OOI CONCEPT OF OPERATIONS

Version 3-00
Document Control Number 1013-00000
2019-06-20

Woods Hole Oceanographic Institution
Woods Hole, MA
www.whoi.edu

in Cooperation with

University of Washington
Oregon State University
Rutgers University

Document Control Sheet

Version	Date	Description	Originator
1.01	12-08-2014	Initial issue	M. Kelly
2-00	12-06-2016	Update	G. Ulses
2-01	01-18-2017	Format and copy edits	S.Banahan
2-02	01-27-2017	System CCB comments incorporated	
2-03	01-30-2017	Edits/formatting	G. Ulses, S. Banahan
2-04	02-02-2017	ECR 1300-00558 System CCB approved	
3-00	06-20-2019	OOI 2.0 Update	P. Matthias

Table of Contents

1 Introduction

The Ocean Observatories Initiative (OOI) instrumented platforms, including fixed moorings, profiling moorings, cabled seafloor nodes, gliders and autonomous underwater vehicles (AUV), provide the potential to resolve compelling scientific and societal issues through sustained measurements of ocean processes and properties. The OOI represents the result of more than two decades of scientific planning, leading to a deployed operating infrastructure based on science requirements derived from science themes.

The OOI platforms, built and deployed during the earlier construction phase, carry multidisciplinary sensors that deliver measurements into a networked software system for processing and distribution. The OOI status of Full Acceptance and Final Commissioning was approved by the National Science Foundation (NSF) on June 3, 2016, initiating the full operational phase of the OOI. The OOI has an expected operation of 25 years or more, and data are freely available to users via the Internet.

The OOI is a facility that provides ocean data from over eight hundred instruments deployed from the sea surface to the seafloor. In addition to providing sustained data from these ‘core’ instruments, the OOI is designed to accommodate new instruments by being ‘sustainable’, ‘configurable’ and ‘expandable,’ to support new work proposed by the earth / ocean / atmosphere community of users.

This Concept of Operations document describes the scope and function of the observatory, and includes the metrics by which the effectiveness of the observatory is evaluated.

2 The Purpose, Functions & Definition of the OOI

2.1 Purpose

The OOI is a networked ocean-focused research observatory with arrays of instrumented moorings, profilers, gliders and autonomous vehicles within deep ocean and coastal regions, as well as a cabled array of instrumented platforms and profilers on or above the seafloor over the Juan de Fuca tectonic plate. This “system of systems” provides ocean scientists, educators, and the public with sustained, time-series data sets that provide insight into interlinked physical, chemical, biological, and geological processes throughout the coastal regions and deep ocean.

The scientific basis for the construction of this networked observatory is documented in community-wide reports that identified the high priority areas of ocean research addressable through a technically advanced ocean observing facility. These science topics have been described in the *OOI Science Plan*[4], *Ocean Sciences at the New Millennium*[2], and *Ocean Research Interactive Observatory Networks (ORION) Workshop Report*[6]. The science in these reports mirrors many interdisciplinary themes described in *Charting the Course for Ocean Science in the United States for the Next Decade: An Ocean Research Priorities Plan and Implementation Strategy*[3].

The OOI infrastructure collects interdisciplinary measurements to investigate a spectrum of phenomena and processes including episodic, short-lived events (meteorological, tectonic, volcanic, geological, geophysical, and ecological), and more subtle, long-term changes and emergent phenomena in ocean systems (circulation patterns, climate change, ocean acidity, geophysical events and ecosystem trends). [Reference: *OOI Science Prospectus*[5]]

The overarching scientific themes of the OOI span six multi-disciplinary domains, and each theme incorporates a multitude of research questions.

- *Ocean-Atmosphere Exchange*. Quantifying the air-sea exchange of energy and mass, especially during high winds (greater than 20 ms^{-1}), is critical to providing estimates of energy and gas exchange between the surface and deep ocean, and improving the predictive capability of storm forecasting and climate-change models.

- *Climate Variability, Ocean Circulation, and Ecosystems*. As both a reservoir and distributor of heat and carbon dioxide, the ocean modifies climate, and is also affected by it. Understanding how climate variability affects ocean circulation, weather patterns, the ocean's biochemical environment, and marine ecosystems is a compelling driver for multidisciplinary observations.

- *Turbulent Mixing and Biophysical Interactions*. Mixing occurs over a broad range of scales and plays a major role in transferring energy, materials, and organisms throughout the global ocean. Mixing has a profound influence on primary productivity, plankton community structure, biogeochemical processes (e.g., carbon sequestration) in the surface and deep ocean, and the transport of material to the deep ocean.

