid-plate (Uninstrumented)

- Seafloor: Primary 0 sensors total
- Cable Extension (Terminated) approximately 5 km in length

**Global Scale Nodes (281 total sensors)**

Node 6 Station Papa

- Moorings
  - 1 Subsurface Hybrid Profiler with 12 sensors
  - 2 Flanking Moorings with 16 sensors each
- Mobile assets
  - 3 Gliders with 3 sensors each

Node 7 Irminger Sea

- Moorings
  - 1 Surface Mooring with 23 sensors
  - 1 Subsurface Hybrid Profiler with 12 sensors
  - 2 Flanking Moorings with 16 sensors each
- Mobile
  - 3 Gliders with 3 sensors each

Node 8 Southern Ocean

- Moorings
  - 1 Surface Mooring with 23 sensors
  - 1 Subsurface Hybrid Profiler with 12 sensors
  - 2 Flanking Moorings with 16 sensors each
- Mobile Assets
  - 3 Gliders with 3 sensors each

Node 12 Argentine Basin

- Moorings
  - 1 Surface Mooring with 23 sensors
  - 1 Subsurface Hybrid Profiler with 12 sensors
  - 2 Flanking Moorings with 16 sensors each
- Mobile Assets
  - 3 Gliders with 3 sensors each

**Coastal Scale Nodes (382 total sensors):**

Node 10 Pioneer Array

- Surface Moorings
  - 1 with 13 sensors; 2 with 11 sensors each
- Surface-Piercing Profiler Moorings
  - 2 with 9 sensors
- Profiler Moorings
  - 4 with 6 sensors each; 1 with 5 sensors
- Multi Function Nodes (MFNs)
  - 2 with 8 sensors; 1 with 9 sensors
- Docking Stations for AUVs
  - 2 on MFNs
- Mobile Assets
  - 3 AUVs with 6 sensors each
  - 6 Gliders with 5 sensors each

**Project Execution Plan**

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Node 11 Endurance Array

*Oregon Line*

Surface Moorings	2 (80 m, 500 m) with 15 sensors each 1 (25 m) with 11 sensors
Surface-Piercing Profiler Moorings	1 (25 m) with 10 sensors 1 (80 m) with 9 sensors
Hybrid Profiler Moorings	1 (500 m) with 13 sensors, cabled to RSN
Midwater Platforms @ 150m	1 (500 m) with 3 sensors
Benthic Experiment Packages /	1 (25 m) with 10 sensors, uncabled
Multi-Function Nodes	2 (80 m, 500 m), with 11 and 9 sensors respectively, cabled to RSN

*Washington Line*

Surface Moorings	2 (80 m, 500 m) with 15 sensors each 1 (25 m) with 11 sensors
Surface-Piercing Profiler Moorings	1 (25 m) with 9 sensors 1 (80 m) with 9 sensors
Profiler Moorings	1 (500 m) with 5 sensors
Multi-Function Nodes	2 (25 m, 80 m) with 10 sensors each; 1 (500 m) with 8 sensors; all uncabled

*Mobile Assets*

Gliders	6 with 5 sensors each
---------	-----------------------

<b>Number of Sensor Types</b>	<b>Number of Sensors</b>	<b>Sensor Location</b>
<b>49</b>	<b>767</b>	<b>All OOI core; Note that a total of 31 suppliers can supply the 49 sensors</b>
<b>33</b>	<b>104</b>	<b>RSN Total</b>
<b>32</b>	<b>663</b>	<b>CGSN Total: 281 Global; 155 Pioneer; 227 Endurance</b>
<b>16</b>	<b>385</b>	<b>Common sensors on both RSN and CGSN</b>
<b>17</b>	<b>34</b>	<b>Unique to RSN only</b>
<b>16</b>	<b>348</b>	<b>Unique to CGSN only</b>

**Table 1** Summary of total sensors and sensor types across all OOI platforms. Note that field spares have not been included in these estimates.

**Shore-side Facilities:**

1. Woods Hole, MA (CGSN)
2. Corvallis, OR (CGSN)
3. San Diego, CA (CGSN)
4. Pacific City, OR (RSN)

**Primary (backbone) Cable Line:**

Cable line from RSN shore station to each RSN Primary Node and from Endurance Oregon Line to RSN Hydrate Ridge Node 1.

