OCEAN OBSERVATORIES INITIATIVE

PROJECT EXECUTION PLAN

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DRAFT v2.0

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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 a division of 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 at the JOI Division. After a competitive bid process, the JOI Division signed subawards with up to 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 will manage the OOI project. OOI 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 IO's schedule of activities. These design reviews will mirror the design reviews set out in the MREFC guidelines and will be important gates for release of funds to the IO. The OOI Project Baseline has been established and is in Appendix 2.

This second version of the PEP has been created to support the OOI Preliminary Design Review and 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.

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 is the second version of the document representing the approach planned at the preliminary design stage of the program. Further 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) grants officer for written approval.

The OOI program will conduct transformational ocean science using an integrated ocean observatory with a network of coastal, regional, and global nodes funded by NSF 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. There is one IO for the coastal and global nodes, another for the regional nodes, as well as one for the cyberinfrastructure that connects the nodes together into an integrated observatory. 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 PEPs are consistent with this OOI PEP and are incorporated by reference in accordance with Appendix A.

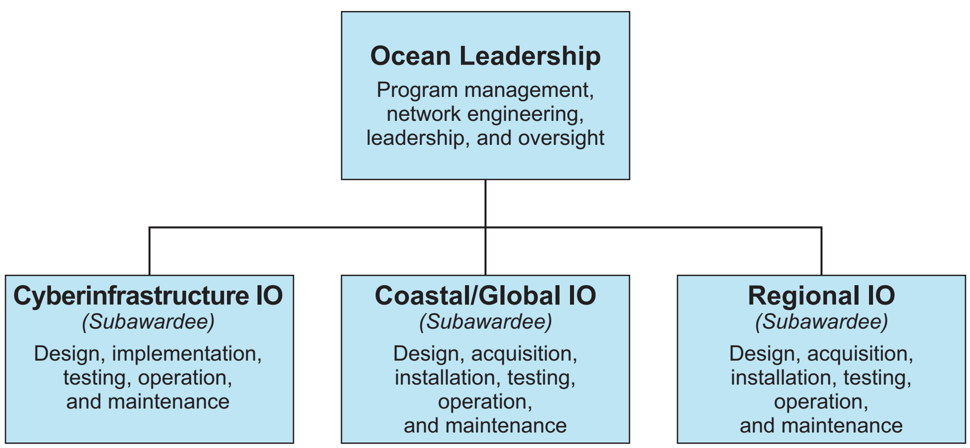

Figure 1: Responsibilities of Ocean Leadership and each implementing organization

NSF's guidance is to plan the OOI with the following budget and funding profile:

Fiscal Year	2008	2009	2010	2011	2012	2013	Total
NSF Management Reserve			2.00	3.00	5.00		10.00
Project Office	1.59	7.97	5.46	4.05	4.00	3.06	26.14
Cyber IO	1.57	5.43	6.36	6.91	4.85	1.89	27.01
Coastal/Global IO	4.01	14.83	28.86	28.09	12.99	5.22	94.00
Regional IO	5.11	43.05	37.60	50.26	25.47	12.48	173.97
Total OOI	**12.28**	**71.28**	**80.29**	**92.30**	**52.31**	**22.65**	**331.11**
Funding	36.11*	80.00	90.00	95.00	30.00		331.11

**combines FY 2007 $5.12m and FY 2008 $30.99m*

The funding profiles in this chart include about an overall 20% contingency, which will be removed from each IO's budget and managed at the OOI overall project level. The contingences were calculated as part of the bottoms-up cost estimate contained in the *OOI Cost Book*. In addition to the contingency held by Ocean Leadership, NSF is holding an additional $10 million in program reserve. The OOI Project Office budget includes $5 million for education and public awareness infrastructure and $6.2 million for environmental assessment work.

The current OOI website (*http://www.joiscience.org/ocean_observing*) serves as a source of information to keep the community informed of progress made on the program. The website includes information on the science planning, the designs and other news related to the OOI. Plans are in progress for a more dynamic, comprehensive web presence.

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, El Niño events, and natural hazards like 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 of 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 (*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 *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 time scales of seconds to decades; (2) spatial measurements 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 the current versions 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 major elements of the OOI Network are the Global-Scale Nodes, the Regional-Scale Nodes, the Coastal-Scale Nodes, and the integrating Cyberinfrastructure.

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 air-sea interactions and gas exchange, processes at critical high-latitude sites for which little or no time series data exists, the global carbon cycle, ocean acidification, and global geodynamics.

The Regional Scale Nodes (RSN) will enable oceanic plate-scale 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; geophysics of subduction zones and transform faults; seismicity, magmatism, and deformation across the Juan de Fuca Plate and Cascadia Subduction Zone; 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.

The OOI will be a broadly distributed, multi-scale network of observing assets bound together by an interactive Cyberinfrastructure (CI) backbone that will link the physical infrastructure elements, sensors, and data into a coherent system of systems. OOI science goals will be supported by the CI through provision of 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.

Another goal for the OOI is to promote awareness, appreciation, and understanding of ocean discoveries, and showcase the transformational role of ocean observatories in understanding the ocean through a program of education and public awareness. A collaborative effort involving all elements of the OOI Network and associated educational resources will bring in the OOI concept of adaptive and continuous access to remote parts of the ocean to the broadest spectrum of learning environments.

Scientific discoveries arising from the OOI will provide new opportunities for ocean education and outreach through the capabilities for real-time data transmission and real-time display of visual images. As observatory science expands, particularly with the establishment of IOOS systems, there will be an unprecedented need for scientists, engineers, and technicians skilled in the use of observing system data, development of models and visualization tools, and operation and maintenance observing system infrastructure. The facilities comprising the OOI will provide the ideal platforms to train this new generation of oceanographers, earth scientists, and other marine professionals.

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

In order to make the next significant step forward in understanding the oceans and seafloor below, phenomena must be observed at spatial and temporal scales appropriate to the processes and systems being studied.

The infrastructure provided to research scientists through the OOI will include the cables, buoys, deployment platforms, moorings and junction boxes, required for power and two-way data communication to a wide variety of sensors at the sea surface, in the water column, and at or beneath the seafloor. The initiative also includes components such as unified project management, data 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 at time scales of seconds to decades
- Spatial measurements 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
- Access to deployment and maintenance vehicles that satisfy the needs of specific observatories
- Facilities for instrument maintenance and calibration
- A data management system that makes data publicly available
- An effective education and public awareness program

The OOI is a network of marine nodes:

1. Coastal and Global Scale Nodes (CGSN): New construction facilities in the coastal zones on both the East and West Coasts of the U.S. and deep-sea buoys primarily focused on deployment in high latitudes.
2. RSN: A regional electro-optical cabled network consisting of interconnected sites on the seafloor spanning several geological and oceanographic feature and processes. In addition the RSN is linked to the Coastal Endurance Array to provide power and bandwidth at two locations on that line.

The nodes are integrated through the CI, providing connections to scientists and classroom, and allowing the OOI to function as a single, secure, integrated network. The entire OOI is shown schematically in Figure 2.

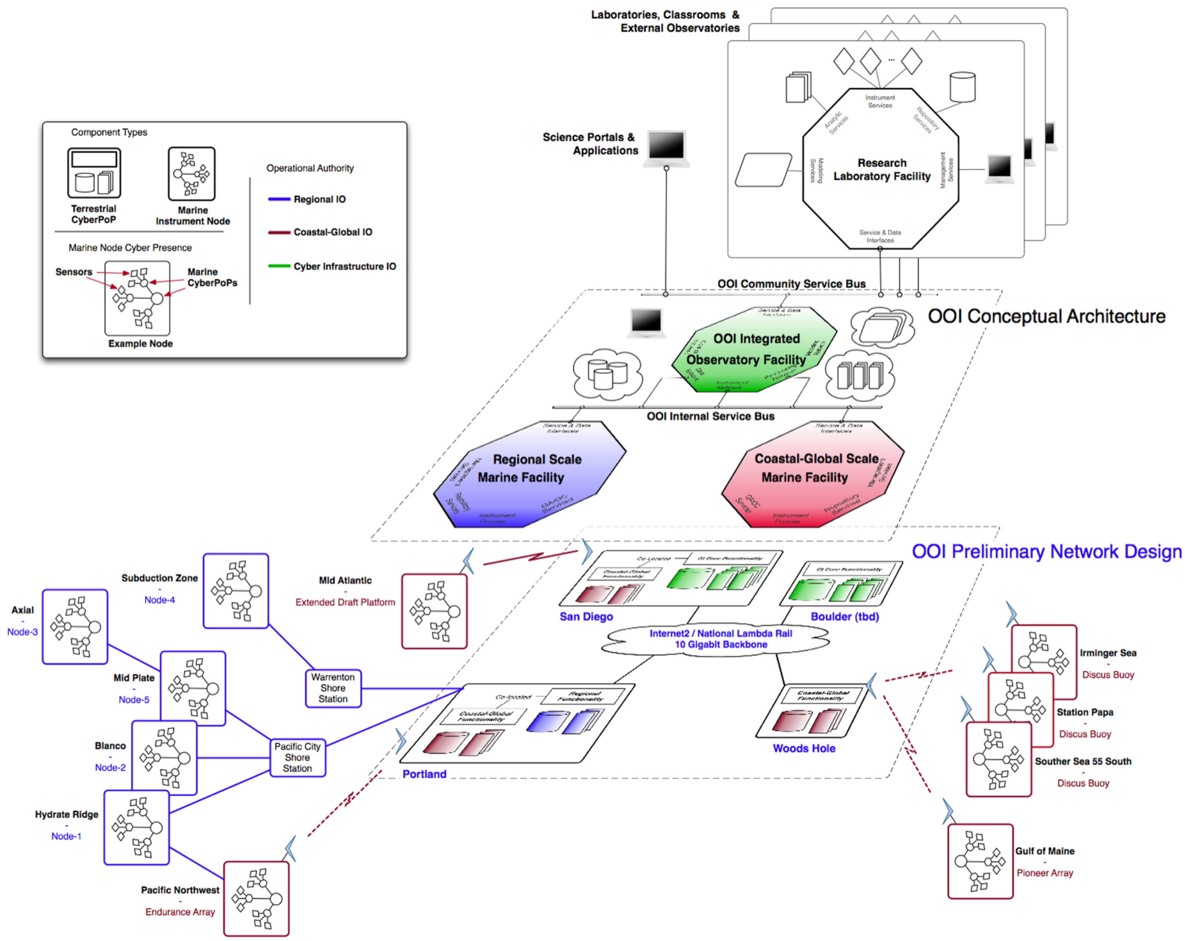

Figure 2: Schematic representation of the OOI.

The CGSN will provide sustained, adaptable access to investigate dynamic and heterogeneous processes in coastal global systems.

Fixed arrays of moorings and seafloor cables will provide continuous observations at appropriate scales to investigate process studies of highest priority to the coastal research community. The fixed arrays established by the OOI will be augmented by the use of mobile platforms such as underwater gliders and AUV to capture the temporal nature of environmental variability. The infrastructure constructed will be a mix of “permanent” stations to document long-term variability and “relocatable” mooring arrays targeted towards high-frequency, spatially-variable environmental processes. The settings for the relocatable Pioneer Array is off the coast of Massachusetts while the fixed coastal Endurance Array is off the Oregon and Washington coastline.

