OCEAN OBSERVATORIES INITIATIVE

PROJECT EXECUTION PLAN

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Note: This document has been edited to remove information that is considered confidential and/or sensitive to ongoing or future financial negotiations for OOI procurements. Information removed has been replaced by the insertion of “[redacted]”.

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Executive Summary

The Ocean Observatories Initiative (OOI) project will construct 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 three 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 will be 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 will conduct 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 was created to incorporate the changes approved by the National Science Board (NSB) in May 2009. It will be modified as the project moves forward. The philosophy in writing this PEP is to incorporate 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 will be updated throughout the development and implementation phases of the OOI. This version of the document represents the approach planned at MREFC project initiation. 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 will be sent to the cognizant National Science Foundation (NSF) program officer for written approval.

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 will fund the planned facility through its Major Research Equipment and Facilities Construction (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.

The OOI program is managed through the OOI Program Office housed within the Consortium for Ocean Leadership (Ocean Leadership) 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 three implementing organizations (IOs) for the development, construction, and operation of the OOI. The Woods Hole Oceanographic Institution is the IO for the coastal and global nodes, the University of Washington for the regional nodes, and the University of California, San Diego for the cyberinfrastructure that connects the nodes together into an integrated observatory. A fourth implementing partner for building related education and public engagement infrastructure will be identified through a competitive procurement process after MREFC project initiation. Figure 1 shows the responsibilities of Ocean Leadership 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.

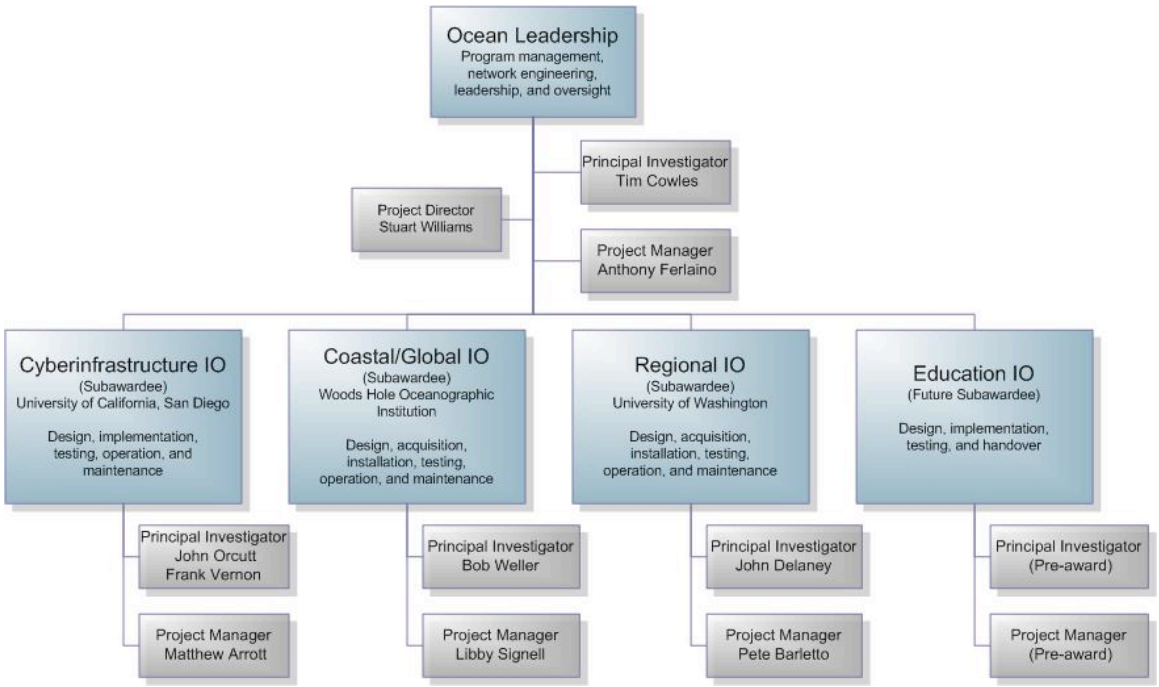


Figure 1 Responsibilities of Ocean Leadership and each Implementing Organization

NSF's guidance is to plan the OOI with a technically driven funding profile and allocation:

OOI Funding [redacted]

	PY 1	PY 2	PY 3	PY 4	PY 5	PY 6	Total
Project Office							
Contingency							
Cyber IO							
Coastal/Global IO							
Regional IO							
Education IO							
Total OOI							

The funding profile and allocation above has been 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 will be removed from each IO's budget 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 OOI Cost Book is the cost estimate controlled source.

This schedule assumes funds for the OOI construction will be provided by NSF in a timely manner to support a September 1, 2009, MREFC project initiation. Project planning and preparation for implementation will continue through FY 2009 and close out in the first quarter of FY2010, providing a transition to MREFC. This period is referred to as the “Pilot Period.”

The current OOI website (http://www.oceanleadership.org/ocean_observing) 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. Work on a more dynamic, comprehensive web presence will commence during the Pilot Period.

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 will support 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 21st 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. Most recently, following 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, the Regional Scale Nodes, the Coastal Scale Nodes, the integrating Cyberinfrastructure, and the Education and Public Engagement 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_2 uptake and ocean acidification are changing ocean properties.

The Global Scale Nodes (GSN) will support 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 Regional Scale Nodes (RSN) will enable 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 Coastal Scale Nodes (CSN) will support 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 will 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 uncertainties 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 transports and are recipients of climate signals from the poles and the equator will have comprehensive sampling by the CSN; and 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 where shelf topography, strong water mass property gradients, and propagation of signals from polar and equatorial regimes as well as basin scale modes are seen.

The OOI's broadly distributed, multi-scale network of observing assets are bound together by an interactive Cyberinfrastructure (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 permit 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 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 will include 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 cyberinfrastructure (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. Coastal Scale Nodes (CSN): New observing facilities in contrasting coastal boundary current regimes on the East and West Coasts of the U.S.
2. Regional Scale Nodes (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. Global Scale Nodes (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.

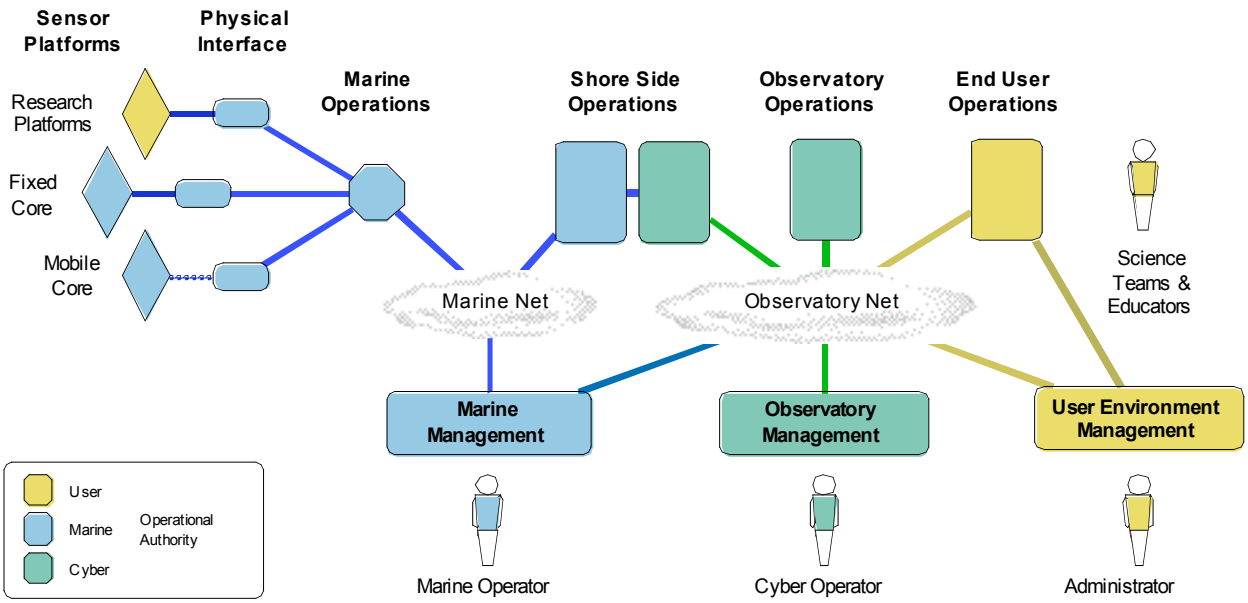


Figure 2. OOI Integrated Observatory.

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 to be specified more completely by negotiation between the CI IO and the EPE IO once the EPE IO has been identified. 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 Coastal Scale Nodes (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 Final Network Design* (FND) provides additional details on the OOI's coastal-scale platforms. A combination of moorings and movile 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 currently being installed 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 Global Scale Nodes (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 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 Draft EPE IO Request for Proposals provides additional details on the strategy to design and build this subsystem.

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 five separate releases that incrementally build the final capability. Ensuring an optimal level of performance in real-time without informational bottlenecks will pose significant challenges and require unique multi-tiered project management, engineering, construction, testing, operation and maintenance approaches.

2 Construction Approach

The NRC, in its report *Enabling Ocean Research in the 21st 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 agreement is expected, with MREFC funding, prior to the planned project start date of September 1, 2009.

After a competitive bid process, OL made three subawards for development and implementation, one for the CI and two for the marine IOs. The CI award was made to University of California San Diego (UCSD). One marine IO award was made to Woods Hole Oceanographic Institution (WHOI) for the Coastal and Global Scale Nodes (CGSN) development and implementation. The other award for a marine IO was to the University of Washington for the Regional Scale Nodes (RSN) infrastructure. The EPE IO will be indentified via competitive selection process in project year one of the construction phase.