- *Coastal Ocean Dynamics and Ecosystems*. Understanding the spatial and temporal complexity of the coastal ocean is a long-standing challenge. Quantifying the interactions between atmospheric and terrestrial forcing, and coupled physical, chemical, and biological processes, is critical to elucidating the role of coastal margins in the global carbon cycle, and developing strategies for managing coastal resources in a changing climate.

- *Fluid-Rock Interactions and the Subseafloor Biosphere*. The oceanic crust contains the largest aquifer on Earth. Thermal circulation and reactivity of seawater-derived fluids modifies the mineralogy of oceanic crust and sediments, leads to the formation of hydrothermal vents that support unique micro- and macro-biological communities, and concentrates methane to form massive methane gas and methane hydrate reservoirs. The role that transient events (e.g., earthquakes, volcanic eruptions, and slope failures) play in these fluid-rock interactions and in the dynamics of benthic and sub-seafloor microbial communities remains largely unknown.

- *Plate-Scale, Ocean Geodynamics*. Lithospheric movements and interactions at plate boundaries at or beneath the seafloor are responsible for short-term events such as earthquakes, tsunamis, and volcanic eruptions. These tectonically active regions are also host to the densest hydrothermal and biological activity in the ocean basins. The degree to which active plate boundaries influence the ocean from a physical, chemical, and biological perspective are largely unexplored.

All data/metadata are freely available to the public. All OOI data including instrument-level measurements and derived data products are available via the OOI Data Portal and other national data archives. The OOI website provides all data, metadata and data processed via conventional algorithms through a data subscription service or direct retrieval from OOI storage. Data quality and data management utilize generally accepted protocols, factory calibrations and at sea calibration procedures.

2.2 Function

The OOI functions as a facility in support of the needs of users to conduct research across a wide range of science themes, within an expandable observing infrastructure that spans widely-differing ocean domains. The OOI functions to provide:

a. OOI Long Term Time Series Datasets: The OOI core instrumentation enables a time series of data that serve a diverse, multidisciplinary research community and improve understanding of complex, interlinked processes across a range of spatial and temporal scales. The user base includes the following: oceanographic researchers and modelers of all types, educators and students, and the general public. The OOI sites have high time/space resolution and contemporaneous surface forcing and water column observing which make them well-suited to validate/verify models and motivate model improvement.

b. In-situ Ocean Laboratory: The OOI cabled infrastructure has nearly unlimited power and data transmission head room, while the uncabled infrastructure has modest power head room. Both allow OOI users to develop and apply new technologies by connecting their instruments or concepts to the OOI network via new supported proposals. The opportunities include high risk/high pay off disruptive technologies and/or next generation sensors. The OOI supports the addition of new sensors and operations through new funded proposals to the NSF, not included in the $44M O&M budget.

2.3 Definition

The deployed infrastructure of the OOI has a planned operational period of performance of 25 years, with an O&M budget ceiling of $44M per year (as of 2019). User needs are met through careful management and QA/QC of data delivered through the data paths provided by the infrastructure.

a. Data – metadata, current operating status, and full operational history of all instruments and platforms:

- The main website for the OOI program is oceanobservatories.org. All information cited below can be either retrieved from or linked to from this site.
- All documentation, including technical drawings, specifications, operating procedures, test plans and results, cruise plans, and cruise reports are maintained in the Alfresco DMS, which can be accessed through the OOI website (https://oceanobservatories.org/technical-data-package/), or directly (https://alfresco.oceanobservatories.org/).
- Through the Data Portal (https://ooinet.oceanobservatories.org), users view or download data products from any platform or instrument at any OOI site, from any operational time interval, in one of several formats. More information about data delivery and document and data access is provided in Section 4 of this document. The Data Portal is also called OOINET – a name used frequently inside of this document and inside the OOI program.
- Raw unprocessed/minimally processed instrument data can be downloaded from the Raw Data Archive using the link on the data download button on the plotting page of the Data Portal or users can use the link on the Data drop down menu on https://oceanobservatories.org which will take the user to https://rawdata.oceanobservatories.org/files/.
- Telemetered data from the OOI Cassandra and Postgres databases are processed nightly into an ERDDAP data platform found on the Data drop down menu on https://ocenaobservatories.org. The ERDDAP URL: is https://oceansobservatories.org/erddap-server/

b. Marine Infrastructure

The OOI consists of marine infrastructure that is deployed across:

Two active open ocean sites (OOI Global Array sites), each with instrumented moorings, profilers, and gliders arranged as a triangular array 30-50 kilometers on a side:

- Station Papa, Gulf of Alaska
- Irminger Sea, off southeastern Greenland

The OOI serves data from two additional open ocean sites were deployed and operated until 2017:

- Southern Ocean, off southern Chile; An OOI Surface Mooring deployed to this location provides data through 2019
- Argentine Basin, in the southern Atlantic

Two seafloor sites on the Juan de Fuca plate (OOI RCA sites), each with instrumentation and profilers connected to high-power, high-bandwidth cable:

- Axial Seamount including the Base and Caldera sites of active venting at the western boundary of the plate
- Continental Margin including the Slope Base and Southern Hydrate Ridge sites

Two coastal regions (OOI Coastal Array sites), each with instrumented moorings, profilers, and mobile assets:

- Endurance Array, cross-shelf lines at Newport, Oregon (44° 39' N) and Grays Harbor, Washington (47° 00' N), including gliders collecting measurements within and around the array. There are wired connections to the Regional Cabled Array of instrumented benthic experiment platforms at the 80m and 600m locations and water column profilers at the 600m locations on the Oregon line.
- Pioneer Array, cross-shelf/shelf-break rectangular array south of New England, with two AUVs and five gliders.

At each of these sites, the instrumentation is configured to sample at rates consistent with the default science objectives of the facility, and gliders and AUVs execute approved mission plans (horizontal pattern and vertical cycle pattern). The physical distribution of buoys at each open ocean and coastal site, and the mission plans for gliders and AUVs, extend the horizontal and vertical scales of measurements of ocean properties and processes at those sites. Sampling rates and mission plans are posted and accessible to all users through the OOI website. New configurations and mission plans may be proposed by users through the proposal process.

The Pioneer Array coastal observatory off the East coast is planned as a relocatable array with an operational window of 5 to 7 years. Relocation will be addressed through an NSF proposal process.

Site Locations, instrument counts and baseline design details are available at http://oceanobservatories.org.

The OOI marine infrastructure consists of:

a. The total OOI mooring count for the 2 global arrays, 2 coastal arrays and the Regional Cabled Array (Figure 1) is 34 instrumented moorings with 2-way communications, some with multi-source power capabilities (undersea cable, solar, battery and wind).
b. Mobile assets, including a deployed fleet of up to 20 instrumented gliders and two AUVs. The gliders are buoyancy driven vehicles that are battery operated and carry sensor payloads. The AUVs are propeller-driven and are battery powered and include sensor payloads.
c. 900km of undersea cable in the Northeast Pacific, across the Juan de Fuca tectonic plate, connected to a shore station that provides high power and bandwidth, with instrumented sites at Axial Seamount and Southern Hydrate Ridge, and one un-instrumented site at mid-plate. An extension cable connects the mid-shelf and offshore locations of the Oregon Line of the Endurance Array. The RCA has 7 primary nodes where the power is stepped down to medium voltage, permitting cabled subnets to be connected with appropriate power transformation for distribution to instruments and instrumented platforms.
d. There are over 750 instruments deployed on the moorings, cabled, and mobile assets.