**CI CyberPOPs:**

1. Instrument Development Kit (IDK), Hardware – San Diego, CA
2. Observatory Acquisition Points (OAP), Hardware – Portland, OR; Woods Hole, MA
3. Observatory Distribution Points (ODP), Hardware – McLean, VA; Seattle, WA, San Diego, CA
4. Observatory Execution Points (OEP), Hardware – distributed (TeraGrid, Open Science Grid, Amazon ECC, Microsoft Computing Cloud, UW Digital Well)
5. Operations Management Point (OMP), Hardware – Woods Hole, MA; Corvallis, OR; San Diego, CA; Seattle, WA; Washington, DC

**CI Construction Projects:**

1. Sensing & Acquisition (S&A) Subsystem Construction Project
2. Data Management (DM) Subsystem Construction Project
3. Analysis & Synthesis (A&S) Subsystem Construction Project
4. Planning & Prosecution (P&P) Subsystem Construction Project
5. Common Execution Infrastructure (CEI) Subsystem Construction Project
6. Common Operating Infrastructure (COI) Subsystem Construction Project

**CI Software Releases:**

1. Data Distribution Network
2. Managed Instrument Network
3. On Demand Measurement Processing
4. Integrated Modeling Network
5. Interactive Ocean Observatory

**EPE Infrastructure categories:**

1. Tools
  - Web-based interfaces
  - Visualization
  - Interactions with models, simulation runs
  - Digital merger with non-OOI databases
  - Educational modules
2. Resource Storage, Retrieval and Archiving
  - Educational Resource Database
  - Library of cultural formats
3. Virtual Participation
  - Virtual laboratories and work environments
4. People Resources
  - Scientist/Educator/Student Networking
5. Public Engagement
  - OOI Program-wide web presence

**Project Schedule Milestones (Baseline)**

<b>Item</b>	<b>Milestone / Task Name</b>	<b>Date</b>
1	Project Start - Authorization to proceed	Sep, 2009
2	Implementing Organization Sub-Awards	Sep, 2009
3	Release RFP for Education	Dec, 2009
4	Extension Cables including Cable Terminations Development - Prototype Test Complete	Apr, 2010
5	EPE Contract Award Date	Jun, 2010
6	Extension Cables including Cable Terminations Development - Factory Test Complete	Aug, 2010
7	LV Node Development - Prototype Test Complete	Aug, 2010
8	J-Boxes Development - Prototype Test Complete	Aug, 2010
9	Global Glider PRR	Jan, 2011
10	Winch and Profilers Development - Prototype Test Complete	Jan, 2011
11	Coastal Gliders PRR	Mar, 2011
12	R1 Integrated Observatory Network - Acceptance Complete	Apr, 2011
13	LV Node Development - Factory Test Complete	May, 2011
14	J-Boxes Development - Factory Test Complete	May, 2011
15	RSN Primary Infrastructure Cable Construction Complete	May, 2011
16	Vertical Moorings Development - Prototype Test Complete	Jun, 2011
17	Irminger Sea PRR	Aug, 2011
18	Argentine Basin PRR	Aug, 2011
19	Endurance OR Uncabled Array PRR	Aug, 2011
20	Pioneer Coastal Profiler PRR	Aug, 2011
21	Station Papa PRR	Aug, 2011
22	AUV and AUV Dock PRR	Sep, 2011
23	Winch and Profilers Development - Factory Test Complete	Oct, 2011
24	Endurance Cabled Endurance Array PRR	Oct, 2011
25	RSN Shore Station Build out Complete	Dec, 2011
26	R2 Integrated Observatory Network - Acceptance Complete	Apr, 2012
27	Southern Ocean PRR	May, 2012
28	Endurance Washington Surface Moorings and Winched Profiler PRR	May, 2012
29	Endurance Array Installation Readiness Review/ PCA - Gliders	May, 2012
30	Pioneer P1 - P4 PRR	May, 2012
31	Pioneer Coastal Gliders Installation Readiness Review/ PCA	Jun, 2012
32	Vertical Moorings Development - Factory Test Complete	Jun, 2012
33	Argentine Basin Installation Readiness Review/ PCA	Jan, 2013