Ocean Leadership coordinates the work of the IOs and provides a single point-of-contact to NSF. Ocean Leadership has implemented a system engineering and program management team with representatives from each subawardee. The Ocean Leadership 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

Ocean Leadership'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. These documents will be updated to reflect the post-FDR design revision prior to the start of MREFC funding.

2.2 Construction and Installation Strategy

Each IO will contract with one or more entities for the construction and installation of its elements of the OOI, or construct 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 will conduct 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 IMS. Progress along this path will be 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, and then it can be deployed. 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 Ocean Leadership has overall responsibility for the oversight of the OOI project. In addition, Ocean Leadership 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 Consortium for Ocean Leadership, 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 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. Ocean Leadership currently comprises 44 full voting members, 31 non-voting associate members, and six non-voting affiliates. A 15-member Board of Trustees, which is elected by the voting members, has oversight responsibility for the corporation and its programmatic commitments.

Ocean Leadership'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 will be carried out by three competitively selected IOs, which are led by research or educational institutions, and an additional to-be-determined implementing partner for the education and public engagement infrastructure. The existing IOs are responsible for the CI, RSN, and CGSN; they were chosen via a competitive process to be University of California, San Diego (UCSD) and partners, University of Washington (UW), and Woods Hole Oceanographic Institution (WHOI) and partners, respectively. Authority and responsibility is transferred to the IO institutions via corporate subawards from Ocean Leadership, 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.

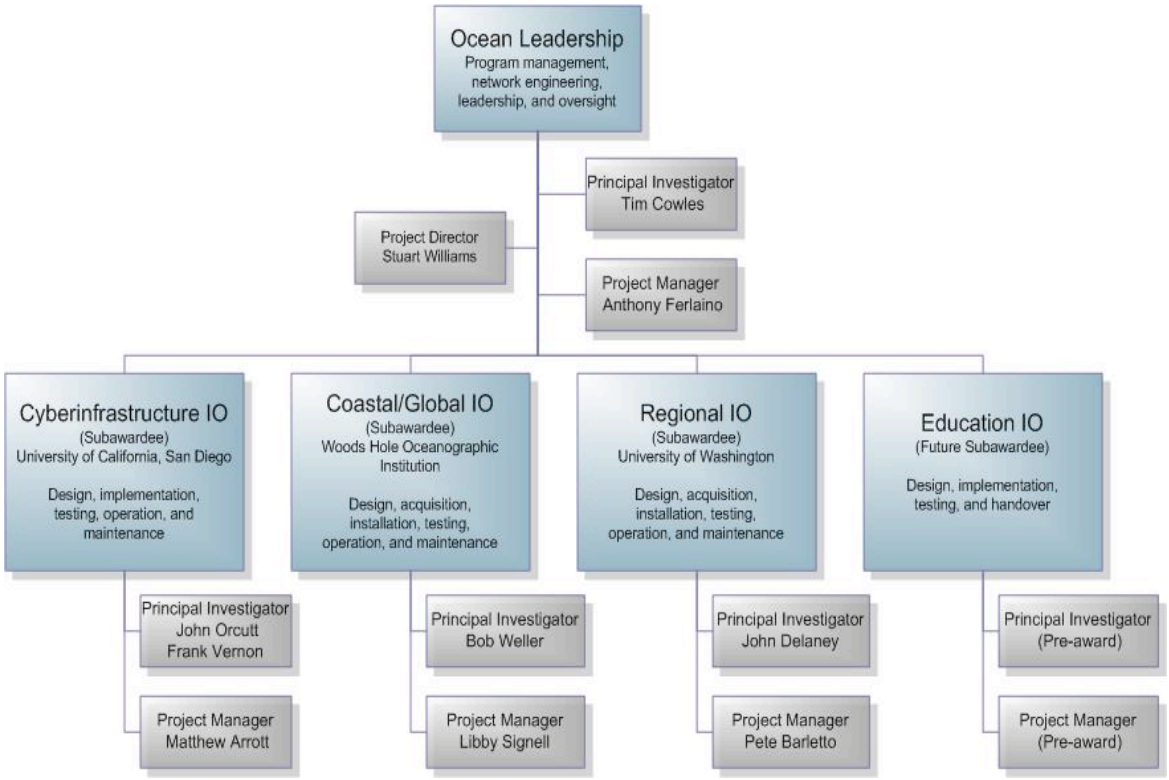


Figure 3. OOI Management and Oversight Structure

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 will generally make 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 will manage 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 polices, 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.

With the beginning of significant MREFC capital investment, the planning and development function will be 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 will be 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 will also convene via web-enabled meeting utilities and will have 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 serve as a resource pool for specific roles during MREFC execution. For example, PAC representation is envisioned in the membership of the higher level Change Control Boards described in the *OOI Configuration Management Plan*, and in the membership of the Facility Governance Group 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 agreements are in place. OOI will provide a foundation for the future establishment of numerous, substantial partnerships and synergistic collaborations. The OOI CI will ease access to the network's real-time data as well as data in third-party archives to support analyses and modeling.

Within NSF programs, an important partnership exists with the Monterey Accelerated Research System (MARS) test bed 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 was populated with sensor experiments in late 2008. In addition to equipment and design testing, MARS will also serve 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.

In a direct financial partnership, the Massachusetts Technology Collaborative, an independent economic development organization chartered by the Commonwealth of Massachusetts, has committed an initial $2 million in state funding toward implementation of the OOI's Pioneer Array by the WHOI partnership. Future additional support is under consideration and contingent on the OOI's inclusion in NSF's MREFC budget. 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, are already implementing 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.

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 partner with NOAA PMEL to establish and maintain the long-term Station Papa global site. NOAA PMEL will deploy and maintain the 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. DFO IOS cruises to the site will provide additional ship-based sampling opportunities and are potentially a resource to assist in glider deployments. As the program is initiated, CGSN will work with NOAA PMEL and DFO IOS to catalyze and coordinate scientific sampling and programs at and around Station Papa and continue the effort to sustain observations and expand observations and understanding in the region.

There is considerable international interest in the role of the high-latitude North Atlantic in climate change and in observing and understanding trends and variability. Moored observations have been made in the Irminger Sea under the Long-term Ocean Climate Observations (LOCO) effort by the Royal Netherland Institute for Sea Research (NIOZ) and by IFM-GEOMAR of Kiel, Germany. EuroSITES, the European Ocean Observing Network, is the planning group that coordinates long time-series ocean observing by European groups, and is a regional group under

the OceanSITES global umbrella. Collaboration with EuroSITES to coordinate observations and research in the Irminger Sea is being pursued. IFM-GEOMAR has made a commitment to continue moorings in the Irminger Sea over the next several years; the CGSN team has started discussions aimed at coordinating work in the Irminger Sea in 2013 (when the CGSN Irminger Sea site will be established) and beyond in conjunction with the EU 2014 funding milestone. The RSN and CGSN team will also investigate opportunities for collaboration with the Marine Institute in Galway, Ireland on high latitude North Atlantic observing programs and research. CGSN has begun discussions with a PI at the University of Galway about development of sensors for the OOI that could potentially be funded jointly by the U.S. NSF and Irish agencies.

The CGSN Global sites (as time series site) have been included in OceanSITES planning. OceanSITES is an action group of the Data Buoy Cooperation Panel of the Joint Commission on Oceanography and Marine Meteorology (JCOMM) of the World Meteorological Organization (WMO) and the International Oceanographic Commission (IOC). As a result, there is international coordination of the siting of the CGSN Global sites and an international framework for open data exchange and sharing. In the United States, the NOAA Climate Observation Program, which plans and funds long-term climate observations in the ocean for NOAA, acknowledges the CGSN Global sites in its planning activities. Directors of international oceanographic institutions have been working under the framework of the Partnership for Ocean Global Observations (POGO) to improve utilization of research ships. The CGSN PI will provide the schedule of CGSN global deployments to the POGO team in order to further explore the development of international research vessels as a back-up for the use of UNOLS vessels. A subset of the POGO institutions participate more formally in the Observing Facilities Exchange Group (OFEG) in Europe and are actively bartering ship time across institutions. The CGSN PI will alert OFEG to needs for the Irminger Sea and other global sites and alert the NSF when there appear to be alternatives to the use of University-National Oceanographic Laboratory System (UNOLS) vessels.

The CGSN team is exploring collaborations and capacity building for ocean observing with the Center for Oceanographic Research in the eastern South Pacific (COPAS), University of Concepcion. The COPAS Development Plan includes establishing ocean observations inshore of the OOI Southern Ocean site and a research station in Patagonia. Both COPAS and CGSN face the need to develop logistics support in a port convenient to this region, with Punta Arenas the CGSN port of choice. 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. Thus, CGSN will continue to pursue this opportunity for complementary observations and establishing a maintenance site at COPAS facilities. 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. Discussions have also begun with colleagues in Argentina to examine the possibilities for Argentine ship time and/or collaborative research activities at the Argentine Basin site

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

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 indentured 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.