Marine infrastructure is summarized in **Figure 1.**

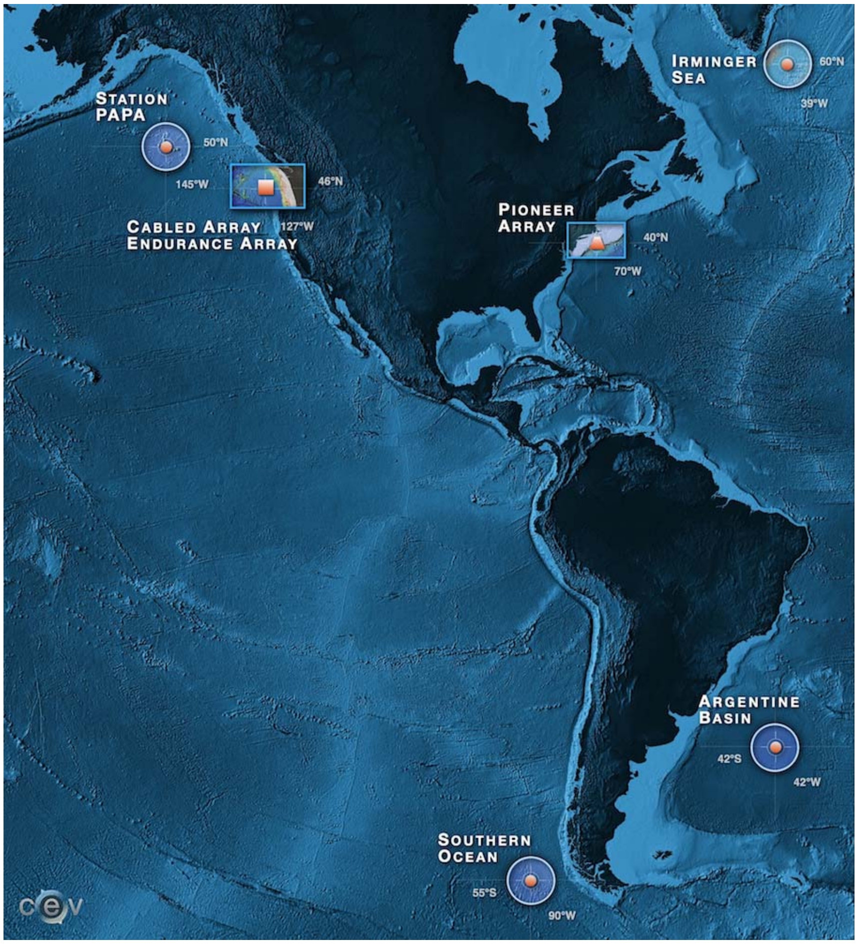

Figure 1. Distribution of OOI sites, spanning four Global array locations (North Pacific: Station Papa; North Atlantic: Irminger Sea; Southern Pacific: Southern Ocean; Southern Atlantic: Argentine Basin), two Coastal array locations (Pioneer south of New England, Endurance Array off Oregon & Washington), and one Regional Cabled Array over the Juan de Fuca tectonic plate (including both Axial Seamount and Hydrate Ridge/Continental Margin). The fixed and mobile platforms across these arrays support the installation of over 750 oceanographic sensors from 47 categories of instruments. The Argentine basin and Southern Ocean Sites were de-scoped in 2017, although the OOI continues to serve the collected data from these arrays.

2.4 Stakeholders

The stakeholders of the OOI span a broad range of interests and perspectives, from members of the public to employees of academic/research institutions who serve as members of the OOI O&M team. Each of these different groups is able to participate in the OOI in several ways:

a. Scientists & Researchers (external to the OOI team) have opportunities to:
   - Use and interpret data from the OOI.
   - Propose to use *in situ* laboratory capabilities of the OOI to address specific ocean science research topics.
   - Propose to extend the capabilities of the OOI through the addition of new sensors or sampling approaches.

- Participate in OOI cruises for training or to meet non-OOI objectives.

b. Educators & Students (external to the OOI team) have opportunities to:
    - Develop lessons using “real world” real time OOI data.
    - Use OOI time-series data to illustrate ocean properties over different time scales.
    - Participate in OOI cruises for training or to meet non-OOI objectives.
c. Public Users of OOI data (including other agencies/international) have opportunities to:
    - Observe real time changes in ocean conditions at many locations.
    - Observe the connections between atmospheric, ocean and shoreline conditions over a range of time intervals.
d. OOI Marine Operators have responsibilities to:
    - Operate and maintain mobile assets (gliders and AUVs).
    - Operate and maintain moored and seafloor assets.
    - Monitor and provide status on all deployed marine infrastructure.
    - Deploy and recover OOI infrastructure at intervals that support continuous observations at the array locations.
e. OOI Network/Cyberinfrastructure Operator has responsibilities to:
    - Operate and maintain system software, network infrastructure, and land-based processing, distribution, and storage hardware.
f. OOI Data Team has responsibilities to:
    - Evaluate observatory data quality, and define and implement improvements to data quality control (QC) procedures.
    - Compile metrics based on observatory instrument and platform performance, and recommend technical improvements.
g. Program Management Office (PMO) has opportunities to:
    - Provide overall program direction, management, and oversight.
    - Build on OOI successes to extend advocacy for effective ocean research and education.
    - Broaden the awareness of research opportunities based upon ocean observatories.
    - Foster scientists in the creation of published OOI papers.
h. Funding Agency – National Science Foundation has opportunities to:
    - Encourage the use of the installed OOI infrastructure and its sustained data in the design of new research initiatives.
    - Foster development of opportunities for multi-scale, multi-parameter data integration and analysis, based on the sustained observations from the OOI.

3 Operational Organization, Roles, Responsibilities, Budget, Staffing

3.1 Organization

Woods Hole Oceanographic Institution (WHOI) is the NSF Awardee for the full scope of the OOI, under a Cooperative Agreement between WHOI and the NSF. The Cooperative Agreement sets the terms and conditions for the OOI as a an operate/maintain-to-cost facility. WHOI-PMO has sub awardees (Implementing Organizations or "IOs) with responsibilities for the O&M of major elements of the observatory.