## Project Execution Plan

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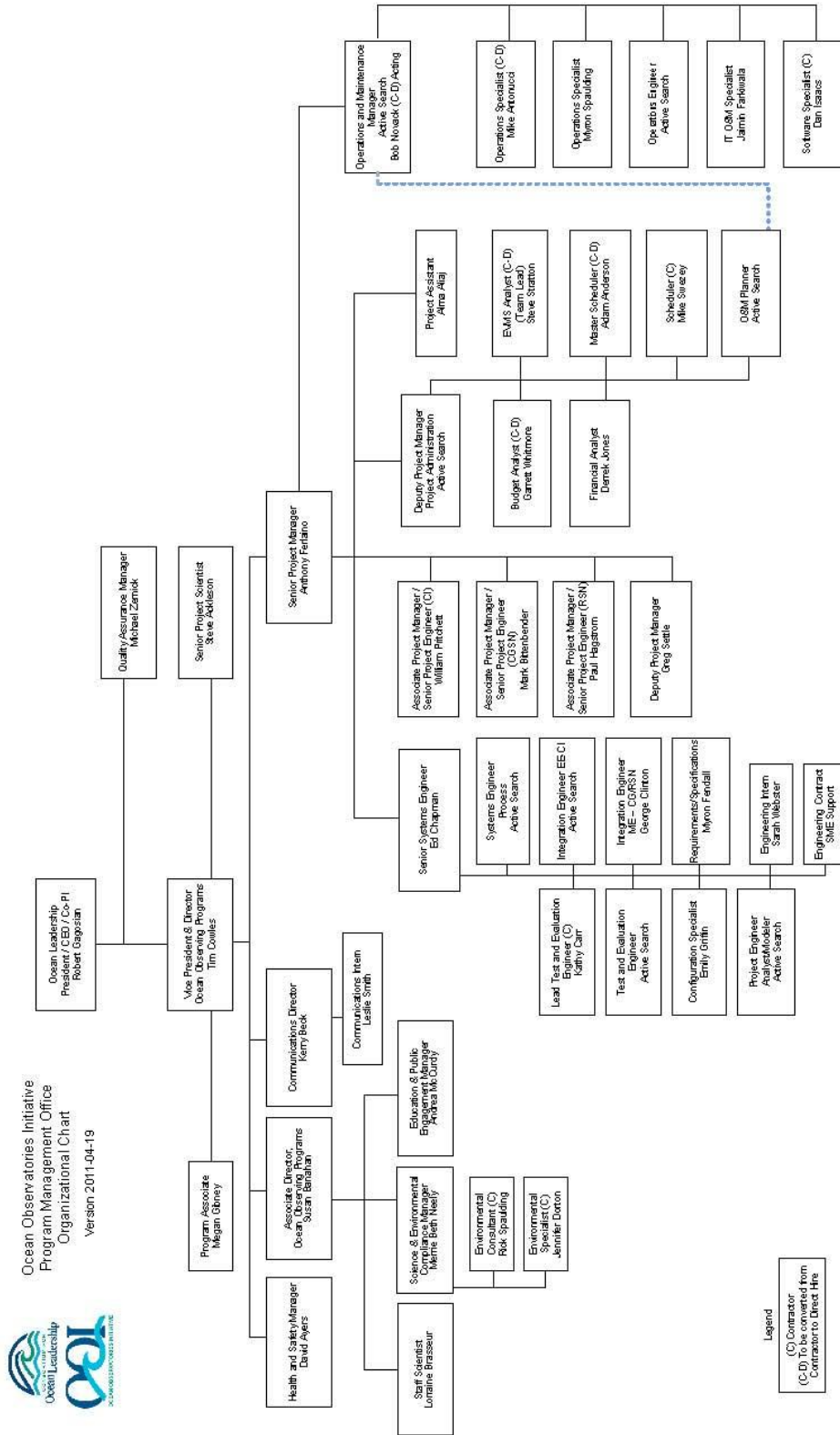
<b>Item</b>	<b>Milestone / Task Name</b>	<b>Date</b>
34	Installation Readiness Test Complete - Hydrate Ridge	Mar, 2013
35	Endurance Array Installation Readiness Review/ PCA - Uncabled	Apr, 2013
36	Station Papa Installation Readiness Review/ PCA	Apr, 2013
37	Irminger Sea Installation Readiness Review/ PCA	Apr, 2013
38	Installation Readiness Test Compete - Axial	May, 2013
39	AUV Installation Readiness Review/ PCA	Jun, 2013
40	R3 Integrated Observatory Network Release 3 - Commissioning Complete	Jun, 2013
41	Endurance Array Installation Readiness Review/ PCA - Cabled	Aug, 2013
42	Pioneer P1 - P4 Installation Readiness Review/ PCA	Aug, 2013
43	Pioneer Coastal Profiler Installation Readiness Review/ PCA	Aug, 2013
44	Site Acceptance Complete - Axial	Aug, 2013
45	Site Acceptance Complete - Hydrate Ridge	Oct, 2013
46	Southern Ocean Installation Readiness Review/ PCA	Dec, 2013
47	R4 Integrated Observatory Network - Acceptance Complete	Feb, 2014
48	Endurance WA Installation Readiness Review - Surface Moorings and Winched Profilers	Apr, 2014
49	R5 Integrated Observatory Network Release 5 - Commissioning Complete	Aug, 2014
50	Education Infrastructure Operational	Aug, 2014
51	OOI - Planned End of Project	Aug, 2014
52	Schedule Contingency - End of Project (3/1/2015)	Mar, 2015