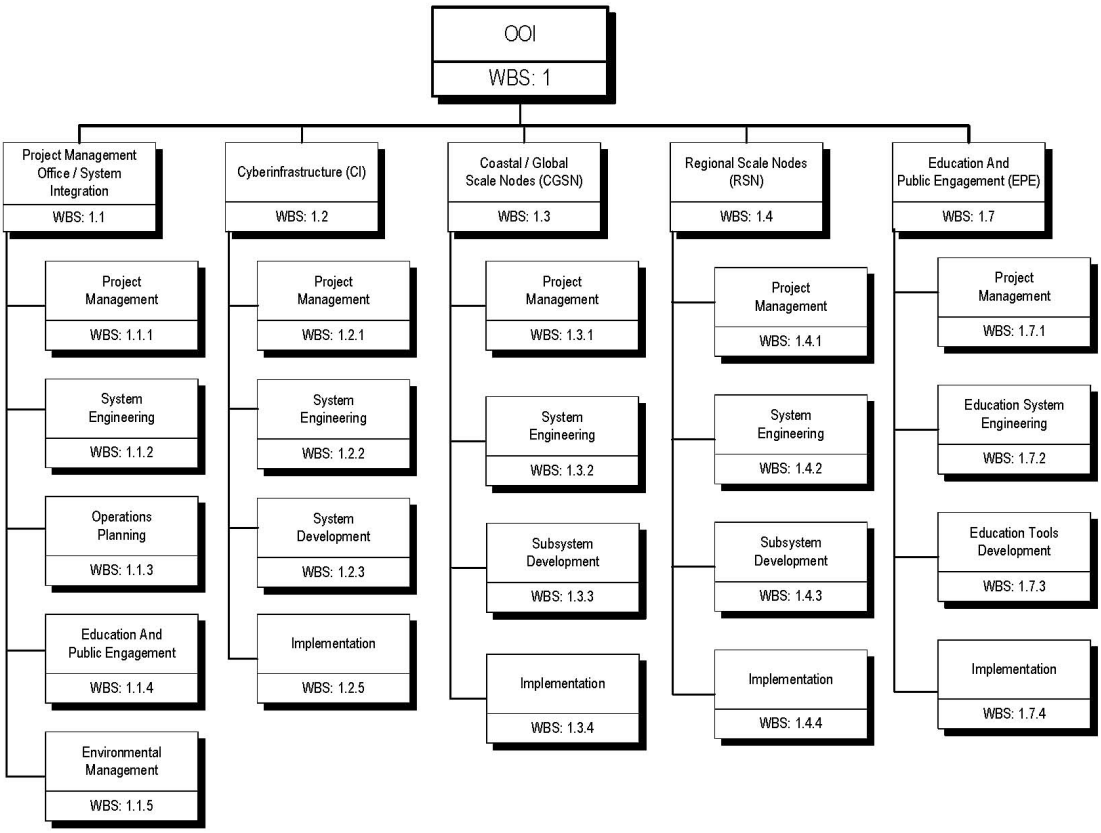


Figure 3. OOI Work Breakdown Structure at level 3

The integrated preliminary 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. The full WBS and accompanying WBS dictionary have been developed in MS Project and MS Excel respectively and are available as "1040-00000_IMS_OOI.mpp" and "1041-00000_WBS_Dictionary_OOI.xls". As the detail design engineering effort progresses additional tasks may be identified in the lower levels and the WBS would be updated. Any changes to the WBS will be 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 will be accomplished 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 (BCWS) from Cost Book, monthly actual costs (ACWP) from the respective IO and OL accounting systems and monthly schedule status from Microsoft Project, from which Cobra calculates the Earned Value (BCWP). Cobra uses these components (BCWS, ACWP and BCWP) to calculate standard periodic and cumulative EV variances (e.g. SV, SV) 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 will submit to the NSF on a monthly basis are available from within wInsight.

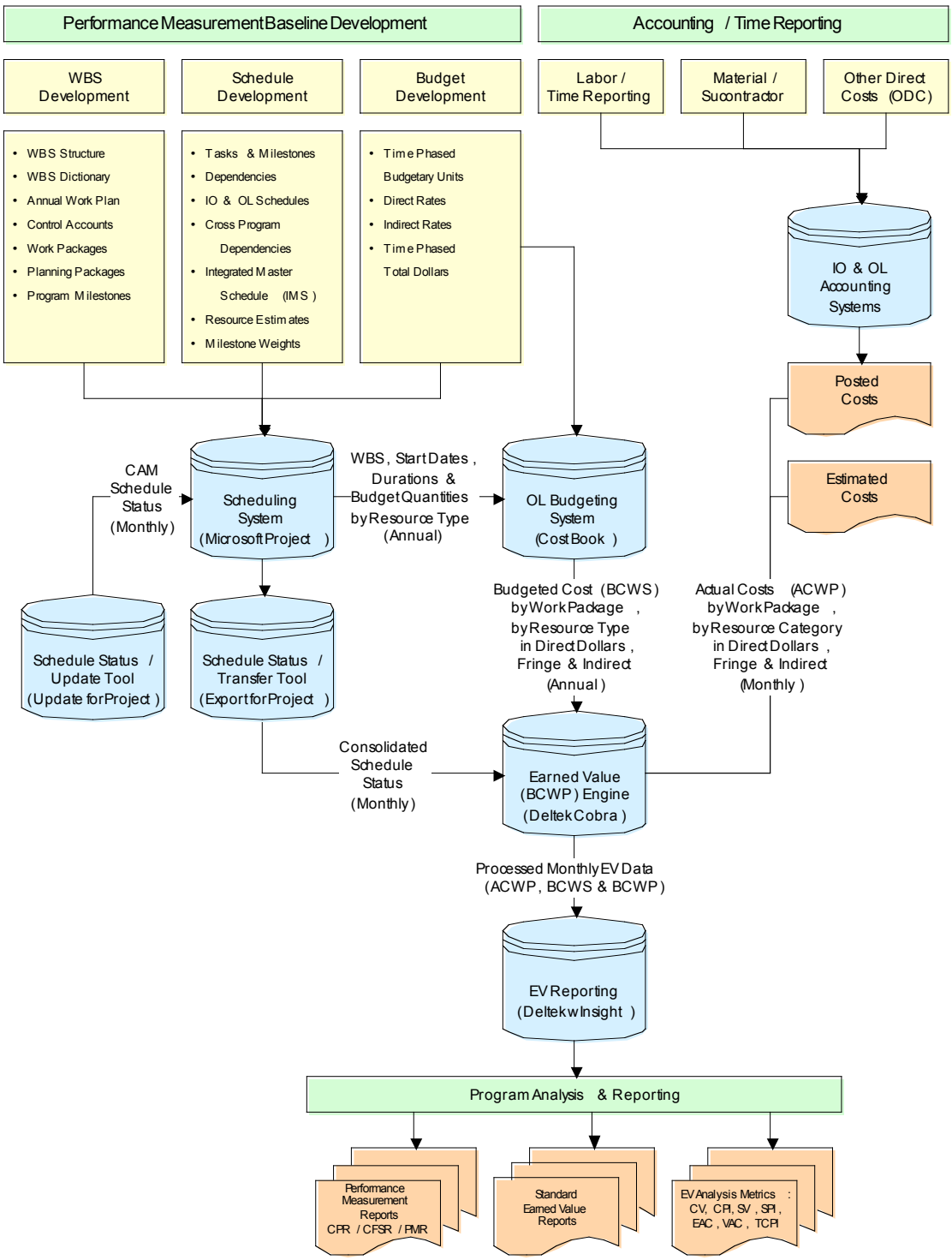


Figure 1, OOI Earned Value Management Infrastructure, describes the interaction of these tools and key EVMS data components.

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 are being 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 will be 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 will be 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 will consider 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 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 and to identify, collect, and prioritize assigned, customer, user, or operator requirements for the system, and portions thereof, including any requirements for development, production, test, deployment/installation, training, operations, support/maintenance, and disposal of the system's products.

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.