The Global Scale Nodes (GSN) comprise a set of highly capable interactive moored buoys focused on high latitude locations where surface-to-bottom ocean data needs are greatest. These nodes will consist of robust, self-powered, telemetering buoys providing ample data-return rates and improved power capacity. Extension cables on the bottom at some locations and acoustic links at other locations will provide for data input from bottom features of interest linked back to the buoy for transmission via satellite to the network. In a significant change from that which was presented at the Conceptual Design Review (CDR), based on inputs from the various OOI science reviews, mobile assets (gliders) and flanking moorings have been incorporated to provide a broader context for the data being acquired. The PND provides additional details on this OOI element.

The RSN will instrument the southern two-thirds of the Juan de Fuca tectonic plate in the Northeast Pacific Ocean off the coastline of Oregon, Washington, and Vancouver Island. The Canadian government’s NEPTUNE (NorthEast Pacific Time-series Undersea Networked Experiments) array is currently being installed on the northern third of the same plate. Together these two systems will monitor the entire Juan de Fuca plate to allow the science community to conduct plate-scale experiments. A permanent electro-optical seafloor cable will connect five seafloor nodes at key locations and will provide power (tens of kilowatts) and high bandwidth (data transfer rates of 10 to 100 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 PND provides additional details on this OOI element.

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 PND provides additional detail on this OOI element.

The detailed PND for each of the marine elements and the CI are incorporated by reference into this issue of this PEP. These documents formed the basis for the baselines shown in Appendix 2.

The OOI is envisioned to be a network that can be arranged or 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 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 a division of Ocean Leadership, for the establishment of a project office to coordinate ocean observing activities in 2004; a new agreement is expected that will be funded with MREFC funding prior to the planned start date of July 1, 2008.

After a competitive bid process, the JOI Division made two subawards, one for the CI and one for the CGSN IOs to conduct the detailed design, engineering, procurement, installation, testing, and commissioning of the OOI elements. A separate design and study contract was awarded to the University of Washington for development of the RSN infrastructure. Based on its excellent performance to date, and a successful review of their part of the OOI at Preliminary Design Review (PDR), it is anticipated that an award for the RSN implementing organization function for RSN will be made prior to the commencement of MREFC funding.

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 (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 will work with systems engineers at each of the IOs to define component requirements and interface requirements with the other IOs. *OOI Science User Requirements* and *OOI System Requirements* will drive the designs of the OOI elements. Design and infrastructure development will be the responsibility of the IOs.

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. This will entail the development of detailed request-for-proposals, evaluation of bids, negotiation of contracts, and management of the resulting implementation contracts. Each IO will conduct periodic reviews with the suppliers and with Ocean Leadership for contact management and coordination. Each physical OOI observatory will conduct integration testing prior to installation. Integration testing will include both available sensors and the CI.

During the development of the preliminary design the sequencing of the acquisition of the major components was analyzed with the intent to reduce program risk and meet the constraints caused by the budget funding profile in the MREFC planned budget for OOI. In a significant shift from CDR, changing from a loop to a star configuration reduced the RSN design and construction risk. As a result, the acquisition of this major component of the whole OOI system can be accomplished earlier, providing the added advantage of reducing the cost risk to the program as it is desirous to buy the undersea cable as early as possible while the marine telecommunications industry is still in a down turn. The remaining components were sequenced in the schedule based upon pushing the higher risk items (e.g., high-latitude global buoys) later in the program so that adequate time is allowed to design and solve the technical issues associated with locating these assets in such severe weather regions.

2.3 Initial Operations Strategy and Commissioning

The OOI is a distributed network of marine nodes, some of which are cabled and some that 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 five-year development and implementation 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 Cyberinfrastructure Operational View documentation there is a detailed explanation of Commissioning and Activation of components on the OOI. This documentation explains that commissioning is a one-time process conducted to certify that a component is registered and meets the OOI interface standards. A test on land 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 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 subaward.

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 a “Transition to Operations” plan that will be developed. After successful completion of the operational readiness testing, the OOI will be presented to NSF for acceptance. Operation from that point forward will be in accordance with the concept of operations that will be developed during the next phase of the OOI project.

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 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, JOI and the Consortium for Ocean 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 46 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. These IOs are responsible for the CI, RSN, and CGSN; they were chosen via a competitive process to be University of California, San Diego (UCSD), University of Washington (UW), and Woods Hole Oceanographic Institution (WHOI), 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 with NSF. The Program Director for Ocean Observing Activities and NSF have approval authority over candidates for the PI and other key personnel of each IO subaward; the IO PIs hold responsibility and authority for work carried out under the subaward or convey it to their staff. They hold or delegate responsibility for technical approval of work carried out under acquisitions made from the IO subawards.

The OOI Program Office is responsible for integrating the work of the IOs and other subawardees developing the OOI facility, guiding and monitoring their progress and compliance with annual work plans and budgets, 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 take 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.

Each IO has a specific management structure appropriate for the nature of work and its institutional parameters. All IOs have, in additional to the PI, a Project Manager, Systems Engineer, Education and Outreach Specialist, Project Scientist, and other specialized or support personnel as needed to execute the work plan.

3.2 Executive Oversight Committee

The NSF will form an external OOI scientific oversight committee (OOI-SOC) to periodically assess program progress, evaluate the impact of proposed changes in infrastructure on the achievement of program goals, and recommend changes in direction and reallocation of resources as appropriate. This committee will be composed of informed but non-conflicted members of the ocean science, engineering, and education communities, and may include representatives from other major ocean science planning activities. This committee will formulate recommendations to NSF's Ocean Sciences Division, which will provide guidance based on the committee's recommendations to the OOI Program Office.

3.3 Community Advisory Structure

Ocean Leadership will manage the construction of 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. With the beginning of significant MREFC capital investment, the planning and development function will be carried out by a fiscally and contractually accountable management structure that seeks and incorporates guidance from the advisory structure at multiple levels. The transition from the initial to the construction-phase advisory structure will be completed shortly after the PDR.

The construction-phase advisory structure will be led by a Science and Program Advisory Committee (SPAC). The SPAC provides overall strategic planning and science leadership for the OOI facility, is the main formalized conduit for community input into the implementation and management of the OOI facility, and is the primary consultative group for the Program Director for Ocean Observing Activities and management team. The SPAC will be populated by individuals representing broad expertise in relevant ocean science disciplines, and having significant leadership skills and management experience. The SPAC will meet regularly to receive updates on program execution, formulate guidance on the scientific direction of the facility, and consider specific advisory requests from program management. The SPAC will assess community responsiveness to the transformative capabilities of the OOI facility and will provide strategic planning on science programs catalyzed by the OOI. Until the SPAC has been populated, the interim Observatory Steering Committee (OSC) from the initial advisory structure will remain constituted as the primary advisory body for the OOI facility.

In consultation with and within available resources provided by the Program Director for Ocean Observing Activities, the SPAC will form subcommittees or *ad hoc* advisory groups as appropriate during the construction of the OOI facility. The SPAC will initially form two standing subcommittees, a Partnerships and Community Development Subcommittee, and a Sensor Strategy Subcommittee. The Partnerships and Community Development Subcommittee is a catalytic agent for developing the user community for the OOI facility research platforms and education products. It will devise a suite of community engagement methods, such as thematic workshops, special sessions at scientific meetings, and lecturer series; it will also advise on the education component of the infrastructure investment. This committee will also foster links between the OOI and other national and international research programs and observatory systems, which may lead a broader support base in the future for network enhancements and expansions. As recommended by a recent review of OOI science goals, Sensor Strategy Subcommittee will consider needs, challenges, and opportunities for sensors for the OOI facility, particularly the development and integration of new sensors meeting long-term stability and performance characteristics requirements of the network.

A nominating committee, whose membership is approved by the Ocean Leadership Board and the NSF, will initially populate the construction phase advisory structure, and, in consultation with the OOI Program Office and the NSF, will devise committee Terms of Reference.

3.4 Interagency and International Partnerships

The construction of the OOI facility as described in the PND does not formally require interagency or international partnerships to be completed; however, because the OOI will enable sustained and configurable observations of remote ocean environments, it will provide the foundation for 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 the Monterey Bay Aquarium Research Institute (MBARI). Using designs that have been prototyped for the OOI, MARS deploys an 8-port science node at 891-m depth on a 52-km submarine cable that will be populated with sensor experiments in early 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 up to $10 million in state funding toward implementation of the OOI's Coastal Scale Nodes by the WHOI partnership. Corporate partnerships will be sought at a variety of levels. For example, Technip, a major infrastructure supplier to the oil industry, is interested in underwriting the development, and construction of an Extended Draft Platform for use at OOI Global Scale Nodes.

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 IOOS, an operationally oriented approach to ocean observing intended to serve societal and national needs. The OOI 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, over time. IOOS, in turn, will contribute to the OOI effort by supporting a broadly distributed set of core observations, which will provide context in which the interactive, detailed OOI experiments can be posed. In reciprocity, OOI's science-driven observations and experiments can be integrated into the suite of observations available to NOAA and IOOS. 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. 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 lead to the development of the Littoral Battlespace Sensing, Fusion and Integration 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 project office has regular technical and strategic coordination with the NEPTUNE implementation group. Scientists at Canada's Department of Fisheries and Oceans, as well as university researchers in the Pacific Northwest, are interested in Ocean Weather Station Papa and integrating observing efforts over the region. The planned European Seafloor Observatory Network (ESONET) is somewhat more application-oriented than the OOI, but they are discussing similar technology. A planned European ocean time-series sampling, EuroSITES, has sought collaboration with OOI on open ocean observations, and has placed several key scientists planning OOI on its advisory committee. Japan, through its ARENA (Advanced Real-time Earth monitoring Network in the Area) Program, is developing cabled seafloor observatories whose central focus is geophysics and dynamics. This program's research priorities include advancing understanding of ocean circulation, hydrates, hydrothermal fluxes, marine fisheries and mammals, and deep-sea microbiology. China, Korea, Singapore, South Africa, Australia and several Persian Gulf states, are all developing similar ocean observing programs focused on coastal and offshore resources.

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.

3.5 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.