IRR - Installation Readiness Review

PCA - Physical Configuration Audit

PRR - Production Readiness Review

Appendix A-5: PMO and IO Organizational Structure



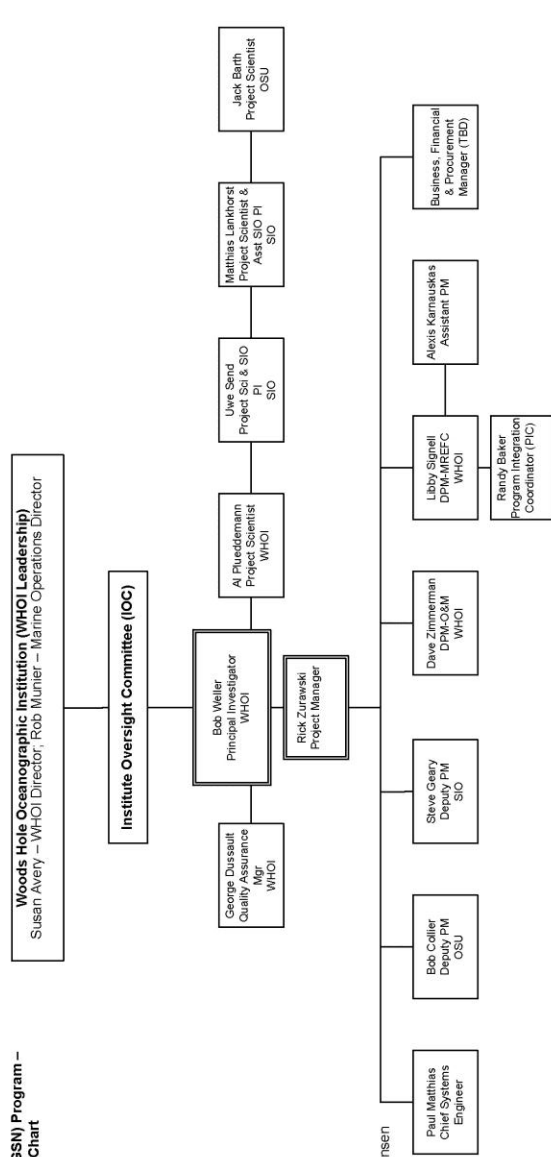
Legend  
(C) Contract  
(C-D) To be converted from Contract to Direct Hire







OOI - Coastal Global Scale Nodes (CGSN) Program - Construction Organization Chart 04-22-11



**CGSN Support Staff**  
 Risk Manager - Ian Owen  
 CM / DM - Diana Wickman / Kevin Mackie  
 Planning - Joanne Davis / Lynn DeValerio  
 Accounting - Cindy Tobey / Michael Pinnetti  
 Administration - Aileen Jensen / Kelsey Johansen

Cross Product Teams	OSU Ed User / CSPP Support / BEP / ISMT2 / Glider Support	AST2 Test Steve Parks / CSM / CPM	Surface Steve Glazy / Coastal / Global / Fuel Cell	WHOI Profiler TBD / CPM	SIO Global Ed User / AST2 - GHP / Hybrid / Mesoflanking / Global Glider	Testbed / Modelling Jan Owen	Vehicles / Instrument Pioneer / CSPP / GSPP	Arrays Liz Caporelli (Acting) / Pioneer / Endurance / Global
Systems Engineering Sheri White								
Hardware / Software Steve Hilliard								
Mechanical / Deployment Don Peters								
IV and T Requirements Marcos Sasate-Cordora								
Logistics TED								
Manufacturing Ed White								
Science/ Instruments Al Plueddemann								