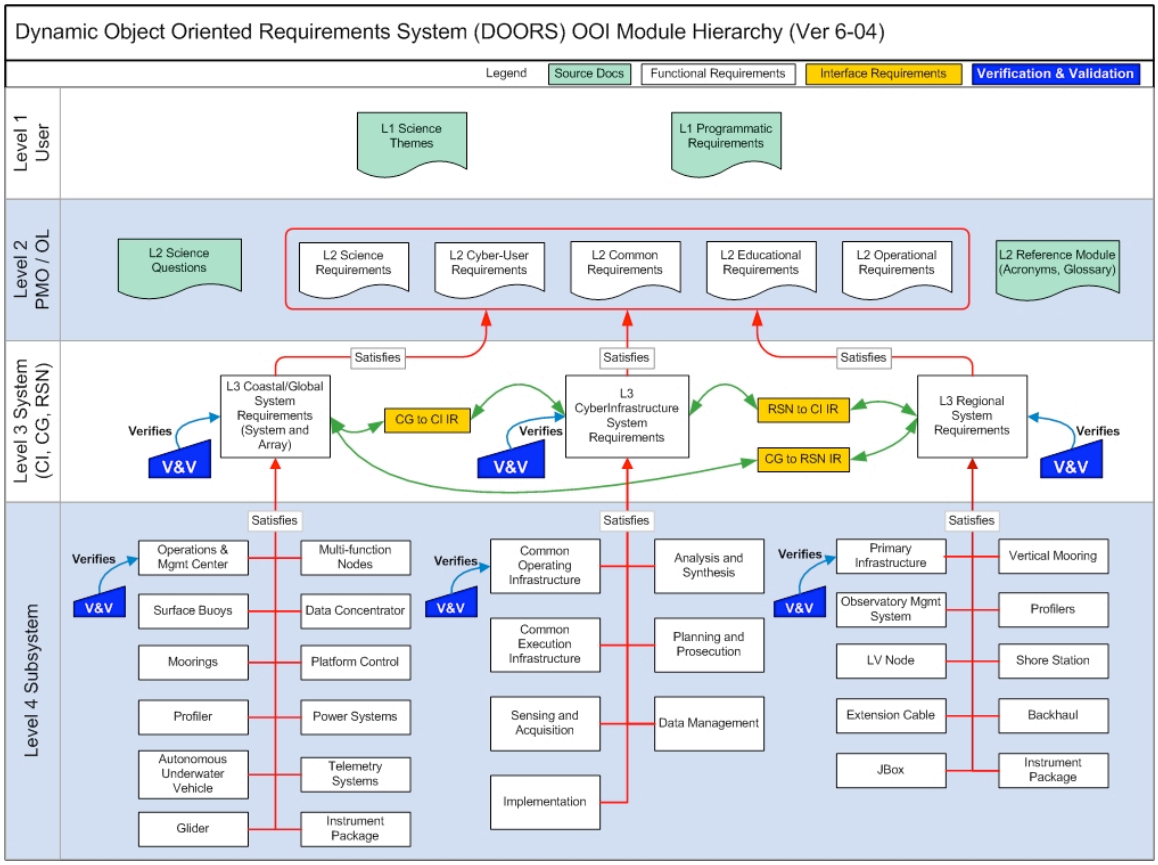


Figure 4. OOI Requirements Module Hierarchy

These requirements are the basis for the design and will serve as the reference to validate and verify the design through the test and commissioning process.

All the requirements, starting with the science requirements at the top level, are maintained in the DOORS database. 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 will be 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 observatories 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. The CI PEP identifies five annual CI releases of incremental 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. A comprehensive requirements review process will be implemented during the Pilot Period that includes internal engineering and user analysis. At least five times during the construction of the OOI there will be official consideration of end user feedback in the context of a 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 will be maintained and enforced under the program. The requirements will be used to develop the Interface Control Documents (ICD) 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 will be coordinated through the QA Manager for Ocean Observing Activities at OL who will report 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 OL COTRs will coordinate with the OL 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 will be developed during the Pilot Period for QA Planning, Evaluations and Audits. Processes 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 plans to hire a Quality Management Systems consultant, a recognized expert in the quality assurance field, to assist with and perform Quality Management functions on the OOI project. The Quality Management Systems consultant will provide guidance to the COTRs, will schedule and conduct quality audits of IO and subcontractor facilities, will assist with evaluation of the IO Quality Plans and procedures and will provide quality performance metrics to OL staff on a routine basis.

3.9 Risk Management

A formal risk management program has been implemented for the OOI. This program is described in the *OOI Risk Management Plan*, which is incorporated into this PEP by reference. The risk management plan follows an accepted standard risk management approach of planning, identifying potential risks, assessment, analysis and developing mitigation strategies or handling. Risk 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 management plan provides substance for and formalizes the Risk 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 consequence to the program. Risk management is an organized process to effectively reduce such risks to achieve program goals. The process includes planning, identification, assessment, analysis, and handling of potential risks, implementation of risk-handling options, and a monitoring effort to track the effectiveness of the risk management program. The goal of risk management is to define methods or identify alternatives that mitigate or minimize risks to an acceptable level.

Risk management consists of five separate, but interrelated activities:

- Risk Planning
- Risk Identification
- Risk Assessment
- Risk Analysis
- Risk Handling

In one sense, everyone involved in the OOI program contributes to risk management; i.e., all program participants are responsible for exposing risk items within their purview so that the negative impact of such risks can be minimized, but the organization that deals with risk on a regular basis is the Risk Management Board (RMB).

The RMB is led by the Ocean Leadership (OL) Project Director, or his/her delegate, as the Chair of the RMB. Mandatory and adjunct members of the RMB may voice their opinions and provide advice, but the Chair is responsible for any and all final decisions. The OL Risk Manager serves as the secretariat of the Risk Management Board with responsibility for hands-on maintenance of the Risk Register (database), generating the necessary reports to support Risk Management Board meetings, tracking the current status of each risk item, and tracking the status of risk handling activities against specific risk items.

The RMB is further comprised of Risk Managers from each of the IOs and the lead for risk on the Project Office Team. Each IO Program Manager, or his/her designee, is the IO's default representative Risk Manager. Regular membership on the RMB embraces the various managers and leads within 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 IPT Leads. Also, there will be occasions when additional technical experts and members of the IO's technical staff may be asked to attend RMB meetings, or become ad-hoc members, to effectively evaluate or address risk issues.

There are four risk-handling techniques, or options as part of the standard process and in the plan. Risk avoidance eliminates the sources of high risk and replaces them with lower-risk solutions. Risk transfer is the reallocation of risk from one part of the system to another or the reallocation of risks between the Government, the prime contractor, or subcontractors. Risk control manages the risk in a manner that reduces the likelihood of its occurrence and/or minimizes the risk's effect on the program. Risk assumption is the acknowledgment of the existence of a particular risk situation and a conscious decision to accept the associated level of risk without engaging in any special efforts to control it.

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 will comply 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 will implement 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 plans to hire an expert consultant in the EH&S field to manage the OOI EH&S program. The EH&S manager will be a key member of the OL staff and will report directly to the OL President. The EH&S manager will chair the OOI Safety Steering Committee. The EH&S manager will conduct 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 potential impacts on the human and natural environment associated with the proposed design, installation and operation of the Ocean Observatories Initiative (OOI) were assessed in a Programmatic Environmental Assessment (PEA) (National Science Foundation [NSF] 2008). The PEA analysis concluded that installation and operation of the proposed OOI as presented in the 2008 Final PEA would not have a significant impact on the environment and a Finding of No Significant Impact (FONSI) was signed on February 4, 2009 (NSF 2009). A Supplemental Environmental Report (SER) (NSF 2009) was also prepared to assess the potential impacts of proposed modifications to the design, installation and operation of the OOI.

The OOI Final Design was approved in May 2009; more details are now available to move forward from the programmatic stage to the site-specific stage of analysis. The NSF has funded Ocean Leadership to produce an environmental assessment (EA) to address installation and operation of the OOI Network that will meet the NSF legal responsibilities for compliance with the National Environmental Policy Act of 1969 (NEPA; 42 U.S. Code [USC] §4321 et seq.), the Council of Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] §§ 1500-1508), and the NSF regulations for implementing NEPA found in 45 Code of Federal Regulations (CFR) Part 640. The environmental assessment will be tiered off of the PEA and address the environmental impacts of the site specific design of the OOI.

NSF will invite the appropriate federal agencies with regulatory responsibilities to be cooperating agencies at the outset of this effort. Cooperation will facilitate the identification of potential issues to be addressed in the EA, encourage efficiencies in conducting reviews, and enable NSF and the cooperating agencies to meet their NEPA compliance responsibilities and other

environmental compliance necessary for the issue of permits. The EA will address as many compliance and/or regulatory requirements as practicable.

The OL Program Office will develop an Environmental Compliance and Permitting Plan early in the first year of the construction phase. The plan will define the roles and responsibilities of the RSN and CGSN IOs, all proposed subawardees, the Program Office and NSF with respect to the EA process and identify the Cooperating Agencies. The plan shall address all oversight responsibilities. The Program Office will provide an updated permit and compliance list and develop strategy and timelines for drafting the EA.

3.11.2 Permitting Responsibility

The marine Implementing Organizations (IO) will be responsible for obtaining all necessary permits, licenses, and authorizations from governmental, military, and regulatory agencies in order to construct, install, and operate the infrastructure. The Regional Scale Nodes (RSN) and Coastal-Global Scale Nodes (CGSN) Implementing Organizations have retained environmental engineering consultants to conduct analyses of the permits and environmental compliance documentation required for the different components of the OOI. The RSN and CGSN IOs will develop baseline schedules for securing required permits, licenses, authorizations and/or approvals; that information will be incorporated into the OOI Integrated Master Schedule (incorporated by reference).

As some components of the RSN and CGSN Endurance Array are linked, the Interface Agreement between the RSN IO and CGSN IO (incorporated by reference) specifies that CGSN shall be responsible for all surveying and permitting that is unique and attributable to the Endurance Array Sites in coordination with the RSN (reference RSN-CGSN IC-006). RSN shall be responsible for surveying and permitting specific to the cable installation at the Endurance Array Oregon Sites including the line to the Oregon Line 80m Low Voltage Node in coordination with the CGSN (reference RSN-CGSN IC-007).

The list of necessary permits, licenses, authorizations, and other environmental compliance documents, by installation site, will be updated in the OOI Permit and Environmental Compliance List (incorporated by reference).

3.12 Testing and Acceptance

OOI shall verify that each end system, subsystem, and task defined by the IO and OOI system design solution conforms to the requirements of the selected logical and physical solution representation. Each of the five (5) stages, Material/Prototype/Bench Testing, Factory Testing, Readiness Testing, Acceptance Testing, and Commissioning outline the selection and definition of the appropriate method for verification. Each stage defines verification procedures to be followed for the method selected; the purpose and objective of each procedure, pretest action, and post-test action; and the criteria for determining the success or failure of the procedure.

All five (5) stages of validation, verification and testing also look to perform the planned verification using the selected methods and procedures within the established verification environment to collect and evaluate verification outcomes to either show conformance to the requirements of the selected logical and physical solution representation or to identify variances (untraceable requirements and constraints, anomalies, variations, voids, and conflicts). They also resolve variances, as appropriate, and re-verify to establish compliance, when the cause of the variance was failure to properly complete the fully characterized design, as well as re-verify according to a redesigned verification plan, test method, or procedure when variances were determined to be caused by poor verification or inadequate verification environmental preparation.