3.2 The Functional Structure of the OOI

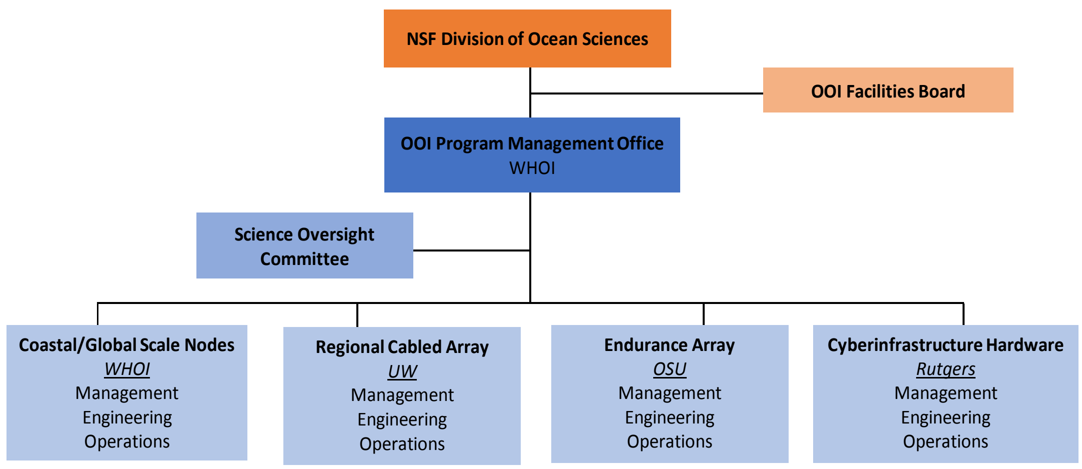

Figure 2. Functional organization chart for the OOI.

The roles and responsibilities of OOI organization include the following:

Observatory Management

- Subaward management, oversight and compliance.
- Annual safety and quality reviews.
- Tracking of the configuration history of all observatory assets.
- Implementation of and compliance with approved configuration.
- Property management.
- Ensuring infrastructure operation and QA/QC data delivery.
- Infrastructure Performance Metrics.
- Weekly, Monthly, Quarterly, and Annual Reporting as required.

Science Oversight Committee

- Provides advice to the OOI Principal Investigator on marine infrastructure, performance, and improvements, which can lead to enhanced science delivery.
- Serves as a resource available to the CI Data Management team, providing QC feedback as subject matter experts.
- Serves as a resource available for OOI user workshops in explaining the technical aspects of the OOI.
- Responsible for OOI Community Engagement.
    - Participation in National Meetings;
    - Community Webinars;
    - Regional Stakeholder Outreach;
    - Regional Science and Technology Outreach;
    - Maintenance and Refreshment of the OOI Website.

OOI Facilities Board

- Have the leadership role in community oversight of the OOI Science Plan
- Serve as the prime scientific and technical conduit between the oceanographic community and NSF regarding OOI
- Help identify collaborative relationships with potential governmental, industrial, educational, and international partners in the OOI, where appropriate.
- Ensure fair and consistent access to the OOI by all sectors of the user community.
- Monitor community adherence to applicable NSF policies for data collection, sample archiving, etc. as pertains to OOI activities.
- Monitor the appropriateness of existing, and/or facilitate the evolution of, performance standards for hardware and cyberinfrastructure, and in doing so address issues such as short-and long-term instrument calibration, incorporation of novel technologies, sampling, expansion of technological upgrades, etc.

Engineering

- Cabled – oversee and optimize performance of cabled assets, respond to technical and emergency issues within the Cabled Array, identify and address technical issues from performance metrics.
- Uncabled – oversee and optimize performance of uncabled assets, respond to technical and emergency issues within the Global and Coastal Arrays, identify and address technical issues from performance metrics.
- Cyberinfrastructure – oversee and optimize performance of software and system assets, respond to technical and emergency issues within the Cyberinfrastructure, identify and address technical issues from performance metrics.

Operations

- Data management – oversee and optimize OOI data management, providing review of data quality, root cause analysis of data deficiencies, and analysis of data delivery metrics.
- User Support – provide User Support to resolve questions on Observatory performance, data delivery, and OOI proposal workshops.
- Glider Pilots – oversee and optimize performance of gliders and AUVs in compliance with the OOI Instrument Sampling Plan and approved mission profiles, as well as responding to alerts and alarms.
- Shore Station Technicians – oversee performance of the Regional Cabled Array, including the primary infrastructure, fronthaul, backhaul, shore station located in Pacific City OR, and respond to technical and emergency issues.
- Shared use of University-National Oceanographic Laboratory System (UNOLS) technical staff whenever possible.