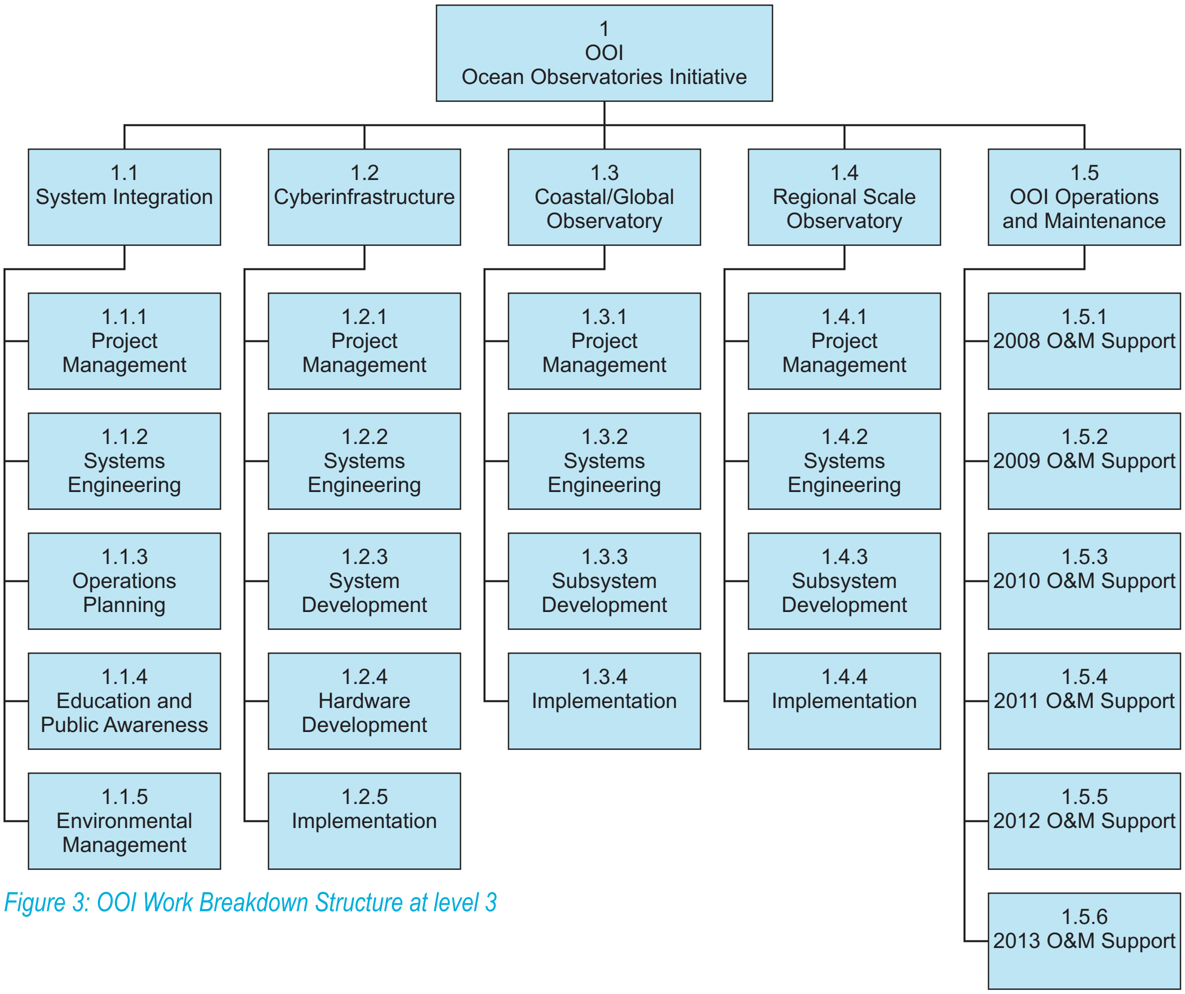

Figure 3: OOI Work Breakdown Structure at level 3

The integrated preliminary WBS has been developed with the IOs and includes over 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 MSProject and MSExcel respectively and are available as "OOI WBS.mpp" and "OOI WBS Dictionary.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 System Implementation Plan*.

3.6 Cost and Schedule Management

Cost and schedule management will be accomplished by using an Earned Value Management System (EVMS). Ocean Leadership has procured an EVMS toolset from forProject Inc. that seamlessly integrates into Microsoft Project. Scheduling will be accomplished in MS Project. A centralize procurement was done by Ocean Leadership to save costs, with instances of the forProject software installed at each IO with web connection to the main program at Ocean Leadership. The software is installed and integrated. The WBS was developed to insure that the EVMS process will yield information on the state of the project. Control accounts with underlying Work Packages have been established and will be used to track progress on a monthly basis. The progress reports will include the Budgeted Cost of Work Performed, the Actual Cost of Work Performed, and projected costs to complete. The Cost Performance Indices and the Schedule Performance Indices metrics will be tracked and reported. The basic tracking will be accomplished by reviewing the cost and schedule variances. The forProject system is compliant with ANSI/EIS 748, so all the standard EVMS reports are available. In addition, Ocean Leadership will export the results each month to WinSight, an EVMS analysis toolset that helps identify areas of the project that need attention. Cost and schedule variances will be color coded so areas that need attention will be easy to locate. The WinSight software is also very good at establishing trends by plotting the data in graphical form, allowing the project team to quickly focus on key problem areas in the project.

3.7 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 have accounting systems that range from robust to marginal 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.

3.8 Configuration Management and Change Control

The OOI 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 generate the Technical Data Package (TDP) required for the design, manufacture, and deployment of the OOI facility. The plan provides details as to how the various types of documents shall be prepared, configuration management requirements, 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.

3.8.1 Requirements Management

The Executive Steering Committee, now known as the Observatories Steering Committee, developed a Science Plan for the OOI in May of 2005. From this and the outputs of the past decade's numerous community workshops, the OOI project office has developed the *OOI Science User Requirements* (SUR) that sets the high-level OOI science requirements. In a flow down process, the *OOI Systems Requirements Document* (SRD) 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 represents the ten key science questions that the OOI is being built to address. These questions are a distillation of the science that the oceanographic community, through a series of meetings and workshops, has recommended that a networked ocean observatory tackle. An important requirement that does drive the OOI is that there be growth in both power and bandwidth provided in each element of the infrastructure so that during the 25-year planned life of the system additional science questions can be addressed.

The SRD will be expanded into additional levels of requirements to drive the engineering designs. The detailed performance requirements will be captured and documented by each IO's system engineers in collaboration with Ocean Leadership's System Engineer. The requirements will be captured and tracked in a DOORS (Dynamic Object Oriented Requirements System) database.

3.8.2 Interface Management

The OOI design is an integrated, interactive network of observatories with three major observatory elements covering coastal, regional, and global spatial scales connected via an integrated cyberinfrastructure. The observatories will also be linked, to the extent practical, by common instrument interfaces and infrastructure components. Preliminary engineering design and integration among Ocean Leadership and the three IOs has produced a preliminary design providing an integrated and interactive network of observatories.

Systems engineers from each IO meet regularly with OOI System Engineer to integrate the subsystems, and develop and document appropriate interface specifications between OOI elements. The preliminary engineering design effort has produced a comprehensive set of subsystem interface requirements, specified standard instrument 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 Agreement* (IRA) is 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 program. The IRA defines 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 are captured in the IRA document and will mature with the detail design engineering and culminate in technical data represented in Interface Control Drawings and maintained under configuration control in the OOI's document management system. The CMP establishes the activities, responsibilities, processes, and methods used to maintain the configuration of the OOI project and to manage changes to the design and scope of the system. The plan provides the background information and outlines the approach to be followed to generate the TDP required for the design, manufacture, and deployment of the OOI system. The CMP provides details on preparation of documents, configuration management requirements, required TDP quality assurance procedures, and the operation of the design change control board (Engineering Change Board).

3.9 Quality Assurance and Quality Control

The approach to quality is documented in the *OOI Quality Assurance Plan*. The responsibility and guidance for the overall quality assurance of the OOI will be coordinated through the Program Director for Ocean Observing Activities at Ocean Leadership and the corresponding Contracting Officer Technical Representatives (COTRs). The quality assurance and quality control functions for the OOI will be primarily implemented by the IOs as this is where the hardware and software will be built and accepted. Any subcontractors to the IOs are expected to have and maintain an ISO 9001 certification or appropriate equivalent. The OOI Project Office may choose to audit selected major suppliers.

The quality plan specifies procedures for key aspects of a program including system design, construction, testing, and maintenance. Detailed procedure specifications that fall under the agreed upon quality plan include the following:

- Engineering Documentation Control
- Engineering Change Order Approval

- Design and Assembly Documentation Requirements
- Manufacturing Practices Specifications
- Material Tracking Procedures
- Testing and Acceptance Requirements
- Software Revision Control and Documentation Procedures
- Inspection at Subcontractors

Ocean Leadership plans to hire an outside firm expert in quality assurance to conduct an annual OOI quality audit.

3.10 Risk Management

A formal risk management program has been implemented for the OOI. This program is described in *OOI Risk Management Plan*, which is incorporated in this PEP by reference. This risk management plan follows a traditional risk management approach of identifying potential risks, applying a severity ranking, analyzing potential cost impacts, and developing mitigation strategies.

The *Risk Management Plan* establishes a team approach to reviewing and tracking the major risks to the program. These higher-level risks will be reviewed and tracked by the System Engineer/Project Manager (SE/PM) management team at its monthly meeting. Each IO will track lower level risks for the components they are developing within their own project management structure.

In the development of the *OOI Cost Book*, the contingency for each work package was set by analyzing the technical, cost, and schedule risks. The OOI Risk Register was used to help set the level of contingency in each area. The higher the risk, the greater the contingency.

The identified risks to the OOI project as of the date of this document are documented in the OOI Risk Register in Appendix 3.

3.11 Health, Safety, and Environment

The OOI project and each IO will comply with all applicable health, safety, and environment policies and requirements of the NSF and each of the IOs. In conjunction with the IOs, the OOI Project Office will coordinate safety and environmental audits of OOI installations including any ground stations and ship-borne facilities.

On behalf of NSF, Ocean Leadership has contracted with TEC International to conduct a Programmatic Environmental Assessment (PEA) for the OOI. As needed, this firm will also provide Environmental Impact Statements (EIS) for areas that are identified as high risk.

Each IO will be responsible for obtaining any necessary permits from governmental, military, and regulatory agencies in order to construct and install the infrastructure. All infrastructure drawings must comply with local ordinances and codes and be approved by a Professional Engineer (PE) with standing in the state of installation.

Each IO will develop safety procedures for personnel involved in the operation of the observatory. Guest scientists will be required to understand and adopt these policies. Further, each IO will develop a process to qualify instruments to be sure that the instruments will not harm or damage any part of the OOI. No instruments will be allowed on the OOI without proper certification. Both the personnel training and the instrument safety qualification records will be kept in the project operational records.

3.12 Testing and Acceptance

A Test Plan will be developed that documents the approach for testing of the 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. A DOORS database of requirements has been created and will be maintained through the entire program implementation.

Each IO's PEP contains a more detailed explanation of the testing, acceptance, and commissioning process. 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 and confirmed to be consistent with its pre-deployment characteristics. Each IO, in conjunction with the OOI Project Office, will identify and correct any physical, documentation, or performance deficiencies before presenting the system to the OOI Project Office for acceptance.

3.13 Annual Work Plans

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

Ocean Leadership with its 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 fiscal 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-year construction.

Ocean Leadership with its IOs will also plan the use of initial operations of the OOI as component parts of the system begin initial operations during the five-year construction period. This annual plan will show what the NSF Research and Related Activities (R&RA) funding provides for in terms on operating the control center, establishing the maintenance processes, and establishing the rotating pool of spares and repair parts necessary to maintain the OOI system.

3.14 Document Control and Reporting

An initial document management system has been implemented to track and control documents for the OOI. The initial system uses the web-based collaboration software program Basecamp to establish multiple project areas to store documents. Although this toolset has been useful to help establish and track documents and designs as they are developed, additional tools are being studied for possible inclusion into the OOI workspace. The CI IO has taken the lead on studying the available tools and will make a recommendation on what software systems to use during the time between PDR and the start of the MREFC funding.