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 verification results, including: corrective actions taken; lessons learned; outcomes achieved; tradeoff, effectiveness, and risk analyses completed with resulting key decisions; and tests activities.

A Test Plan will be developed for each formal test within OOI. The responsibility for testing will reside with the IOs. The systems engineers at each IO, in conjunction with the OOI System Engineer, will be responsible for verification and validation to ensure that science, engineering design, performance, and interface requirements are met throughout implementation. Each requirement will be verified and traced to the verification event, through the DOORS database of requirements.

Each IO's PEP contains a more detailed explanation of the testing, acceptance, and commissioning process, as well as the *OOI Commissioning Plan and Quality Assurance and Quality Control Plan*. The high-level guidance for testing is contained in the *OOI Systems Engineering Management Plan* (SEMP). The general approach is factory testing, followed by an integration test at a shore-based site prior to deployment in the water. After installation, each observatory system will be tested (Acceptance) and confirmed to be consistent with its pre-deployment characteristics. Commissioning is the final integration and operational readiness test of the series, performed at the Array level.

3.13 Annual Work Plans

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

Ocean Leadership and the IOs will prepare the 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 the *OOI Cost Book*. 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 will 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 will show 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 will efficiently store 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, which the OOI DMS will automatically inherit from the Alfresco base. 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 will be able to do so.

Ocean Leadership will coordinate 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 will include a section that analyzes the cost and schedule variances from the EVMS. Annual reports will be 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 off-the-shelf products. The one 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. 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%. 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 (President of JOI). 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.

The selection of the Education and Public Engagement (EPE) IO will be conducted through the same process after MREFC project initiation.

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. With commencement of MREFC funding and full implementation of the Project Management Control System, COTRs will 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 will be 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). 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 will be incorporated into the IO subawards; therefore NSF and Ocean Leadership will review 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 will develop an Advanced Acquisition Plan for OOI Acquisitions which is to be included in Ocean Leadership's Annual Work Plan. The worksheet will identify anticipated new high-value awards or acquisitions across the program. The Advanced Acquisition Plan will specify 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 will assist 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 will be implemented by OL under the direction of the Ocean Leadership Director of Contracts and Grants. It will be used to audit Implementing Organizations (IOs) in the management of their property systems. Each IO will have 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 will maintain formal written policies, plans and procedures that provide an effective property control system for each type of 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 Ocean Leadership Director of Contracts and Grants, to the Ocean Leadership Contracting Officer's Technical Representatives (COTR), and to the Ocean Leadership Property Administrator responsible for the custody of OOI equipment. If an incident of loss, damage or destruction (LDD) occurs, the Ocean Leadership Director of Contracts and Grants and the Ocean Leadership Property Administrator will be 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 Ocean Leadership Property Administrator will be performed on an annual basis.

4 Security

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

4.1 Physical Security

[redacted]

4.2 Cyberinfrastructure Security

[redacted]

4.3 Operational Security

[redacted]

5 Operations and Maintenance

5.1 Operations and Maintenance Planning

Initial Operations and Maintenance in the OOI Project Office will start in Project Year 1 with the hire of a full time O&M Manager (OMM) to plan O&M. The OMM will assist with the selection of insurance brokers to protect OL interests in the ownership of OOI assets. The OMM will perform logistics analysis of OOI systems and equipment, will perform maintenance planning and staffing analysis and will oversee 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 Ocean Leadership and the IOs can establish requirements for governance, daily operations, maintenance, administration, policies and procedures. This plan establishes two groups, the Facility Governance Group (FGG) and the Facility Operators Group (FOG). [redacted]

[redacted]
Figure 5.

Concurrently, the IOs will start 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*, Appendix A-4, Proposal Process for the OOI). 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 require engagement with OOI personnel in the early stages of proposal preparation. Potential investigators will be provided guidance and information regarding feasibility assessments, facility usage, budgeting, technical and cyberinfrastucture 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. Information about the OOI proposal process will be available on the OOI website and will also be discussed at upcoming OOI Community Workshops to be held after the start of construction. 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 Office will convene the first in a series of regional community meetings early in the construction period 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 at a generic annual budget level between $50-100K per year. Specific plans for these workshops will be developed with advice from the Program Advisory Committee and NSF/OCE and evolve as responses to initial regional meetings is gathered. 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.

5.3 Service levels, maintenance, and logistics approaches

Service levels, maintenance, and logistics approaches will be defined for the OOI as the engineering design progresses. There are a wide variety of maintenance options that will affect both cost and service levels. Additionally, the requirements for maintenance of science instruments will require the specification of service level agreements on different levels. For example, if an instrument needs to be serviced frequently, then the availability of that instrument will be lower than for a less-frequently serviced sensor, which in turn will have lower availability than a backbone cable in the network.

The current estimates by the marine IOs for annual maintenance (cruises) at each site are:

- Regional Scale Nodes:
  - One planned visit to each site during summer of every year; duration is 20 days/site.
  - One unplanned backbone repair every three to five years; assume duration of about 7 days per repair.
- Global Scale Nodes:
  - One planned visit to each site every year; duration is 22 to 28 days at sea per site, depending on transit time.
- Coastal Scale Nodes:
  - Two planned mooring servicing visits to each site every year.
  - Duration for Pioneer Array mooring cruise is 12 days/visit.
  - One visit to Endurance Array Oregon Line each year requires an intermediate vessel and, in collaboration with RSN a large vessel with ROV capability.
  - Duration for Endurance Array Oregon Line visits by intermediate vessel is 10 days per visit per line; duration for the CGSN-RSN visit is 8 days.
  - Duration for Endurance Array Washington Line visits by intermediate vessel is 12 days per visit per line.
  - Pioneer Array has 4 trips per year (3 days each) of a small vessel for glider/AUV servicing.
  - Endurance will use a small boat for glider servicing several times a year.

5.4 Estimate of Operational Costs

As part of the design process, operational costs have been estimated for each element of the observatory. A $50 million constraint (FY2013 dollars) on annual O&M was the controlling cost parameter for the design of the OOI. The conceptual design was modified to meet the O&M limit by changing the design elements and altering the technical baseline of the system. At PDR there was the same $50 million limit on O&M costs in FY2013 dollars, plus a limit of $331 million for the MREFC costs. These constraints were met at PDR and were modified for FDR to reflect the use of a programmatic constraint of $55 million for O&M in FY 2015 dollars. The FND was developed to meet this constraint.

The directed variant design will be developed with a technically informed O&M cost ceiling of $67.9M in FY2016 dollars. The variant FND includes the addition of the Washington Line of the Endurance Array as well as an additional Global Site in the Argentine Basin. Scope was removed from the Regional Cabled array; an overall net increase in sensors on the system of systems drives a larger requirement for operations and maintenance.

6 Reviews

Multiple review mechanisms will be employed during construction of the OOI facility to ensure effective management, performance, and compliance with requirements. The sponsoring agency, NSF, will conduct reviews in accordance with the MREFC process. As with other large facility programs, NSF will organize 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) have and will be conducted at key junctures. For larger complex configuration items, this may be a progressive or incremental review, culminating in a system-level reviews that essentially validate the completeness of preceding configuration-item-level FDRs and ensures adequate interfaces between all configuration items. Completion of the FDR sets the production baseline for the construction. This review step is discussed further in the CMP and SEMP.

Regular, issue-specific technical and cost reviews will also be 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 will be 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.

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 will also help determine progress toward satisfying the technical review entry requirements and help prepare the materials constituting technical review package and presentation package.

The *ifdr* (*internal final design review*) is an internal engineering technical review (not to be confused with the NSF Final Design Review process) conducted by the OOI Program Office to evaluate the progress, technical adequacy, and risk associated with the detail design solution prior to the release of drawings/specifications for manufacture or purchase of materials. Emphasis is on complete representation of the design; to the degree to which the proposed design meets the associated requirements, the nature, and extent of any derived requirements that are introduced as a result of specific design choices, and the overall risk to proceed into implementation.

The *ifdr* may be incremental, provided the capstone *ifdr* takes into account the inter-relation of the entire system and address issues that arise with respect to conflicts in module fit and operation with relation to each other and the system. For large complex configuration items, the *ifdr* may be a progressive review, culminating in a system level FDR which essentially reviews the completeness of preceding *ifdr*s and ensures adequate interfaces between the configuration items. For the product or products under review, the complete subsystem design is presented, highlighting all design changes made with respect to the design disclosed in the PDR, and providing rationale for the changes.

All OOI systems are required to undergo an *ifdr* after the external FDR and start of the MREFC project. This type of *ifdr* is commonly referred to as a "critical" review, prior to releasing first production drawings to manufacture components of any production equipment, hardware and software.

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*.

Once development is underway, prior to formal acceptance testing, Test Readiness Reviews (TRR) are planned. This activity conducts a multi-disciplined technical review to ensure that a subsystem or system is ready to proceed into formal test. The Test Readiness Review (TRR) assesses test objectives, test methods and procedures, scope of tests, and safety, and confirms that required test resources have been properly identified and coordinated to support planned tests. The Test Readiness Review (TRR) is an internal review conducted to evaluate the overall readiness to enter formal verification testing. Emphasis is on complete definition of the unit under test and the environment needed to conduct the test, availability of resources and facilities, and on establishment of clear pass and fail criteria.

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.