3.3 The Management Structure of the OOI

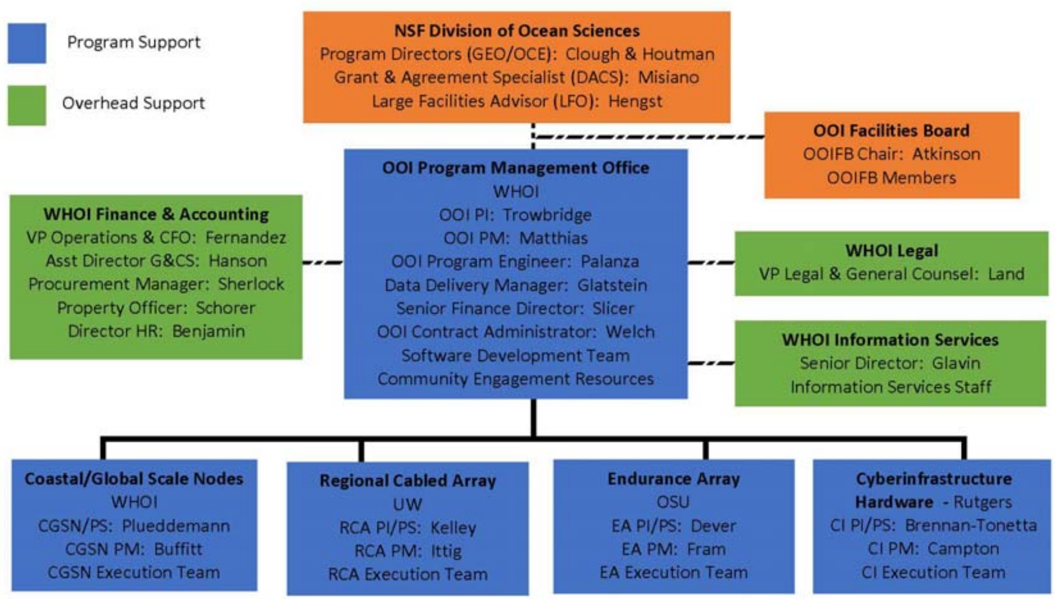

Figure 3. Management organizational chart showing implementing organizations.

3.4 Operations & Management Budget

The OOI Operations & Management Budget is $44M per year in 2019, with the NSF as the sole funding agency. The annual budget is comprised of three major components organized via a Work Breakdown Structure (WBS).

1 **Operations:** Costs associated with PMO and IO management personnel, cyberinfrastructure hardware and software, and leases, utilities, telemetry,

permits, travel, and other fixed and variable costs related to the overall management of the OOI by the PMO and all IOs.

2 **Refurbishment:** Costs associated with the refurbishment of recovered marine infrastructure (moorings, junction boxes, instruments, and other subassemblies). This includes equipment and material procurements, instrument and equipment vendor costs, and labor to clean, disassemble, replace parts and/or equipment, reassemble, integrate, and test moorings and other sub-assemblies in preparation for scheduled deployment cruises (biannual for coastal moorings; several times per year for mobile assets) as follows:

Irminger Sea (once per year)
Station Papa (once per year)
Pioneer (twice per year)
Endurance (twice per year)
Regional Cabled Array (once per year)
Gliders/AUVs (multiple times per year)

3 **Deployment and Recovery Cruises:** Costs associated with the recovery and deployment of moorings, seafloor equipment, instruments, gilders and AUVs. This includes ship time (including transit days) and remotely operated vehicle (ROV) as required, logistics, labor, travel, and other associated costs for all the arrays.

Details on the OOI budget allocated to each component by WBS account are found in the current year approved OOI Operations and Management Annual Work Plan (AWP).

4 Data Management, Data Delivery, Data QC

4.1 Data management, delivery and quality control

The CI Data Management component provides all data handling processes that occur after data have been delivered to the raw data server within the Data Portal architecture.

Marine IOs have primary responsibility for measurements flowing from:

Cabled systems:

- Instrument to port agent
- Port agent to CI Qpid
- Port Agent logs to RCA SAN
- RCA Archive to CI Raw Data Server

Uncabled systems:

- Instrument to data logger/controller on platform (mooring, profiler, glider, AUV)
- Logger/controller to telemetry or local storage on platform
- Telemetry to Operations and Management Component (OMC) or recovered from local storage to OMC
- Transfer from OMC server to raw data server.