Ocean Leadership will coordinate monthly reports to NSF on the OOI project. The reports will include a section that analyzes the cost and schedule variances from the EVMS. Quarterly and annual reports will be produced in phase with the federal government's fiscal year.

3.15 Contingency Management

Cost: A management contingency in the amount of approximately 20% of the OOI budget has been created and will be managed by the Program Director for Ocean Observing Activities. The contingency amount, shown in the budget table in Appendix 4B, was arrived at from a bottom up estimate including an assessment of the risks associated with various elements of the OOI project. In addition to these funds, the NSF is holding an additional $10 million in program management reserve funds at NSF. Combining the Ocean-Leadership-held contingency and the NSF Program Reserve totals approximately 23% contingency for the whole program.

Scope: The IOs were tasked to analyze their preliminary designs to determine what upscope and downscope options were possible. These lists of potential changes were briefed by the IOs to the iOSC at the November 2007 meeting. Based on their recommendations each IO has established the up scope listing that would be used if any funding becomes available as the system is constructed and the available contingency funds become clearer.

Schedule: During the development of the preliminary design the overall schedule was analyzed. The overarching constraint on the schedule is fitting the development and implementation of all the component pieces of the OOI to the funding profile in the MREFC account. The controlling path to the completion of the project is along the development of the CI as this development is spread over the entire five years of the design and implementation. Although no specific schedule contingency has been included in the CI development, there are a number of features in the development of the CI that create a low risk to this approach. CI plans a series of releases with the focus on providing the critical control and data storage capabilities in the early releases to match the fact that the OOI will become operation from the very first software release, Release 1. A new release is planned every 12 months. The system control, data management, and integrated data analysis are all finished by the completion of Release 3 at the end of the third year. The final two releases are focused on modeling and improving the interactive capabilities of the CI. As the program makes the gradual transition to operations the development team will wind down and the operations staffing will increase. If the CI or some other component development were to extend past the five year planned period for development, then contingency would be used to buy additional schedule. The entire CI design and implementation team has a monthly cost of $2.25M, which means a six month extension to its effort would cost the program $375K.

Contingency funds will be used to mitigate specific risks that arise on the program and to provide a source of funds as change orders are approved. Requests to release contingency funds may be made through the OOI Change Control Board. Requests will be approved by the OOI Management Team, Ocean Leadership, and NSF in certain cases, as outlined in the *OOI Configuration Management Plan*.

3.16 IO Selection, Performance Management, and Acquisition Planning

3.16.1 Selection of IOs

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.

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.

IO subawards are incrementally funded for performance on an average 120-calendar day cycle. 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.

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 and at monthly coordination meetings where all IO program managers and the NSF program officer are present.

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 Navel 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 notify the NSF Program Officer prior to awarding any new subaward or subcontract, not already in the approved budget, that exceeds $250,000 award value. This clause has been incorporated into the IO subawards; therefore Ocean Leadership will review and approve new IO subawards above $250,000 before the IOs can sign them.

To provide NSF with insight into all planned awards greater than $250,000 in each budget year,

Ocean Leadership and the IOs have developed a Procurement Plan Worksheet to be included in the IO annual work plans. These will be provided to NSF as an attachment to Ocean Leadership's Annual Work Plan to identify anticipated new high-value awards or acquisitions across the program. The Procurement Plan Worksheets specify whether the anticipated acquisitions are sole source versus competitive; the estimated award value, award lead-times, and contract type. With other coordination measures, this planning process will assist the OOI Program Office in integrating acquisitions across the IOs when technically appropriate.

3.16.4 Specific Strategies for IO-based Acquisitions

Although Ocean Leadership has the option of making bulk acquisitions across the program, the majority of the OOI construction budget will be executed by the IOs. The type and complexity of IO-specific acquisitions is determined by the scope of work of each award.

After the IO subawards, the single largest acquisition within OOI project is the installation of the primary submarine cable infrastructure of the RSN component of the facility. The primary infrastructure extends from shore station power and transmission equipment to the primary nodes off shore and delivers the power and bandwidth to the secondary infrastructure. It is intended to be supplied under a single Design Build contract and represents nearly half of the RSN capital budget. The RSN IO, UW, will acquire the primary infrastructure in accordance with Washington State Law (Second Substitute House Bill 1506, Chapter 494, Laws of 2007, approved May 15, 2007 and effective July 1, 2007) that specifies a specific process for public works projects ("Alternative Public Works"). This recent legislature allows for Design Build procurement very much in line with what is typical in the submarine cable industry. UW has the benefit of both submarine cable experts on staff and a Capital Projects Office (CPO) with a history of large capital project construction and management within the regulatory environment of Washington State.

The acquisition plan is generally as follows. The process begins with the certification of the university as a qualified public entity with the requisite skills and experience to manage a build project or projects. UW's CPO expects to receive this certification in January 2008. Following certification, the contracting entity (UW) is required to issue a Request for Qualification (RFQ) in the appropriate (e.g., industry) publications. The RFQ defines the project in high-level terms and requests interested parties to indicate their interest and provide details of their qualifications.

Responses are reviewed for suitability and any contactors that are not judged to be technically and financially suitable are eliminated. A Request for Proposal (RFP) is then developed and reviewed by Ocean Leadership and NSF prior to issuance to the set of qualified suppliers. The RFP will contain very detailed requirements for the technical, commercial, and schedule needs of the RSN. Also provided with the RFP will be a clear set of criteria that will be used to evaluate the responses. The criteria will include the various categories as well the relative weighting that will be applied. Compliance with the requirements contained in the RFP will serve as a baseline for the scoring criteria. Adjudication will be conducted by UW RSN Project Team, UW CPO, Ocean Leadership and outside experts. Once a successful bidder is decided, UW will continue negotiations to develop a final executable contractual agreement, and UW, Ocean Leadership, and NSF will review contractual documents prior to signature.

The process above is expected to require 9 months or more. Work on the RFQ will begin in early 2008, so that the supplier can be selected shortly after the beginning of MREFC funding.

For the CGSN IO, two specific subawards were approved within the initial subaward from Ocean Leadership. These subawards will be between WHOI and partner institutions Scripps Institution of Oceanography (SIO) and Oregon State University (OSU). They will be executed to cover the entire period of performance. Work will be shared among the partners based on capabilities with respect to design and build requirements. In addition, a consulting agreement with an industrial partner, Raytheon Integrated Defense Systems, was approved in the initial subaward. The procurement to Raytheon for systems engineering and project management support services will extend over the entire period of performance and procurement value will depend on actual tasking.

CGSN material procurements will follow the procedures of the responsible institution. Annually, WHOI as an institution procures about $21.5 million of material, and has a well-established base of dependable suppliers, which can be used for many of the supplies anticipated for implementation of the CGSN. Supplier management will be predicated upon pre-contract planning, a competitive selection process to obtain the best subcontractors and suppliers possible, use of proven controls and processes to ensure success, and an unwavering commitment to the quality of the final product. Make or buy decisions will be made as the design details are finalized. Broadly, sensors, gliders, and AUVs will be purchased. Fabricated mooring components will be made in-house or procured based on schedule and cost. Vendor selection and monitoring will take place in accordance with standard institution procedures. Synergies between RSN and CGSN, particularly cabling in the Pacific Northwest Endurance Array and common instrumentation, will be exploited to reduce costs. Commercial off-the-shelf (COTS) sensor and vehicle procurements are estimated to account for nearly 15% of the CGSN budget in the preliminary design.

The scope of requirements for the OOI cyberinfrastructure demands that the CI IO develop and deploy infrastructure over a very wide geography in a field where rapid change is the norm. The strategy for acquiring the necessary CI capabilities is to build a core unified design using integration and operation teams that contract with specific institutions and vendors having the specific expertise, technologies and/or services required for execution. The CI IO has three categories of supplier relationships. Two are strategic and the third is a straightforward product/service relationship with COTS vendors.

The first and most critical type of strategic supplier relationship comprises the Construction Partnerships, which bring specific domain knowledge, expertise and technologies to the program. These partnerships take two forms. First, Development Partners provide engineering manpower coupled with specific core technologies for inclusion in the OOI cyberinfrastructure. Second, Design Partners bring specific domain knowledge and experience in the development of a particular aspect of the CI. Contracts with Development Partners are on the order of thirty to sixty months of effort; with Design Partners, they are on order of six to twenty months. In both cases, the contracts are phased with the development cycles to which the Partners are materially contributing (either two or three release cycles). There are twelve Construction Partners. All were qualified and selected as a part of the OOI IO proposal process and the NSF Information Technology Research grant, LOOKING (Laboratory for the Ocean Observatory Knowledge Integration Grid), that assessed the current architectures, technologies and future trends of existing observatory initiatives.

The second class of strategic supplier relationship is the Infrastructure Partnership. The CI IO identified the need for three such relationships; two that provide scalable on-demand computing and long-term online data storage, and one that provides high bandwidth network connectivity (order 10Gbps) nationally with international links. Candidates were identified as a part of the proposal process and one of the computing infrastructure relationships was selected. Further qualification and selection of the other two will occur in the later half of the OOI construction project, when detailed information on OOI's capacity requirements are available and the costs/benefits of on-demand computing infrastructure have been established.

The deployed cyberinfrastructure within the marine IOs' operations environment, the shore-side cyberinfrastructure point-of-presence (CyberPoP) and marine CyberPoP, are straightforward acquisitions of COTS computing, storage and networking equipment. The procurement and build-out of this infrastructure starts in the first year of MREFC funding and continues through the fifth year of construction funding with the deployment of the High Bandwidth Stream Processing CyberPoP at the shore end of the RSN.

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

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

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

4.2 Cyberinfrastructure Security

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

The CI IO will also have responsibility to ensure that the OOI data and programs are not susceptible to cyber attacks in the form of viruses, etc. and to ensure that the data cannot be corrupted by outside influences. A formal tracking system that documents the cause and resolution of each attack or intrusion will be implemented. The system will utilize two different service buses: one for the CI data interactions (Community Service Bus) with the users and the other for the CI interactions with instruments (Internal Service Bus) as exemplified by the conceptual system view within the PND. Similarly, Virtual Local Area Networks will be utilized to separate out varied functionalities within the physical infrastructure.

The CI IO is also responsible for implementing data and system back-up designs for service interruptions or disasters. There will be a full off-site back for all OOI-related data and software that is currently envisioned to reside in Boulder, CO.

4.3 Operational Security

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

Acquisition and public distribution of acoustic and other geophysical data in some regions along the U.S. coastlines poses a significant national security risk. Deploying sensitive arrays in some areas could lead to the need to restrict data access, prevent data acquisition at random intervals, or restrict publication of results. Ocean Leadership and NSF are having discussions with the U.S. military groups about this issue. The OOI will conform to conditions levied by these groups.

In a similar vein, individual PIs who have developed a data source that becomes part of our network may, per the OOI Network data policy, have exclusive rights to the data produced by that data source for a period of no more than one year from the onset of the data stream. The PI will expect the OOI to maintain the security of that data. The OOI will honor any restrictions imposed on data access by the data policy.

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

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

If required, the OOI will monitor its registered users against a terrorist watch list.

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

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

Finally, the OOI must approve any new sensors for use on their observatory element according to a formal process that will developed by the Facility Operators Group. OOI, as part of operational security, will confirm that any sensors planned to be placed on the OOI have been approved by the necessary entity(s).