See Detail

Integrated Product Teams

Cross Product Teams

# Project Execution Plan

OOI - Coasta Global Scale Nodes (CCSN) Program -  
Construction Organization Chart  
Cross Product Team Details  
04-22-11

Randy Baker  
Program Integration  
Coordinator (PIC)

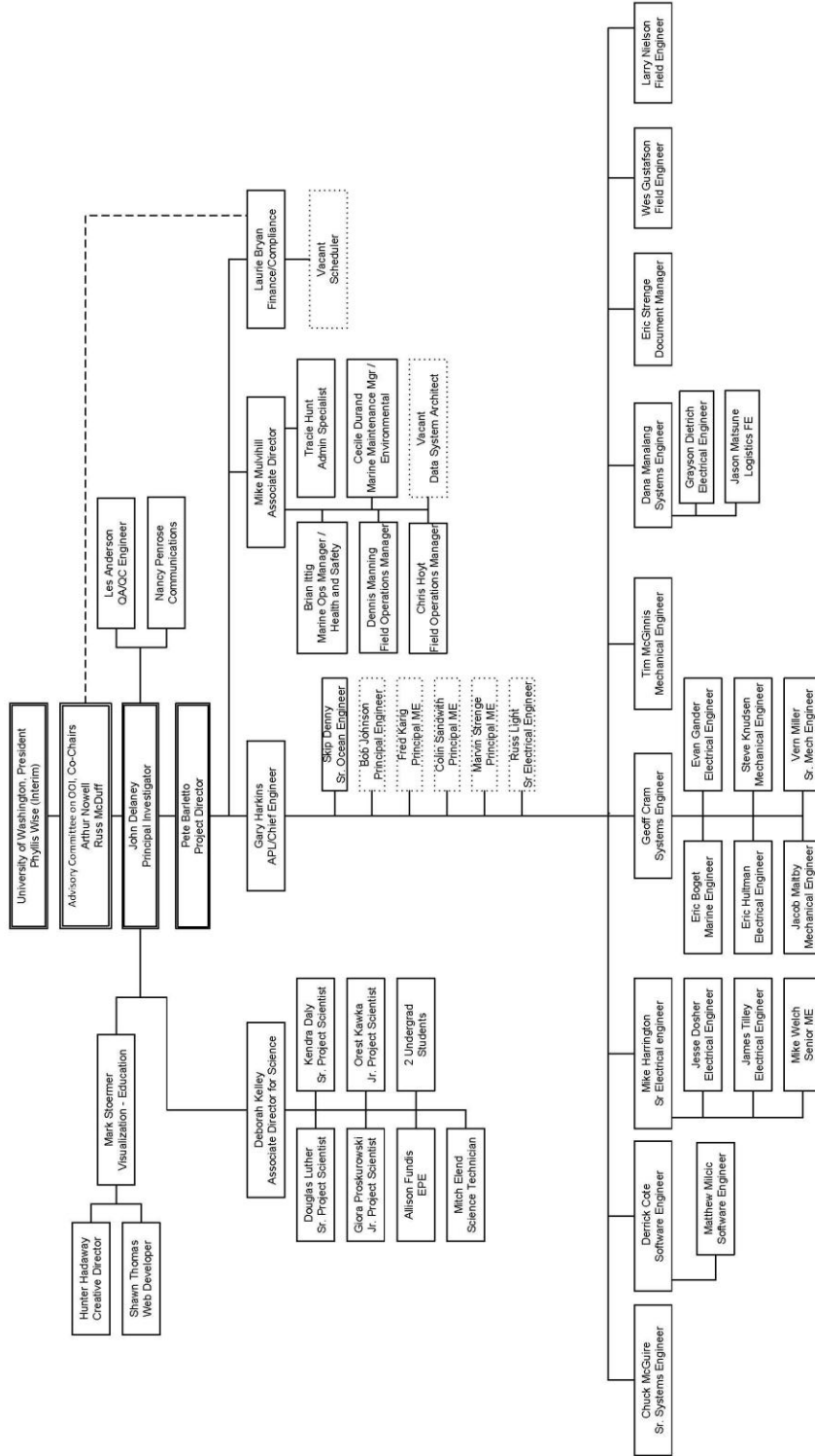
	OSU Ed Dever CSP Support / BEP / ISMT2 / Glider Support	AST2 Test Steve Parks CSM / CPM	Surface Steve Parks Coastal / Global / Fuel Cell	WHOI Profiler TBD CPH	SIO Global AST2 - GHP / Hybird / Mesoscale / Global Glider	OMC / Testbed / Modelling Ian Owen	Vehicles / Instrument Procurement David Zimmerman AUI / CSDP / CSPSP / GSPP	Atrays Liz Caporali (Acting) Pioneer / Entrance / Global
<b>Systems Engineering</b> Sheri White	System Engineer Ed Dever Jonathan Fram	System Engineer Sheri White Bill Marksteiner	System Engineer Sheri White Bill Marksteiner	System Engineer Sheri White Bill Marksteiner	System Engineer Ken Angel	System Engineer Sheri White	System Engineer Sheri White	System Engineer Sheri White
<b>Hardware / Software</b> Steve Holford	Electrical Engineer Linda Faylor	Electrical Engineers Keith von der Heydt, M Robert Pettit, R Patt, E, Jameson, J Zhu, M D Angelo, T Schatz, K McMonagle, J Lund	Electrical Engineers Keith von der Heydt, M Robert Pettit, R Patt, E, Jameson, J Zhu, M D Angelo, T Schatz, K McMonagle, J Lund	Electrical Engineers Keith von der Heydt, Robert Pettit, Kathleen McMonagle, J Lund	Electrical Engineers Roman Heur, Lloyd Green	Electrical Engineers Jim Pfahfifi, John Lund, Kathleen McMonagle	Electrical Engineers John Lund, Kathleen McMonagle	
<b>Hardware / Software</b> Steve Holford	Software Chris Wingard	Software Steve Lerner Michael Eder	Software Steve Lerner Michael Eder	Software Steve Lerner	Software Roman Heur	Software Michael Eder Modeling Subhanshu Mohanty	Software Steve Lerner	