Recovered data are stored permanently as raw data (in instrument-native formats) and ingested into the Cyberinfrastructure where they become permanent records in the CI database. Ingestion of recovered data is completed via the interface to the CI ingest engine. Ingestion of telemetered data records begins manually and continues to operated automatically on every newly received record for the length of the deployment. The Data Portal web frontend provides both raw and calibrated and calculated (L1/L2) science and engineering data products to the end user community.

OOI Data Management is distributed across the IOs, executed as an OOI-wide Data Management team that includes IO data evaluators and operational staff.

Success in Data Management is based on the effective distribution to users of quality (QA/QC) data / data products. Specific tasks for the OOI Data Management (DM) Team are described below:

Data Delivery

The marine IOs monitor the acquisition of data from marine sensors deployed on the OOI infrastructure. Sensor data is delivered to the OMC with associated metadata (e.g., calibration files) for processing. Responsibility for the IO- staffed DM Team begins when the data are delivered to OOINet. Data are delivered to OOINet as:

1) Telemetered data: Data delivered during the platform deployments using remote access such as satellites. The platforms that provide telemetered data include moorings and gliders. Telemetered data represents a sub-set of the total data being collected. The relative percentage of the total data set is a function of power, bandwidth, cost and the specific sensors deployed. Sampling plans and configurations are baselined in system level documents.

2) Recovered data: For platforms that telemeter data to shore during their deployment, “recovered data” refers to the complete data set that is retrieved and uploaded to OOINet upon platform recovery.

3) Streaming data: Cabled infrastructure provides a near real-time data stream that streams to OOINet via the Operation Management System (OMS). Automated processing provides data delivery with minimal latency.

Data quality and data management utilize generally accepted protocols, factory calibrations and at sea calibration and/or validation procedures.
Data delivered to OOINet is processed to generate L0, L1, and L2 data levels (see definitions below), along with QC flags. The data can be pushed, accessed through the UI, and/or delivered upon request based on the specific needs of the user. The OOINet data users include the marine operators, OOI user experience/user interface (UX/UI), external scientists, educators and the general public (including marine resource users). The form and type of the data to be delivered vary based on the requests from the user, but are provided in community standard data formats.

Currently, data undergoes a QC test when a user downloads the data. In the future, selected Quality Assurance of Real Time Ocean Data (QARTOD) standards will be incorporated into the OOI method of data quality control. These QARTOD standards will be applied to current QC tests as well as initiating new testing logic to meet the necessary quality standard.

Along with implementing the QARTOD standards for quality, the program will implement a communication strategy. OOI will track and communicate the results of QC tests and overall metrics of OOI data quality. Alerts to the user community of changes in data and/or changes to the software that effect data will be part of this communication strategy.

The Data Management Team is responsible for (1) ensuring data being delivered to the OOINet is compiled to generate monthly data QC statistics using the provided automated data QC processes, (2) directing/assigning the data evaluators to conduct ‘quick look’ assessments of the science data products, and (3) directing/assigning the data evaluators to conduct ‘deep dive’ assessments and validation of suspect data.

Data Levels: The OOI has adopted commonly used numbered data/data product levels to describe degrees of processing. Each numbered level has a simple descriptive synonym. The italicized text is the formal definition maintained in the OOI requirements repository.

- **Raw Data**: *The data as received from the instrument. These data are in instrument-specific format and may, depending on the instrument, contain data for multiple sensors (interleaved), be in native sensor units (e.g., counts, volts) or have processing steps already performed within the instrument (e.g., primary calibration.)* They are always stored and archived by the OOI. Storage of instrument raw data enables reprocessing and/or reanalysis.

- **Level 0 (L0)**: *Unprocessed data: Data that are in instrument/sensor units and at instrument/sensor resolution. They are sensor by sensor (unpacked and/or de-interleaved) and are available in OOI supported formats (e.g., NetCDF).* These data are sometimes mistakenly called “raw” data. They are always persisted and archived by the OOI. Storage of Level 0 data enables reprocessing or reanalysis. It also enables researchers to perform their own quality control and calibration.

- **Level 1 (L1)**: *Basic Data: L0 data that have been calibrated, are in well-defined scientific units, and may have some initial data QC applied.* QC may utilize simple automated techniques, complex algorithms, or human inspection. Level 1 data are sometimes called "processed" data, though this is not encouraged because it can be confusing. Actions to transform Level 0 to Level 1 data are represented in the metadata of the Level 1 data.