5. Plan for Transition to Operations

5.1 Operations Plan

The *OOI Network Operations Plan*, incorporated by reference, establishes a framework and shared vision in which Ocean Leadership and the various 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). The responsibilities of Ocean Leadership, the FGG, the FOG, the Network Operations Center, each of the IOs, and MARS are delineated; policies and procedures will be promulgated within this framework which is shown in Figure 4.

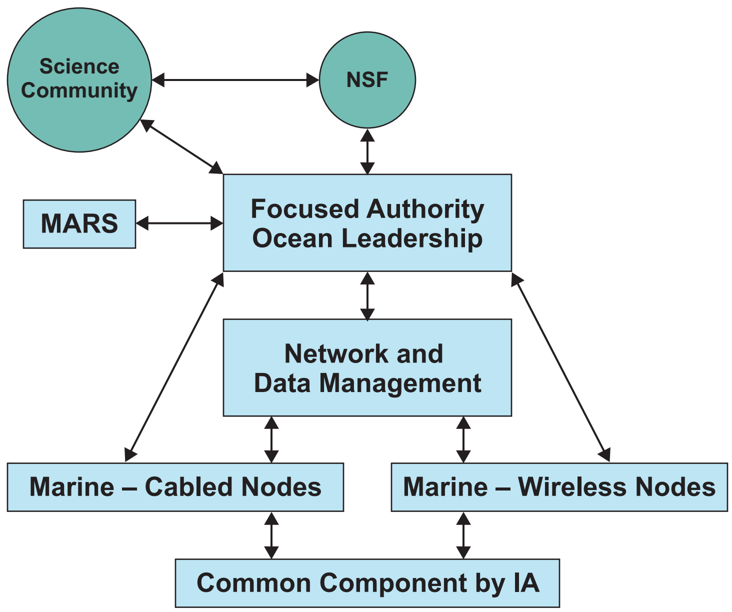

Figure 4: OOI Network Operations Framework

5.2 Science Planning

The OOI Science Plan and related OOI research planning documents describe the science drivers leading to the OOI Network Design. As planning for the OOI facility progresses, science-planning activities will become focused on strategies for fostering and expanding ocean research using the resources of the facility and that cultivate partnerships with other data sets and observing platforms. Implementing and facilitating science planning activities will 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. As described in Section 3 of this document, the primary source of scientific advice for the OOI Program Office will be the SPAC. The SPAC will provide the linkage with the ocean research community and develop strategies for new science programs aligning with OOI science themes and maximizing the utility of the OOI Network. Also active in the science planning process will be the standing subcommittee for Partnerships and Community Development. The latter group will provide advice and develop approaches for broadening the OOI user community.

These construction-phase advisory committees will be established prior to the beginning of MREFC funding. Initial activities that will involve interaction with the prospective OOI user community via a variety of meetings and workshops are under consideration. For example:

- **Regional Meetings –** As OOI Network planning transitions to construction, the iOSC had recommended that the Program Office convene regional meetings to introduce the OOI Network, i.e., its observation capabilities, sensors and instrumentation, concept of operations (including daily operations, policies, procedures), and investigator access to the network, data, and information. These meetings would be held at non-IO institutions with the intent of drawing a broad range of researchers (including graduate students) and educators from academic and agency communities, and coastal and inland institutions.

- **Collaborative Research Workshops –** Supporting multidisciplinary ocean research is a key objective of the OOI. With advice from the NSF and its science advisory committees, the OOI Program Office will convene workshops to facilitate the planning of collaborative research projects employing the resources of the OOI Network. Workshops like this could be designed to include other ocean/earth observatories, other large project, or agency partners.
- **Targeted Workshops –** These would workshops focused on topics such as (but not limited to) assessing the status of technologies needed for OOI, development of new sensors/instruments, identifying new research avenues, and computational, modeling or visualization tools for analysis of the OOI data stream.

The topics for the above workshops may come from the OOI advisory committees, NSF, or the community. Broader science planning will draw in the science activities of other agencies, observing systems, and international organizations.

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 frequently serviced, 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 at each site are:

- Regional Scale Nodes:
  - One planned visit to each site during summer of every year; duration is 12 days per 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 23 days per site.
- Coastal Scale Nodes:
  - Two planned visits to each site every year.
  - Duration for Pioneer Array is 14 days per visit.
  - Duration for Endurance (PNW) Array is three days per visit per site.

5.4 Estimate of Operational Costs

As part of the preliminary design process, operational costs have been estimated for each element of the observatory. During the Conceptual Network Design time period, the ability to meet the $50 million constraint on O&M was the controlling cost parameter. The conceptual design was modified to meet the O&M limit by changing the design elements. With the down scoping that has occurred since the Conceptual Design the first cost (acquisition) is the constraining parameter and the O&M costs are slightly less controlling. One example of this is the reduction in the number of global buoys, which has reduced the O&M costs when compared to the CDR time frame. O&M estimates are included as part of the Cost Book. These estimates will be revised as the OOI concept of operations becomes better defined and as design and operational trade-offs are studied. One of the drivers for the integrated SE/PM team is to carefully review the approach to O&M to look for opportunities to centralize functions to reduce costs. For example, once all the sensors have been fully defined, one solicitation will be considered for procurement with one facility for calibration and maintenance of that set of sensors.

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 and 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 will also be conducted at key junctures. Shortly after the commencement of MREFC funding, the program office will conduct an internal final design review (FDR) to determine the status of all configuration items, and aggregates of configuration items. For larger complex configuration items, this may be a progressive or incremental review, culminating in a system-level FDR that essentially validates the completeness of preceding configuration-item-level FDRs and ensures adequate interfaces between all configuration items. This engineering review must be conducted prior to any IO releasing the first production drawings to manufacture components of any production equipment. Completion of the final design review sets the production baseline for the construction. This review step is discussed further in the CMP.

Regular, issue-specific technical and cost reviews will also be conducted by the project 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.

Ocean Leadership is a research and education community-based organization with a vested interest in the success of the OOI as a research platform that will foster the future of oceanography, and ultimately knowledge about our planet. The organization's Board of Trustees has oversight responsibility for the corporation and its performance against programmatic commitments, and can elect to provide another level of review.

7. PEP Summary

This document describes the plan for managing the OOI Project from Ocean Leadership as envisioned at the end of the Preliminary Design Phase. The document will be updated as the project evolves and will form the framework for interaction between Ocean Leadership and the NSF and between Ocean Leadership and the IOs.

Appendix A: Documents Incorporated by Reference

Release Date	Document Title
May 2005	Ocean Observatories Initiative Science Plan
March 2006	OOI Data Policy
November 2007	OOI Risk Management Plan
June 2007	CGSN Project Execution Plan
July 2006	OOI Systems Requirements Document (SRD)
September 2007	OOI Earned Value Management System (EVMS) Implementation Plan
October 2007	CI Project Execution Plan
October 2007	RSN Project Execution Plan
November 2007	Blue Ribbon Review of OOI Scientific Objectives and Network Design: A Closer Look
November 2007	OOI Configuration Management Plan
November 2007	OOI Network Operations Plan
November 2007	OOI Preliminary Network Design
November 2007	OOI Science User Requirements (SUR)

Appendix B: 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
EIS	Environmental Impact Statement
ESONET	European Seafloor Observatory Network
EVMS	Earned Value Management System
FDR	Final Design Review
FGG	Facility Governance Group
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
IO	Implementing Organization
IOOS	Integrated Ocean Observing System
JOI	Joint Oceanographic Institutions
MARS	Monterey Accelerated Research System
MBARI	Monterey Bar 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
NSF	National Science Foundation
O&M	Operations and Maintenance
OOI	Ocean Observatories Initiative
OOI-SOC	Ocean Observatories Initiative Scientific Oversight Committee
OSC	Observatory Steering Committee
OSU	Oregon State University

PDR	Preliminary Design Review
PEA	Programmatic Environmental Assessment
PEP	Project Execution Plan
PI	Principal Investigator
PND	Preliminary Network Design
RFP	Request for Proposal
RFQ	Request for Qualification
R&RA	Research and Related Activities
RSN	Regional Scale Nodes
SIO	Scripps Institution of Oceanography
SPAC	Science and Program Advisory Committee
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 C: OOI Network Risk Log

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
1001	BOE for CDR Costs are not robust or uniform, so CDR costs could be significantly off.	M/4/3	L/5/1	7/20/06 – Estimate contingency at the WP level IAW the OOI CEP and based on quality of BOE. PDR Costs to be done by responsible IOs.	JOI-D IOs	11/07/07 – Closed. IOs have submitted Cost Books for PDR with contingency at WP level. Significant scope decrease since CDR. Program will down scope if necessary to maintain budget. 7/20/06 – New	NA
1002	If IOs do not ramp up quickly enough, the overall program schedule may slip.	M/4/3	L/3/2	7/20/06 – Judge maturity of management teams of IO bidders. After award, JOI-D conduct meetings and training sessions.	JOI-D	11/07/07 – Recommend closing upon final IO award for RSN. Risk diminished by push-out of PDR and program. Section L of RFP shows how management teams were evaluated. CGSN award made in August and team is still ramping up. RSN award is pending. JOI-D is holding monthly SE/PM meetings that include training on common tools and processes. 7/20/07 – New	NA
1003	If PEA determines that OOI has impact on marine mammals, then mitigation may be required.	H/4/4	M/2/4	7/20/06 – Complete the PEA.	NSF JOI-D	11/7/07 – Risk has decreased due to removal of APOC sensor planned for Aloha Mooring. Next step pending PEA analysis by TEC. 7/20/07 – New	
1004	If PEA determines that OOI has impact on water quality, then mitigation may be required.	H/5/3	M/3/3	7/20/06 – Complete the PEA.	NSF JOI-D	11/7/07 – Next step pending PEA analysis by TEC. 7/20/07 – New	

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
1005	OOI Assets may interfere with fishing activities, so concessions may be required.	H/5/3	M/4/3	11/7/07 – Continue coordination until Fishermen Agreement is signed. 7/20/06 – Carefully plan cable routing; coordinate with fishing industry.	JOI-D RSN IO	11/7/07 – UW proposed alternate cable routing to eliminate cable crossings and to place cable in the general area of other cables for which fishing agreements have been reached. UW has initiated discussion with fishermen groups in Oregon and will use Mike Kelly to coordinate. Oregon fishermen have a standard agreement. Propose to close this when agreements have been signed which will be AFTER PEA is completed. 7/20/07 – New	
1006	If either CR or non-passage of NSF budget, then program schedule will slip due to significant funding requirements in early 2009.	H/4/4	H/4/4	10/15/07 – Closely track the development and approval of the FY 2009 budget.	JOI-D	10/15/07 – New	
1007	If NEPA Analysis is not complete before the NRB review, the OOI will not receive funds in 2008.	M/2/5	M/2/5	11/11/07 – Continue all hands effort to provide needed information for analysis.	JOI-D	11/11/07 – New	
2001	CI Costs at CDR are based on tops down parametric process, so CDR costs could be significantly off.	H//5/4	L/5/1	7/20/06 – Estimate contingency at CI IO and at the WP level IAW the OOI CEP and based on quality of BOE.	UCSD	11/11/07 – Closed. UCSD has submitted Cost Books for PDR with contingency at WP level. Significant scope decrease since CDR. 7/20/06 – New	NA