<b>Mechanical / Deployment</b> Don Peters	Mechanical Engineer Kent Fletcher David Waldorf / Matt Waldorf / Chris Holm	Electrical Assistants Brian Kelly Denise Manchester	Mechanical Engineers Don Peters Rick Coates Jeremy Paulus Dan Duffany	Mechanical Engineer Don Peters	Mechanical Engineer Matt Molobran	Mechanical Engineer Will Sellers	Mechanical Engineer Don Peters	Deploy / Recovery Don Peters John Kemp Will Odrom
<b>IV and T Requirements</b> Marcos Sastrre-Cordoba	IV & T David Neiman	IV & T Marcos Sastrre-Cordoba	IV & T Marcos Sastrre-Cordoba	IV & T Marcos Sastrre-Cordoba	IV & T Ken Angel	IV & T Marcos Sastrre-Cordoba	IV & T Marcos Sastrre-Cordoba	IV & T Marcos Sastrre-Cordoba
<b>Logistics</b> TBD	O&M Tom Keimley		RMA Milena Krasich	RMA Milena Krasich	RMA Ken Angel	Installation TBD	RMA Milena Krasich	Logistics Breeze Simmons
<b>Logistics</b> TBD		Safety Tim Sheehan	Safety Tim Sheehan	Safety Tim Sheehan	Safety Christian Bagler	Safety Tim Sheehan	Safety Tim Sheehan	Field Ops Planning Casper Breeze Simmons
<b>Manufacturing</b> Ed White	Sub Contracts Ed Dever Jonathan Fram Kent Fletcher	Manufacturing Ed White Rick Sisson	Manufacturing Ed White Rick Sisson	Manufacturing Ed White Rick Sisson	Manufacturing Matt Moldovan		Sub Contracts Ed White Rick Sisson	Repair / Refurbishment Ed White Sub Contract Manager (TBD)
<b>Science/ Instruments</b> Al Plueddemann	Project Scientist Jack Barth Michael Vardaro	Project Scientist Al Plueddemann	Project Scientist Al Plueddemann Jack Barth Uwe Send	Project Scientist Al Plueddemann Jack Barth Uwe Send	Project Scientist Matthias Lankhorst	Project Scientist Al Plueddemann	Project Scientist Al Plueddemann Jack Barth Uwe Send	Project Scientist Al Plueddemann Jack Barth Uwe Send

## Cross Product Teams

## Integrated Product Teams

April 22, 2011

Regional Implementing Organization Organizational Chart





Education and Public Engagement Implementing Organization  
Organization Chart  
Version April 20, 2011