Document Title	Document File Name
Ocean Observatories Initiative Science Plan (May 2005)	http://www.oceanleadership.org/files/OOI_Science_Plan.pdf
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	http://www.oceanleadership.org/files/Science_Prospectus_2007-10-10_lowres_0.pdf
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)	http://www.nsf.gov/geo/oce/pubs/OOI_Final_PEA_Jun08.pdf
OOI Integrated Master Schedule	1040-00000_IMS_OOI
CGSN Permitting List	3101-00010_Permit_List
RSN Permitting List	4025-00001_Permit_List_RSN
OOI Permit and Environmental Compliance List	1001-00001_Permit_List_OOI
OOI Cost Book	1050-00000_Cost_Book_Integrated_OOI
OOI Acquisition Plan	1008-00000_Acquisition_Plan_OOI
OOI Property Management Plan	1011-00000_Property_Management_Plan_OOI

Appendix A-2: Acronym List

AUV	Autonomous Underwater Vehicle
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
DOORS	Dynamic Object Oriented Requirements System
ECM	Environmental Compliance Manager
EIS	Environmental Impact Statement
ESONET	European Seafloor Observatory Network
EVMS	Earned Value Management System
FDR	Final Design Review
FGG	Facility Governance Group
FND	Final Design Review
FY	Fiscal Year
FOG	Facility Operators Group
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
IO	Implementing Organization
IOOS	Integrated Ocean Observing System
JOI	Joint Oceanographic Institutions
MARS	Monterey Accelerated Research System
MBARI	Monterey Bay Aquarium Research Institute
MREFC	Major Research Equipment and Facilities Construction
NASA	National Aeronautics and Space Administration
NEON	National Ecological Observatory Network
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
O&M	Operations and Maintenance
OMM	Operations and Maintenance Manager
OOI	Ocean Observatories Initiative
OSC	Observatory Steering Committee
OSU	Oregon State University
PAC	Program Advisory Committee
PCA	Physical Configuration Audit
PDR	Preliminary Design Review
PEA	Programmatic Environmental Assessment
PEP	Project Execution Plan
PI	Principal Investigator

PMP	Property Management Plan
PND	Preliminary Network Design
RFP	Request for Proposal
RFQ	Request for Qualification
R&RA	Research and Related Activities
RSN	Regional Scale Nodes
SDE	System Development Environment
SIO	Scripps Institution of Oceanography
SRD	System Requirements Document
SUR	Science User Requirements
TDP	Technical Data Package
UCSD	University of California, San Diego
UW	University of Washington
VENUS	Victoria Experimental Network Under the Sea
WBS	Work Breakdown Structure
WHOI	Woods Hole Oceanographic Institution

Appendix A-3: Current Membership, Program Advisory Committee

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
Charles Greene	Cornell University
Naomi Leonard	Princeton University
Larry Mayer *	University of New Hampshire
Mike Purdy	Lamont-Doherty Earth Observatory
Verena Tunnicliffe	University of Victoria
Warren Washington	National Center for Atmospheric Research
Michael Wysession	Washington University

* 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 (108 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	9 sensors
Bottom Instrument Package	7 sensors

Node 3 Axial Seamount

Seafloor: Primary and Secondary	26 sensors total
Profiler – Winched	12 sensors
Profiler – Wire crawler	5 sensors
Midwater Platform @ 200m	9 sensors
Bottom Instrument Package	7 sensors

Node 5 Mid-plate

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

Global Scale Nodes (301 total sensors)

Node 6 Station Papa	
Moorings	1 Subsurface Hybrid Profiler with 12 sensors
	2 Flanking Moorings with 17 sensors each
Mobile assets	3 Gliders with 4 sensors each
Node 7 Irminger Sea	
Moorings	1 Surface Mooring with 23 sensors
	1 Subsurface Hybrid Profiler with 12 sensors
	2 Flanking Moorings with 17 sensors each
Mobile	3 Gliders with 4 sensors each
Node 8 Southern Ocean	
Moorings	1 Surface Mooring with 23 sensors
	1 Subsurface Hybrid Profiler with 12 sensors
	2 Flanking Moorings with 17 sensors each
Mobile Assets	3 Gliders with 4 sensors each
Node 12 Argentine Basin	
Moorings	1 Surface Mooring with 23 sensors
	1 Subsurface Hybrid Profiler with 12 sensors
	2 Flanking Moorings with 17 sensors each
Mobile Assets	3 Gliders with 4 sensors each

Coastal Scale Nodes (387 total sensors):

Node 10 Pioneer Array (150 total sensors)	
Surface Moorings	1 with 14 sensors; 2 with 12 sensors each
Winched Profiler Moorings	1 with 9 sensors; 1 with 8 sensors
Profiler Moorings	4 with 6 sensors each; 1 with 5 sensors
Multi Function Nodes (MFNs)	1 with 8 sensors; 1 with 9 sensors; 1 with 10
Docking Stations for AUVs	2 on MFNs
Mobile Assets	3 AUVs with 5 sensors each
	6 Gliders with 4 sensors each

Node 11 Endurance Array (237 total sensors)

Oregon Line

Surface Moorings	2 (80 m, 500 m) with 16 sensors each
	1 (25 m) with 12 sensors
Winched 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
Low-Voltage Benthic Node	1 (25 m) with 10 sensors, uncabled
	2 (80 m, 500 m), with 11 and 9 sensors respectively, cabled to RSN

Washington Line

Surface Moorings	2 (80 m, 500 m) with 16 sensors each
	1 (25 m) with 12 sensors
Winched Profiler Moorings	1 (25 m) with 10 sensors
	1 (80 m) with 9 sensors
Profiler Moorings	1 (500 m) with 7 sensors
Low-Voltage Benthic Node	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

Number of Sensor Types	Number of Sensors	Sensor Location
49	796	All OOI core; Note that a total of 31 suppliers can supply the 49 sensors
33	108	RSN Total
32	688	CGSN Total: 301 Global; 150 Pioneer; 237 Endurance
16	416	Common sensors on both RSN and CGSN
17	34	Unique to RSN only
16	346	Unique to CGSN only

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 Stations:

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

Item	Milestone / Task Name	Date
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

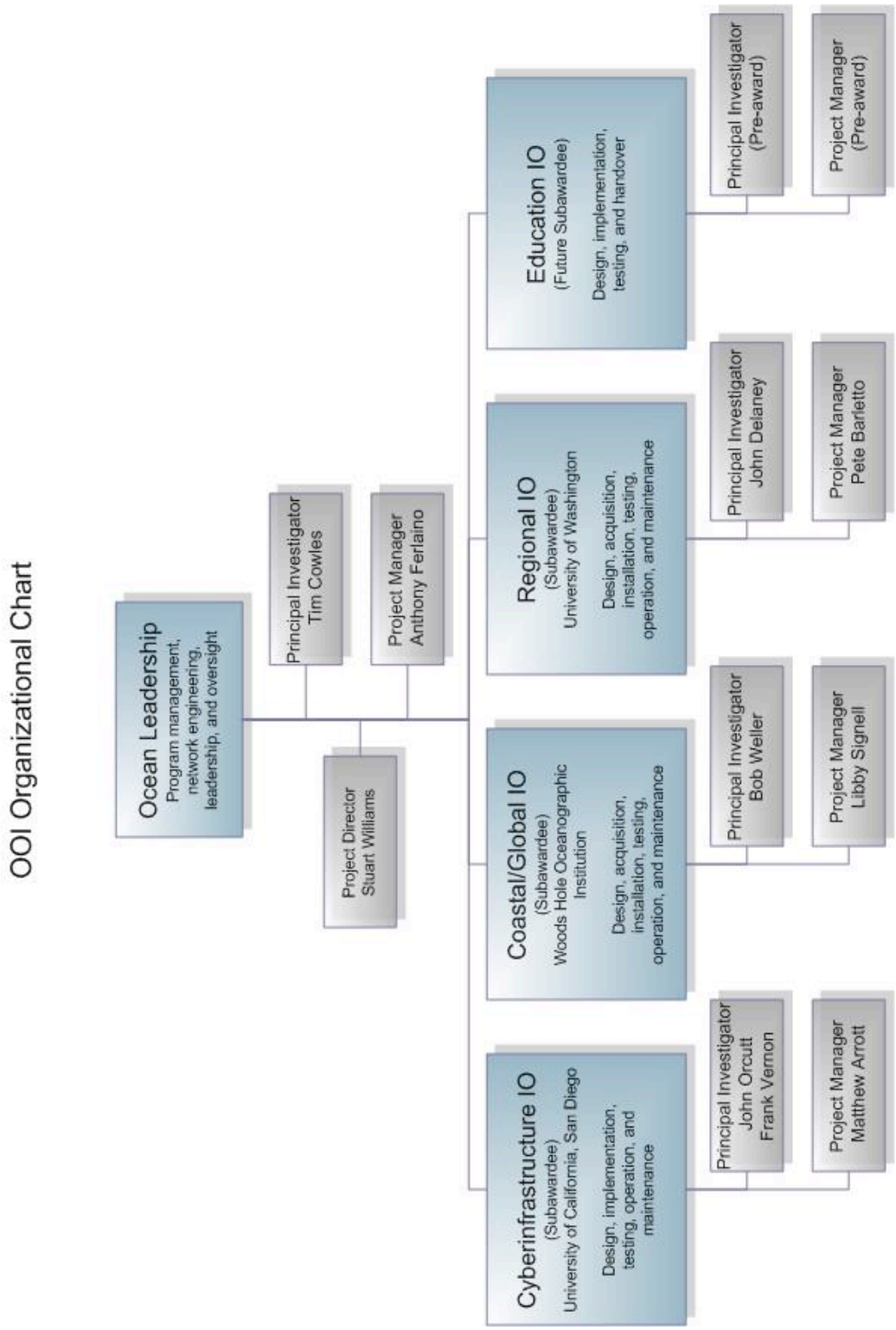
Item	Milestone / Task Name	Date
34	Installation Readiness Test Complete - Hydrate Ridge	Mar, 2013
35	Endurance Array Installation Readiness Review/ PCA - Uncabled	Apr, 2013
36	Station Papa Installation Readiness Review/ PCA	Apr, 2013
37	Irminger Sea Installation Readiness Review/ PCA	Apr, 2013
38	Installation 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