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
2002	CI must adaptively allocate Marine IO resources as circumstances required, so the interface between CI and Marine IOs must be developed to allow state information to be available and adjusted with ease.	M/4/3	M/4/3	7/20/07 – Begin early development of interface agreements with marine IOs. Assess dynamic allocation process for other types of science observatories.	UCSD IOs JOI-D	11/15/07 – SE's have been meeting regularly since July 2006 to develop interface documents. RSN and CGSN PDR versions are complete. 7/20/07 – New	
2101	The CI uses a widely-distributed project team, so there is possibility of miscommunication affecting the CI design.	M/1/5	M/1/5	12/14/06 – Develop formal communication plan, collaboration tools, and team meetings within the joint project team.	UCSD	11/15/07 – All hands meeting held in October; Communication pathways established. 12/14/06 – New	
2102	The OOI is a widely distributed program with several IOs so there is a possibility of misunderstanding developing between the IOs or with the Program Office	H/4/5	M/3/5	12/14/06 – Maintain good communication with Program Office and other IOs	UCSD	11/11/07 – UCSD is actively participating in monthly SE/PM meetings and more frequent OOI teleconferences. 12/14/06 – New	
2103	The OOI needs to maintain partnerships with non-OOI entities or some capabilities of the OOI will not be realized.	M/3/3	M/3/3	12/14/06 – Maintain close relationship with key external entities like IOOS, NEPTUNE Canada, etc.	UCSD	11/11/07 – Established relationship with Raytheon regarding IOOS. 12/14/06 – New	
2104	The CI uses developing software standards, so it may be affected by changes in standards and technology change by providers.	M/2/4	M/2/4	12/14/06 – Monitor evolving standards.	UCSD	11/11/07 – Watching. 12/14/06 – New	
2105	If the project is underfunded, it may not be possible to complete all the features of the CI.	H/5/5	H/4/5	12/14/06 – Maintain tight control of cost, schedule, and scope; Use EVMS effectively.	UCSD	11/11/07 – Baseline scope, cost, and schedule developed; Controls established. 12/14/06 – New	

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
2106	If there is not adequate community outreach and involvement of stakeholders in the project life cycle, then the CI may not address all of the community wishes and needs.	H/5/5	H/4/5	12/14/06 – Maintain community contact and involve stakeholders in system life cycle and at milestone reviews.	UCSD	11/11/07 – Requirements meetings with users scheduled. 12/14/06 – New	
2107	Requirements are being sought from different domains, so some requirements may be redundant or contradictory.	L/1/1	L/1/1	12/14/06 – Monitor and cull requirements on an ongoing basis.	UCSD	11/11/07 – Requirements Management Plan established. 12/14/06 – New	
2108	If requirements are not prioritized adequately, then the CI may not incorporate the requirement into the right software release.	L/1/4	L/1/4	12/14/06 – Institute formal requirements review process at each Initial Operating Capability milestone.	UCSD	11/11/07 – Requirements Management Plan established. 12/14/06 – New	
2109	If the CI subsystems do not interact properly, the design may be unable to support requirements.	M/1/5	M/1/5	12/14/06 – Institute a formal interface control process.	UCSD	11/11/07 – Interface Management Plan established. 12/14/06 – New	
2110	Policy-based resource management element of CI is unproven, so it may not work as intended, take longer to implement than expected, or cost more than anticipated.	M/2/5	M/2/5	12/14/06 – Use proven technologies and early prototyping of critical elements of CI software.	UCSD	11/11/07 – Early prototyping of critical technologies is included in the process. 12/14/06 – New	
2111	Instrument network capabilities are unproven, so it may not work as intended, take longer to implement than expected, or cost more than anticipated.	M/2/5	M/1/5	12/14/06 – Use proven technologies and early prototyping of instrument network subsystem.	UCSD	11/11/07 – Capabilities have been demonstrated for terrestrial networks. 12/14/06 – New	

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
2112	Streaming data capabilities are unproven, so it may not work as intended, take longer to implement than expected, or cost more than anticipated.	M/2/5	M/2/5	12/14/06 – Use proven technologies and early prototyping of critical elements.	UCSD	11/11/07 – Early prototyping planned. 12/14/06 – New	
2113	Instrument vendors do not have an interface standard, so CI may be unable to get all instruments to work with the software.	L/2/2	L/2/2	12/14/06 – Work with instrument vendors to proactively define interface standards.	UCSD	11/11/07 – Plan for contact with vendors and early establishment of standards. 12/14/06 – New	
2114	Stream processing and storage capabilities are unproven, so it may not work as intended, take longer to implement than expected, or cost more than anticipated.	M/1/5	M/1/5	12/14/06 – Use proven technologies and early prototyping of critical elements.	UCSD	11/11/07 – Amazon ECC is operational. 12/14/06 – New	
2115	Advanced concepts in CI architecture are unproven, so it may not work as intended, take longer to implement than expected, or cost more than anticipated	M/3/3	M/3/3	12/14/06 – Monitor design process and use proven development Integrated Product Teams (IPT).	UCSD	11/11/07 – IPT relationships established. 12/14/06 – New	
2116	Multiple technologies have the same functionality, so CI must be able to accommodate.	M/3/3	M/2/3	12/14/06 – Evaluate competing technologies with focus on the ability to integrate them into the CI.	UCSD	11/11/07 – Ongoing evaluation of technologies; Early prototyping of critical Common Operating Infrastructure (COI) technologies. 12/14/06 – New	

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
3001	Pioneer Array plans to re-charge AUVs with solar power through a cabled AUV docking port; this is not a mature tech-nology, so it may not be able to recharge AUV's	H/5/3	H/4/3	7/1/06 – Develop Mitigation Plan	WHOI	9/27/07 – AUVs may be able to be launched from MVCO tower but this would reduce time in study area; ship based support is possible; hybrid of wind, solar, fuel cells will be designed. 7/1/06 – New	
3002	Shallow water instrument plat-forms will be exposed to large waves and seabed instability, so installations will need to be specially engineered to with-stand this environments	M/5/2	M/4/2	10/14/07 – Shallow Endurance Array site is at 25 meters in Oregon Line. Surface expres-sion will be hardened sphere rather than discus buoy. 7/1/06 – Analyze Potential Stresses for Requirement Specification; Develop mitigation plan with required funding.	WHOI	10/14/07 – Built into cost book for PDR. 7/1/06 – New	
3003	If the shallow installations in coastal arrays are entirely within the surface-active layer, then biofouling techniques must be implemented.	M/5/2	M/4/2	7/1/06 – Conduct Survey of Commercial Developments; Incorporate in Reliability Allo-cation and Maintenance Plans; Develop mitigation plan with required funding.	WHOI JOI-D	11/15/07 – PDR CGSN NRE budget includes a biofouling mitigation task aimed at ex-tending glider sensor reliable operation 11/7/07 –JOI-D will stand up sensor committee to advocate for development of anti-biofouling sensors. 10/14/07 – Semi-annual main-tenance is built into coastal operations plan; If available, instruments with shutters or wipers will be chosen; Data monitoring and QC to limit distribution of "bad" data; post calibration after maintenance to reinstate data. 7/1/06 – New	

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
3004	The technology for linking multiple CPIES is not mature, so development funding is needed.	M/5/2	NA	7/1/06 – Develop mitigation plan with required funding.	WHOI	10/14/07 – Closed. This feature of OOI has been eliminated. 7/1/06 – New	NA
3005	If the Navy does not keep military towers in service, then OOI must secure long term access to these towers or develop an alternative.	M/5/2	NA	7/1/06 – Develop mitigation plan with required funding.	WHOI	10/14/07 – Closed. This feature of OOI has been eliminated. 7/1/06 – New	NA
3006	If current technology AUVs and gliders are used in the coastal design, then likely to not be able to accommodate maintenance intervals of six months nor a significant payload of sensors.	M/4/2	M/4/2	11/7/07 – Review payload requirements for AUVs and gliders; develop higher capability or reduce payload.	WHOI	11/15/07 – PDR CGSN NRE budget includes biofouling mitigation task aimed at extending glider sensor reliable operation. Also includes task aimed at extending glider endurance for Global applications. 11/7/07 – New	
3007	Unattended AUV docking at mooring still very unproven; development time may be longer than anticipated.	M/3/3	M/3/3	11/15/07 – Will use cost-sharing funds from the Commonwealth of Massachusetts to accelerate the development of AUV docking.	WHOI	11/15/07 - New	
3008	Cost of cabling PNW 80m and 500m moorings needs update	M/2/4	M/2/4	11/15/07 – Strong science support for cabling the moorings but costs are high. PDR budget uses costs from RSN IO. Consider contracting cabling directly thru JOI-D	WHOI JOI-D	11/15/07 - New	

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
3501	Design of high latitude spar buoy is at an early stage, so severe environmental conditions may cause a cost growth.	H/5/3	L/1/3	7/20/06 – Analyze during preliminary design stage.	WHOI	11/12/07 – Closed. EDP is upscope on program and no spars are likely to be in program. 10/14/07 – High latitude sites will use discus buoys; EDP (spar) will be implemented at mid-Atlantic where environmental conditions are less severe for maintenance and design. 7/20/06 – New	NA
3502	Profiling of upper water column at global sites is still in development, so both cost and performance estimates are based on little data.	H/5/3	H/5/3	7/20/06 – Develop technology further during preliminary design stage.	WHOI	10/14/07 – JOI sponsored profiling workshop in July 2007; winched profilers identified as an enabling technology that NSF should continue to fund outside of OOI; multiple teams will be developing so not a sole design. 7/20/06 – New	
3503	If successful designs for EOM cables and terminations do not work in extreme environments or for more than one year, then costs could increase.	M/4/3	M/4/2	7/20/06 – Conduct longer term and more extreme environmental testing during design phase.	WHOI	9/27/07 – EOM cables are limited to one global site (upscope) and three (and one upscope) pioneer sites to minimize impact; alternative is EM cable. 7/20/06 – New	

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
3504	There is limited reliability information on two-way acoustic modem links, so commercially available links may not meet reliability requirements of OOI.	M/4/3	M/4/2	7/20/06 –Develop technology further and conduct reliability testing during preliminary design phase.	WHOI	9/27/07 – Primary acoustic links have been eliminated on pioneer, by adding surface piercing moorings; global buoys with acoustic links will internally log data, so risk is reduced to timeliness of data and not loss of data; acoustic testing from gliders to instruments is currently being done by SIO. 7/20/06 – New	
3505	If the global sites cannot be serviced more than once a year, then some sensors may not be able to continually provide data due to biofouling.	M/4/3	M/4/3	7/20/06 – Develop mitigation plan with required funding during preliminary design stage.	WHOI JOI-D	11/7/07 – JOI-D will stand up sensor committee to advocate for development of anti-biofouling sensors. 10/14/07 – Instruments with shutters or wipers will be chosen; Data monitoring and QC to limit distribution of “bad” data; post calibration after maintenance to reinstate data. 7/1/06 – New	
3506	If the global seafloor network of sensors fails, it may not be possible to repair it until the next weather window.	M/4/3	M/4/2	7/20/06 – Consider redundancy and reliability of sensors during the design phase.	WHOI	11/7/07 – Closed. Mid-Atlantic site is now upscope. 10/14/07 – The only remaining seabed network is in the mid-Atlantic site which does not have weather window to consider; remaining sites have acoustic and iridium telemetry. 7/20/06 – New	NA

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
3507	If a discus buoy mooring fails (for a myriad of reasons), it will be necessary to retrieve, repair, and re-install.	L/3/1	L/3/1	10/14/07 – Predict mooring forces using accurate environmental data and numerical modeling; Provide for measurement of actual mooring forces to use in the event of a failure. 7/20/06 – Study past failures for trends during preliminary design phase.	WHOI	10/14/07 – Built into cost book for PDR. 7/20/06 – New	
3508	If a electronic or telemetry failure occurs in a catastrophic event, it will be necessary to repair quickly to avoid loss of data.	L/3/1	L/3/1	10/14/07 – Design system for on-board recording and buffering of data; Provide for remote trigger of a system reset for reprogramming and troubleshooting; timely FMEA. 7/20/06 – Study past failures for trends during preliminary design phase.	WHOI	10/14/07 – Built into cost book for PDR. 7/20/06 – New	
3509	If the C-band telemetry link fails on the buoy, there could be loss of data.	L/3/1	L/3/1	10/14/07 – Use iridium as an alternative; Review technology availability and accommodate improvements during life cycle. 7/20/06 – Study past failures for trends during preliminary design phase.	WHOI	11/7/07 – Closed. Mid-Atlantic site is now upscope. 10/14/07 – The only site that would use C-band is Mid-Atlantic, where Iridium is available as a back-up. 7/20/06 – New	NA
3510	If the diesel generator fails on the EDP, then the size and weight of the generators will make them difficult to replace at sea.	L/3/1	L/3/1	10/14/07 – Provide back-up solar, wind systems augmented by storage batteries; Design generators to be modular for replacement at sea. 7/20/06 – Study past failures for trends during preliminary design phase; Analyze redundant power designs.	WHOI	11/7/07 – Closed. Mid-Atlantic site is now upscope. 10/14/07 – The only site that would use diesel generators is Mid-Atlantic. 7/20/06 – New	NA

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
3511	If high latitude buoys become laden with ice, their performance may be limited.	L/3/1	L/3/1	10/14/07 – Design buoy with heavy ice load to be stable; Locate critical items to avoid icing areas; Design to limit ice formation; Use waste heat from power generation. 7/20/06 – Study past failures for trends during preliminary design phase.	WHOI	10/14/07 – Built into cost book for PDR. 7/20/06 – New	
3512	If NOAA decides not to continue to support their surface buoy at PAPA, then the OOI will need to install one or pick up maintenance on the existing one.	H/3/5	H/3/5	11/7/07 – Monitor NOAA plans for Station PAPA and revisit after two years; Develop relationships at NOAA to keep in loop on decisions.	WHOI JOI-D	11/7/07 – New	
3513	Long-term moorings in very harsh, high latitude conditions has never been done; first deployments may fail.	H/3/4	H/3/4	11/15/07 – Design will build on previous experience with moorings in harsh conditions; test deployment planned for Station W off New England coast.	WHOI	11/15/07 - New	
4001	If the interfaces with other parts of the OOI are not firmed up, the RSN development may not be able to proceed.	H/5/5	NA	7/20/06 – Start requirements document and interface control drawings at appropriate time.	UW	10/4/07 – Closed. RSN has developed agreed interfaces with CGSN and CI and will continue to augment these as the need arises; RSN will control system through EMS; Single Contractor will deliver Wet Plan and Primary Nodes. 7/20/06 – New	NA

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
4002	If the RSN is not suitable for 30 year life requirement, reliability, maintainability, and upgradability may be sacrificed.	H/3/5	NA	7/20/07 – Select contractors with required experience and qualifications.	UW	10/4/07 – Commercial telco equipment will be used in wet plant; secondary infrastructure will be maintainable by ROV. 7/20/06 – New	NA
4003	The RSN site environments are purposely harsh, so backbone cable may be subject to breaks and failures.	H/3/5	L/3/2	7/20/06 – Assess cable route by survey; Maintain spare cable and contingency for extra repair; Provide redundant cable paths.	UW	10/4/07 – STAR allows safer cable route; Secondary equipment can be replaced. 7/20/06 – New	
4004	If secondary infrastructure contains armored cable, ROV's may not be able to lay the cables.	M/3/3	L/3/1	7/20/06 – Review data or conduct surveys for route and cable selection; discuss alternate laying techniques with experts.	UW	10/4/07 – There are only a few areas needing armored cable; Advances in ROV cable laying technology will allow laying. 7/20/06 – New	
4005	If the RSN and NEPTUNE Canada are interconnected, the two-way interface may be extremely difficult.	M/4/3	NA	7/20/06 – Prepare wet plant RFP to enable cost and reliability to be evaluated without excluding different communication system options.	UW	10/4/07 – Closed. The RSN and NEPTUNE Canada will not be physically connected; All interconnection is through the CI. 7/20/06 – New	NA
4006	Deep water profiling moorings are unproven technology, so it may take multiple development cycles.	M/4/3	M/4/2	7/20/06 – Develop a test program that includes successful prototype testing prior to manufacturing.	UW	10/4/07 – Test program is included in Cost Book for PDR; fewer deepwater profiling moorings are now in program. 7/20/06 – New	
4007	Environmental permits may be difficult to secure for active acoustics, so some science data may not be available.	H/5/5	NA	7/20/06 – PEA analysis will analyze effects of active acoustics; Don't include active acoustics in baseline.	UW	10/4/07 – Closed. Active acoustics are not planned for initial deployment. 7/20/06 – New	NA

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
4008	If legal liability of ownership is not known, commercial risk may prevent institutions from bidding on project.	H/5/5	NA	7/20/06 – Consult legal expert, Protect facility from damage; Institute safety measures at IO, Implement safe practices for O&M, Purchase insurance.	UW JOI-D	10/4/07 – Closed. JOI-D will accept risk of ownership. IOs will carry contractor risk. 7/20/06 – New	NA
4009	Because there are only a few suppliers who can supply the backbone cable and repeaters, the cost may be unusually high.	M/3/3	M/3/3	7/20/06 – Prepare acquisition strategy; Ensure IO has contracting/legal expertise on team; Assess supplier solvency.	UW JOI-D	10/4/07 – Unrepeatered STAR configuration should open the number of qualified vendors for the backbone cable and nodes. 7/20/06 – New	
4010	If the submarine telecom industry has a comeback, the cost for the backbone cable and infrastructure could increase.	M/3/3	M/3/3	7/20/06 – Monitor market conditions.	UW	10/4/07 – UW is tracking market conditions; STAR configuration allows for non-traditional suppliers; Appropriate contingency established in the PDR cost book. 7/20/06 – New	
4011	The extension cables will be subject to harsh environments, so they may be subject to breaks and failures.	M/3/3	M/3/3	10/4/07 – Conduct trade-off of higher cable protection vs higher maintenance costs. 7/20/06 – Conduct detailed survey around each Node to determine optimum cable placement.	UW	10/4/07 – Initial detailed node surveys planned for summer of 2008. 7/20/06 – New	
4012	Sensor maintenance and calibration intervals are uncertain, so need to develop a logistics approach during development.	M/3/3	M/3/3	10/4/07 – Choose higher reliability sensors and instruments; Develop a concept of maintenance and repair during preliminary design phase.	UW	10/4/07 – Collecting data sheets for sensors from commercial vendors. 7/20/06 – New	

ID	Description of Risk Identify Consequences	Open R/L/S	Review R/L/S	Mitigation Action	Who	Action Status	ECR#
4013	The high voltage power converter has proven to be a tricky technology, so there is only one vendor who has demonstrated capability and they may inflate costs.	M/3/4	M/3/4	10/4/07 – Choose well qualified contractors;, monitor MARS and NEPTUNE development closely; Design nodes for recovery and upgrade of converters.	UW	10/4/07 – New	
4014	If the long-range 10 GigE transmission system cannot handle the RSN distances, then a repeatered option may need to be considered.	M/3/3	M/3/3	10/4/07 – Choose well qualified contractors; Assess and test options early in project.	UW	10/4/07 – New	
4015	Only a select few ROVs are currently capable of laying secondary cables, so there may not be an ROV available when OOI needs one for installation or O&M.	M/2/3	M/2/3	11/5/07 – Work with commercial ROV operators to add the laying capability to their ROV interface.	UW	11/5/07 – New	

Appendix D: Technical Baseline

Physical Infrastructure

Coastal Scale Nodes:

Node 10 Pioneer Array	– Mid-Atlantic coast
Node 11 Endurance Array	– Pacific coast off Oregon

Regional Scale Nodes:

Node 1 Hydrate Ridge	– Juan de Fuca tectonic plate
Node 2 Blanco	– Juan de Fuca tectonic plate
Node 3 Axial	– Juan de Fuca tectonic plate
Node 4 Subduction Zone	– Juan de Fuca tectonic plate
Node 5 Mid-plate	– Juan de Fuca tectonic plate

Global Scale Nodes:

Node 6 Papa	– NE Pacific
Node 7 Irminger	– Irminger Sea
Node 8 Southern Ocean	– Latitude 55 South – off Chile

Science Requirements

MO=Measurement Objective

CSN Measurement Objectives:

ID	Description
CSN-MO-1	Time series of surface meteorological observations suitable for estimation of bulk air-sea fluxes of momentum, heat and moisture as well as direct covariance measurements of momentum and buoyancy fluxes.
CSN-MO-2	Observations of turbulent mixing and gas exchange at the sea surface.
CSN-MO-3	Time series observations of dynamic processes and structure in the surface mixed layer and upper ocean.
CSN-MO-4	Time series observations of surface to near seafloor distribution and variability of standard hydrographic properties, currents, mixing, and biogeochemical parameters such as carbon, other particulate and dissolved materials, optical properties, estimated phytoplankton biomass, and primary production.
CSN-MO-5	Observations of bottom boundary layer dynamics, currents, dissolved properties, community respiration, suspended particulate characteristics.

Measurement Objectives: Endurance Array

ID	Description
All CSN measurement objectives listed plus specific objectives listed below.	
CSN-MO-6	A permanent coastal observatory to provide continuous and coherent multi-disciplinary measurements to resolve long-term trends while providing temporal resolution to observe episodic events and resolve rapidly varying processes.
CSN-MO-7	Permanent cross-margin line(s) of moorings to provide observations of cross-shelf and along-shelf variability over seasonal, interannual, and climatic time scales.

CSN-MO-8	Provide high power and communications bandwidth via cable connections to shore.
CSN-MO-9	Observations of pelagic and benthic organisms, and site-specific events.
CSN-MO-10	Additional capability for power and bandwidth to support future observations (i.e., accommodate the potential of additional sensors) such as zooplankton and other nekton biomass and size class, biogeochemical processes and sediment-seawater exchange, high definition visible images, seafloor imaging, sediment transport, etc.