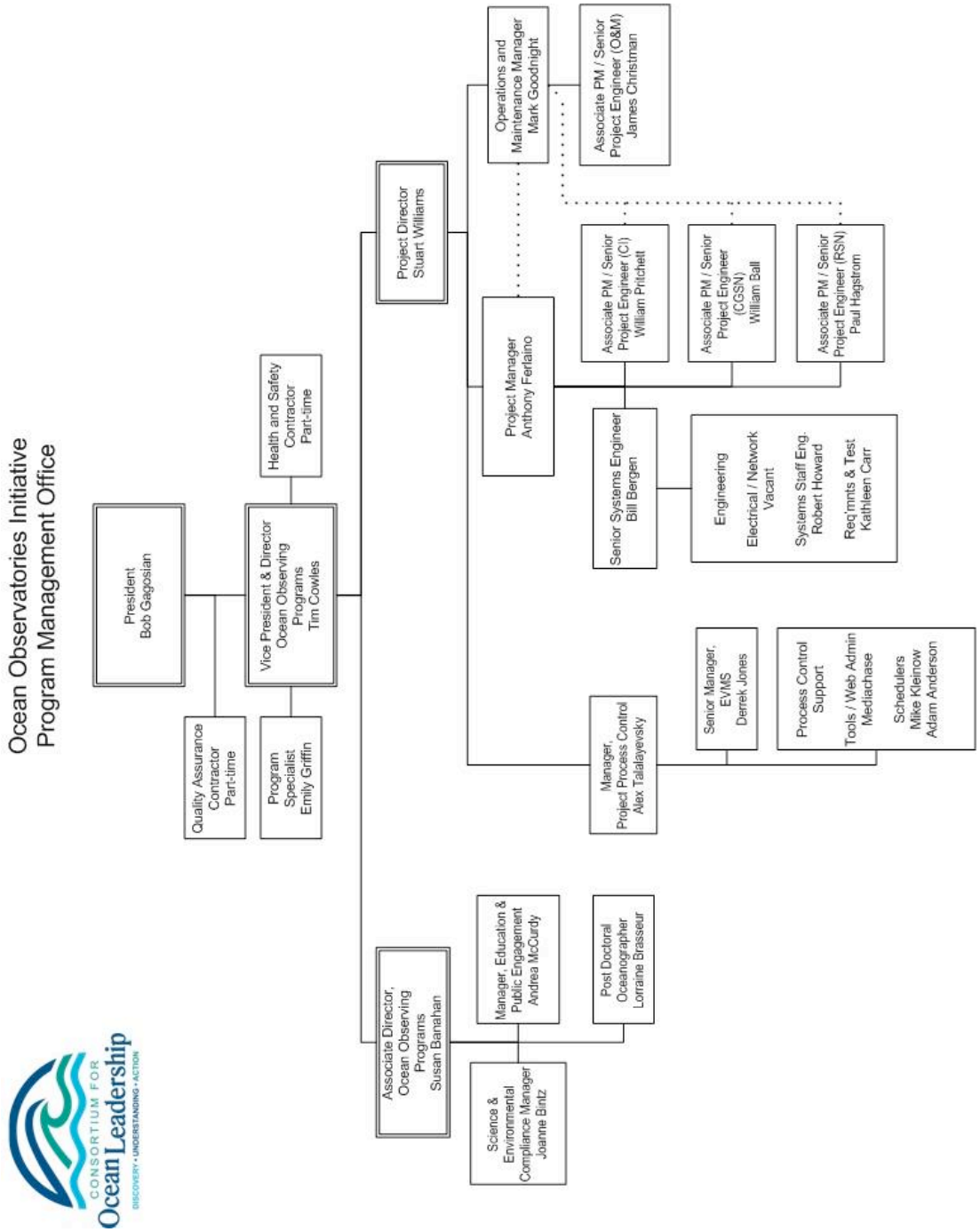
IRR - Installation Readiness Review

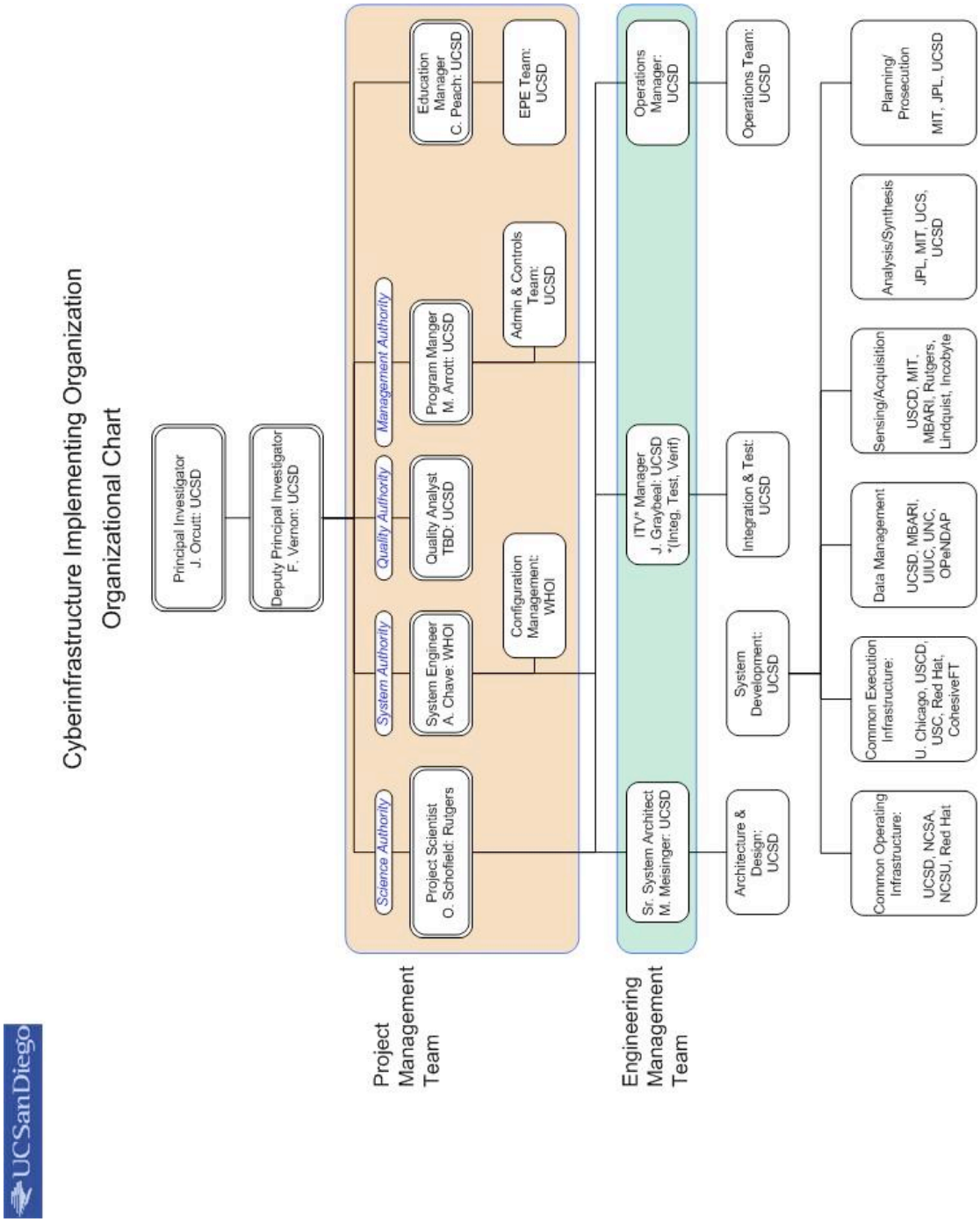
PCA - Physical Configuration Audit

PRR - Production Readiness Review

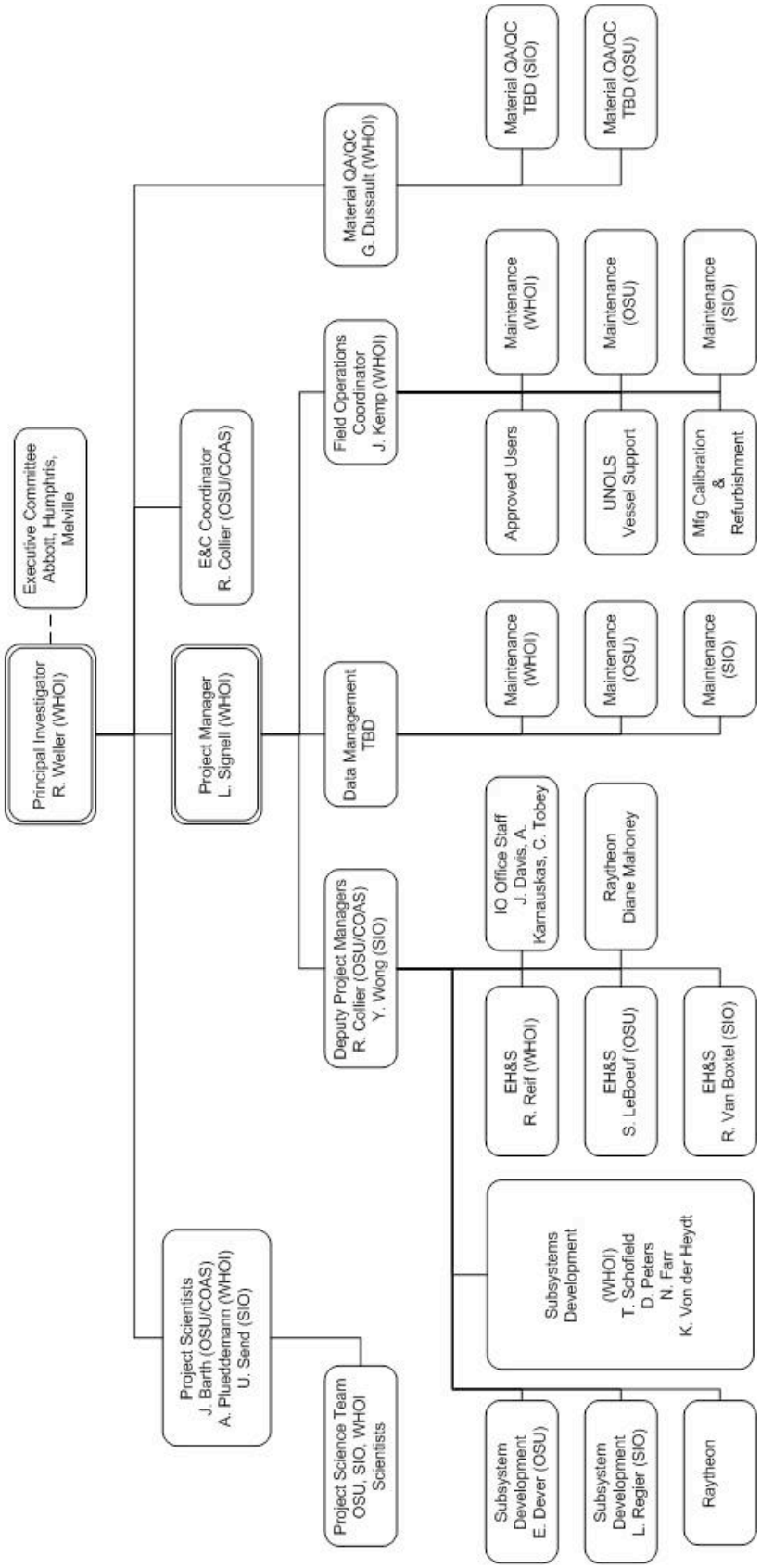
Appendix A-5: PMO and IO Organizational Structure



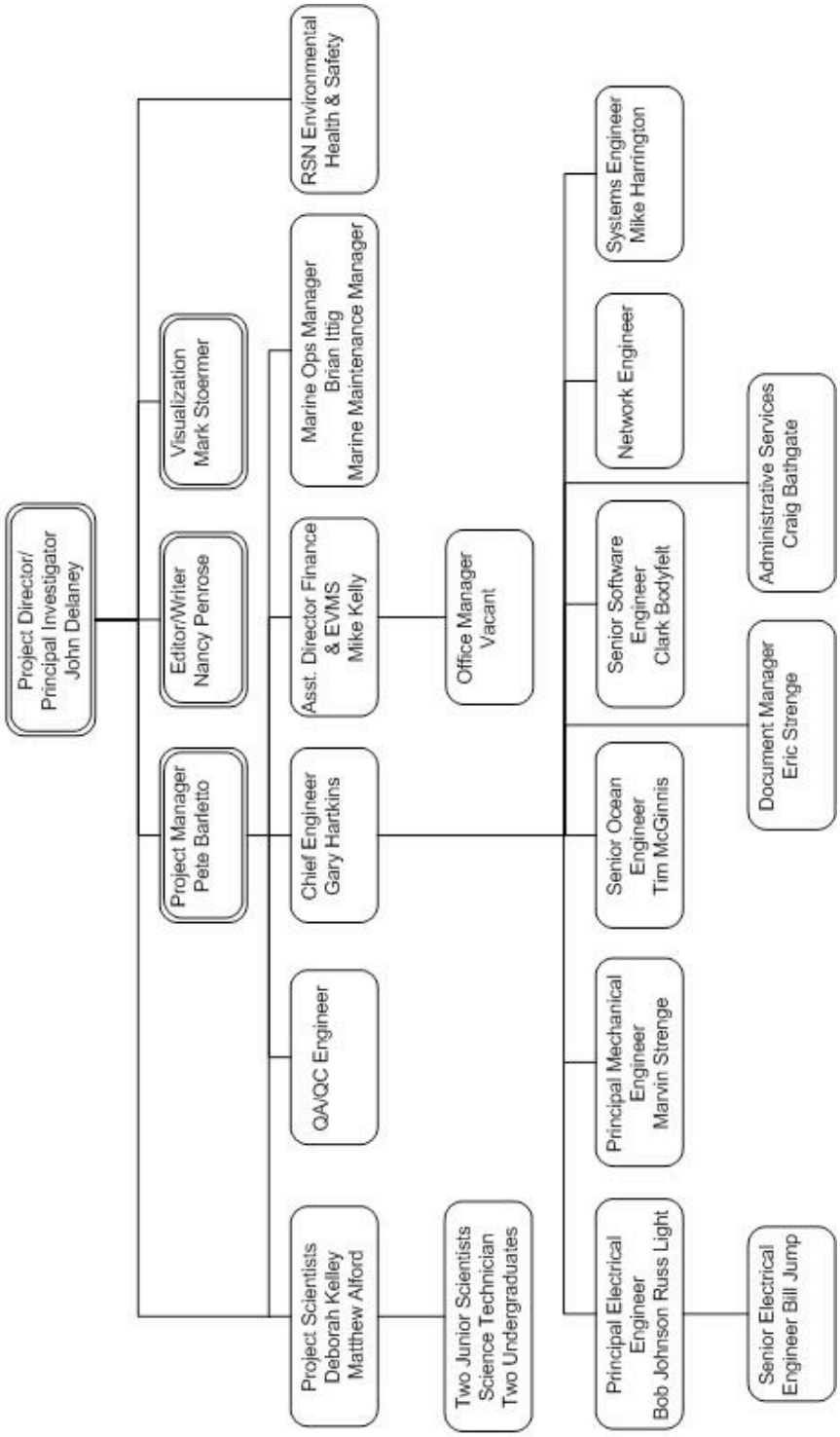

Ocean Observatories Initiative
Program Management Office
President
Bob Gagosian
Quality Assurance
Contractor
Part-time
Vice President & Director
Ocean Observing
Programs
Tim Cowles
Program
Specialist
Emily Griffin
Health and Safety
Contractor
Part-time
Project Director
Stuart Williams
Operations and
Maintenance Manager
Mark Goodnight
Associate PM / Senior
Project Engineer (O&M)
James Christman
Project Manager
Anthony Ferlaino
Associate PM / Senior
Project Engineer (CI)
William Pritchett
Associate PM / Senior
Project Engineer
(CGSN)
William Ball
Associate PM / Senior
Project Engineer (RSN)
Paul Hagstrom
Senior Systems Engineer
Bill Bergen
Engineering
Electrical / Network
Vacant
Systems Staff Eng.
Robert Howard
Req'mnts & Test
Kathleen Carr
Manager,
Project Process Control
Alex Talalayevsky
Senior Manager,
EVMS
Derrek Jones
Process Control
Support
Tools / Web Admin
Mediachase
Schedulers
Mike Kleinow
Adam Anderson
Associate Director,
Ocean Observing
Programs
Susan Banahan
Manager, Education &