Measurement Objectives: Pioneer Array

ID	Description
All CSN measurement objectives listed plus specific objectives listed below.	
CSN-MO-11	A relocatable array of instruments and sensors optimized to focus on high spatial (vertical and horizontal) resolution of continental shelf processes.
CSN-MO-12	Array to be designed to resolve shelf transport processes and ecosystem dynamics.
CSN-MO-13	Array to be configured and instrumented to provide multidisciplinary, synoptic measurements spanning the shelfbreak at high temporal and spatial resolution.
CSN-MO-14	Fixed moorings to be augmented by instrumented AUVs and gliders.

GSN Measurement Objectives:

ID	Description
GSN-MO-1	Time series of surface meteorological observations suitable for estimation of bulk air-sea fluxes of momentum, heat and moisture as well as direct covariance measurements of momentum and buoyancy fluxes.
GSN-MO-2	Observations of ocean wind waves and swell, flow structures within the upper ocean, upper ocean turbulence, and other exchange processes at the air-sea interface and upper ocean during severe storms (i.e., high wind, waves, sea spray).
GSN-MO-3	Observations of turbulent mixing and gas exchange at the sea surface.
GSN-MO-4	Time series observations of dynamic processes and structure in the surface mixed layer and upper ocean.
GSN-MO-5	Time series observations of surface to near seafloor distribution and variability of standard hydrographic properties, currents, mixing, and biogeochemical parameters such as carbon, other particulate and dissolved materials, optical properties, estimated phytoplankton biomass, and primary production.
GSN-MO-6	Observations of bottom boundary layer dynamics, dissolved properties, community respiration, suspended particulate characteristics.
GSN-MO-7	Observations of the global sound field to detect earthquakes, nuclear explosions, track marine mammals.
GSN-MO-8	Observations of global seismicity.
GSN-MO-9	Capability to support investigations of global heat content and large-scale thermal variability.
GSN-MO-10	Capability to support observations of atmospheric aerosols.
GSN-MO-11	Capability to support observations of BSRN compliant direct and diffuse solar radiation.

Note: All sites will not be capable of supporting all objectives.

RSN Measurement Objectives:

ID	Description
RSN-MO-1	Capability to detect and measure phenomena such as: volcanic tremor, seismic events, slow tremor, strong motion, pressure changes, and tidal perturbations.
RSN-MO-2	Measure temporal and spatial scales of seismic activity and impacts to crustal hydrology; collect observations to understand the nature and causes of intraplate deformation; measure temporal and spatial scales of sub-seafloor hydrology and pressure transients, anisotropy, velocity and attenuation.
RSN-MO-3	Measure the spatial and temporal variability of temperature, chemistry, hydrothermal and pore fluid flow in subsurface, black smoker, cold seep, and plume environments.
RSN-MO-4	Provide observations of gas hydrate formation/dissolution, bubble formation, compaction, compression, tidal loading, thermal perturbations, lithification, carbonate formation, and exchange.
RSN-MO-5	Provide capability to support visual observations of macrofaunal community distribution in seep and vent environments.
RSN-MO-6	Provide for future capability to support observations of the composition and concentration of microbial material in subsurface, vent, pore fluid, seep, and plume environments.
RSN-MO-7	Provide the regional seismic measurements that complement on-shore seismic arrays as well as on a larger scale the global seismic network.
RSN-MO-8	Provide measurements of turbulent mixing and exchange of heat, gases, and particulate and dissolved materials from sea surface to seafloor.
RSN-MO-9	Measure turbulent mixing at the water-seafloor boundary in areas of rough topography and up through the water column.
RSN-MO-10	Time series observations of structure and dynamics of physical and biological properties in the mixed layer and upper ocean.
RSN-MO-11	Observe the meso- and larger-scale structure and dynamics in the RSN area, bridging spatial and temporal scales between coastal and global scales for the science themes of Climate Variability and Carbon Cycling, and Ocean Circulation, Mixing, and Ecosystems.
RSN-MO-12	Observe nekton (i.e., fish and marine mammals) and measure abundance, species classification, and biomass flux.
RSN-MO-13	Time series observations of surface to near seafloor distribution and variability of standard hydrographic properties, currents, mixing, and biogeochemical parameters such as carbon, other particulate and dissolved materials, optical properties, estimated phytoplankton biomass, and primary production.
RSN-MO-14	Observations of bottom boundary layer dynamics, currents, dissolved properties, community respiration, suspended particulate characteristics.

System and CI Top Level Requirements:

(Linked to the SRD)

S-S-1	Provide an interactive, globally distributed and integrated observatory network to enable next-generation studies of the complex, interlinked physical, chemical, biological, and geological processes operating throughout the global ocean. Science User Requirements are in a separate document.
S-S-2	The OOI shall observe phenomena at the spatial and temporal scales appropriate to the processes and systems being studied.
CI-PD-1	*The CI is in service to scientific investigation, discovery and innovation*
CI-PD-2	*Development of the CI shall be science-driven*
CI-CE-1	The CI shall be designed to minimize the cost over its (25 year) lifetime
CI-CE-2	To the extent possible CI shall utilize the common hardware and software interfaces with other observatory elements
CI-OC-1	*The CI shall provide a real time (i.e., minimum delay) communication capability*
CI-OS-1	*The national security concerns of the OOI's sponsoring government shall be accommodated*
CI-OS-2	*All resources connected to an OOI observatory shall be authorized and authenticated*
CI-IP-1	*The CI shall implement policy-based governance for resource access and utilization*
CI-IRC-1	OOI standard metadata shall meet or exceed national standards
CI-IRD-1	All resources connected to an OOI observatory shall be discoverable by the CI either directly, by content or through their associated metadata
CI-IRU-1	*The CI shall provide a standard mechanism to manage stateful resources*
CI-IRW-1	*The CI shall provide tools to compose (configure, compile, verify, save, and execute) processes*

Platforms - Core Sensors

Coastal Scale Nodes:

Node 10 Pioneer Array

Surface moorings	3 with 8 sensors total
Winched profiler moorings	2 with 12 sensors per
Profiler moorings	5 with 7 sensors per
Near Surface Sensors	23 sensors
Multi function nodes (MFNs)	3
Docking stations for AUVs	2
Mobile assets	2 AUVs
	10 Gliders

Node 11 Endurance Array

25 m Mooring	1 with 34 sensors
80 m Mooring	1 with 37 sensors
500 m Mooring	1 with 44 sensors
Mobile assets	6 gliders

Regional Scale Nodes:

Node 1 Hydrate Ridge	
Primary	1 with 4 sensors
Secondary	1 with 11 sensors
	1 with Endurance cable
Profiler	1 with 27 sensors
- Sea floor Instrument Pkg.	11 sensors
Node 2 Blanco	
Primary	1 with 4 sensors
Node 3 Axial	
Primary	1 with 4 sensors
Secondary	1 with 4 sensors
	1 (expansion)
Profiler	1 with 27 sensors
- Seafloor Instrument Pkg.	11 sensors
Node 4 Subduction Zone	
Primary	1 with 5 sensors
Secondary	1 with 7 sensors
Node 5 Mid-plate	
Primary	1 with 4 sensors

Global Scale Nodes

Node 6 Papa	
Mooring	1 Subsurface Hybrid w/54 sensors
	2 Flanking w/ 12 sensors
Mobile assets	5 Gliders
Node 7 Irminger	
Moorings	1 Surface w/ 4 sensors
	1 Hybrid Subsurface mooring w/27 sensors
	2 Flanking w/ 12 sensors
Mobile	5 Gliders
Node 8 55S	
Moorings	1 Surface w/ 5 sensors
	1 Hybrid Subsurface w/54 sensors
	2 Flanking w/12 sensors
Bottom	1 MFN
Mobile Assets	5 Gliders

OOI Project Cost Baseline:

Fiscal Year	2008	2009	2010	2011	2012	Total
NSF Management Reserve			2.00	3.00	5.00	10.00
Project Office	6.44	5.07	5.89	5.42	4.86	27.69
Cyber IO	7.96	7.86	4.72	4.19	4.06	28.79
Coastal/Global IO	9.23	17.86	42.57	14.45	11.39	95.50
Regional IO	30.52	45.57	39.38	31.95	21.71	169.12
Total OOI	36.11*	80.00	90.00	95.00	30.00	331.11

**includes $5.12m of FY2007 funding*

OOI Project Schedule Baseline:

Item	Task Name	Finish
1	OOI Construction Project Baseline and U.S. National Science Board Construction Funding Approval	Jul, 2008
2	RSN Authorization to Proceed	Jul, 2008
3	RSN Requirements Readiness Review	Jul, 2008
4	RSN Cable Plant Award	Oct, 2008
5	Release RFP for education	Mar, 2009
6	CI System Software “Release-1” Complete	Nov, 2009
7	Contract Award – Education Infrastructure Facility	Jun, 2009
8	RSN Shore Stations Build Out Complete build out complete	Aug, 2009
9	Pioneer Coastal Profiler CDR	Aug, 2009
10	Education Infrastructure Requirements Workshop	Nov, 2009
11	Station Papa CDR	Nov, 2009
12	Irminger Sea CDR	Nov, 2009
13	PNW Uncabled Array CDR	Nov, 2009
14	Coastal Gliders CDR	Nov, 2009
15	RSN Backbone / Cable Construction Complete	Mar, 2010
16	CI System Software “Release-2” Complete	Feb, 2011
17	PNW Cabled Endurance Array CDR	May, 2010
18	Issue Infrastructure System Engineering Plan	May, 2010
19	RSN Low Voltage Node Design complete	Jun, 2010
20	RSN Junction Box Design complete	Jun, 2010
21	Shore Station Design Complete	Jul, 2010
22	Pioneer Coastal Profiler Installation Readiness Review / PCA	Jul, 2010
23	RSN Secondary Cable Design Complete	Aug, 2010
24	RSN Mooring Design Complete	Oct, 2010
25	RSN Secondary Cable First Article Review	Dec, 2010
26	RSN Junction Box First Article Revew	Dec, 2010

27	PNW Endurance Array Installation Readiness Review / PCA - Gliders	Jan, 2011
28	Pioneer Coastal Gliders Installation Readiness Review / PCA	Jan, 2011
29	Southern Ocean CDR	Apr, 2011
30	Pioneer P1 - P4 CDR	Apr, 2011
31	AUV and AUV Dock CDR	Apr, 2011
32	Complete Design – Free Choice Learning and Post-Secondary Training Environments	May, 2011
33	CI System Software “Release-3” Complete	Jun, 2012
34	Station Papa Installation Readiness Review/ PCA	May , 2011
35	PNW Endurance Array Installation Readiness Review/ PCA - Uncabled	Jul, 2011
36	PNW Endurance Array Installation Readiness Review/ PCA - Cabled	Jul, 2011
37	Irminger Sea Installation Readiness Review/ PCA	Feb, 2012
38	Beta Test – Free Choice Learning and Post-Secondary Training Environments	May, 2012
39	CI System Software “Release-4” Complete	Oct, 2012
40	Pioneer P1 - P4 Installation Readiness Review / PCA	Aug, 2012
41	Southern Ocean Installation Readiness Review / PCA	Nov, 2012
42	AUV Installation Readiness Review / PCA	Nov ,2012
43	CI System Software “Release-5” Complete	Jun, 2013
44	Education Infrastructure Operational	Jun ,2013
45	RSN Start Commissioning Node 1	May,2013
46	OOI Complete	July, 2013