Public Engagement
Andrea McCurdy
Post Doctoral
Oceanographer
Lorraine Brasseur
Science &
Environmental
Compliance Manager
Joanne Bintz


Cyberinfrastructure Implementing Organization
Organizational Chart
Principal Investigator
J. Orcutt: UCSD
Deputy Principal Investigator
F. Vernon: UCSD
Project Management Team
Science Authority
Project Scientist
O. Schofield: Rutgers
System Authority
System Engineer
A. Chave: WHOI
Quality Authority
Quality Analyst
TBD: UCSD
Management Authority
Program Manger
M. Arrott: UCSD
Education Manager
C. Peach: UCSD
Configuration Management: WHOI
Admin & Controls Team: UCSD
EPE Team: UCSD
Engineering Management Team
Sr. System Architect
M. Meisinger: UCSD
ITV* Manager
J. Graybeal: UCSD
*(Integ, Test, Verif)
Operations Manager: UCSD
Architecture & Design: UCSD
System Development: UCSD
Integration & Test: UCSD
Operations Team: UCSD
Common Operating Infrastructure:
UCSD, NCSA, NCSU, Red Hat
Common Execution Infrastructure:
U. Chicago, USCD, USC, Red Hat, CohesiveFT
Data Management
UCSD, MBARI, UIUC, UNC, OPeNDAP
Sensing/Acquisition
USCD, MIT, MBARI, Rutgers, Lindquist, Incobyte
Analysis/Synthesis
JPL, MIT, UCS, UCSD
Planning/ Prosecution
MIT, JPL, UCSD

Costal/Global
Implementing Organization Chart



Regional Implementing Organization Organizational Chart



University of Washington
UW RSN Team