- **Level 2 (L2):** *Derived Data Products: Data that have been manipulated and/or combined and include new values not present in original data*. For example, salinity is derived from conductivity and temperature. The OOI provides only a limited number of derived products.

Sampling rates and mission planning

The deployed configuration of the OOI uses instrument sampling rates established through user workshops or meetings with subject matter experts. Initial mission plans for mobile assets were established through user workshops and external reviews. All sampling rates and mission plans are maintained under configuration control, per the OOI Observation and Sampling Approach (1102-00200). Planned sampling rates and mission plans are modified through ECR. During operations, sampling rates and mission plans may be changed by the Operator to address unplanned issues with power availability or changes to infrastructure.

The Data Management team use automated QC Algorithms, which provide a library of automated algorithm tests that identify and flag suspicious data. OOI will implement automated tests consistent with the IOOS QARTOD (Quality Assurance / Quality Control of Real-Time Oceanographic Data).

Operational Assumptions

- Initial data QC is conducted via automated QC algorithms that insert specific flags as a new column in the data product output.
- The MIO data lead assigns and coordinates "deep dive" investigations on suspect data as resources permit.
- Data evaluators have the ability to generate plots of the scientific data to identify and flag suspicious data.

5 Operational Assumptions and Constraints

The OOI operates 24 hours per day, 7 days a week. Staffing is generally on a 5-day work week, 8 hours per day, with exceptions associated with cruises or on an as-needed basis. The operational status of the observatory is monitored by OOI technical staff, under the direction of the O&M managers for the Global, Coastal, and Regional Cabled Arrays. The O&M Manager is the MIO PM or his/her designate.

The technical staff are the “eyes on” component of the observatory operations. The routine monitoring of operational status is based on ‘dashboard’ alerts/alarms of unexpected alterations (outside pre-approved thresholds) in the configuration of an observatory component.

The mooring builds/turns are funded via reviewed activity-based estimates that correlate the number of work hours to the technical data package drawing/subsystems to produce the fully integrated and tested moorings, ready for deployment. The Woods Hole Oceanographic Institution, Oregon State University, and University of Washington activity-based estimates leverage the availability of experienced technical staff at those institutions.

The Global Array moorings and gliders are turned annually within the appropriate weather window for each location. The Cabled Array moorings are turned annually and a percentage of cabled seafloor instrumentation are turned according to the maintenance schedule for specific instruments and platforms. The Coastal Array moorings are turned every 6 months. A “mooring turn” is defined as the periodic retrieval of an existing mooring (usually done as campaigns for each array) and the replacement of that mooring with a fully instrumented and tested replacement. There are two sets of hardware initially and as the turns take place, the operation consists of cleaning and reusing some parts of the moorings and/or instruments or buying new parts. The integrated and tested mooring is packed up and redeployed to complete the turn. (maintenance workflows are described in Section 9).

These assumptions are described and in the following sections.

5.1 Operational Assumptions – Gliders and AUVs

a. Primary maintenance at occurs at TWR (gliders) and Hydroid (AUVs) to assure calibration of instruments and vehicle refurbishment are standardized. Secondary maintenance and testing occur at WHOI and OSU. Maintenance and refurbishment plans are reviewed on a yearly basis to identify potential cost savings and/or risk reduction measures.

b. Employ efficient deploy/recover logistics for gliders and AUVs.
    1. Use the major EA and Pioneer mooring turn cruises on UNOLS vessels where possible (2 times per year).
    2. Leverage other UNOLS cruises for glider retrieval/redeployments.

3. Utilize small vessels on an as-needed basis for glider and AUV cruises that occur between the mooring turns. A contract with a small vessel operator would supply vessel time. Primarily trained OOI personnel- perform the deployments and recoveries. If dictated by logistics, or emergencies, an alternative plan is to utilize UNOLS technicians.
4. Prior to deployment, coastal glider functional checkout, mission configuration, and limited burn in occur at WHOI (Pioneer) and OSU (Endurance). WHOI and OSU glider burn-ins demonstrate vehicle ability to function in the laboratory at near-atmospheric pressures. Whenever practical, post-recovery data retrieval are performed at WHOI (Pioneer) and OSU (Endurance), or at remote sites by qualified technicians prior to return to TWR.
5. Prior to deployment, AUV functional checkout, limited burn in, and data retrieval occur at WHOI (Pioneer). WHOI AUV burn-ins demonstrate vehicle ability to function in the laboratory at near-atmospheric pressures.
6. To supplement laboratory burn-ins, WHOI and OSU may perform at sea testing and trials of vehicles during scheduled cruises if budget and schedule allow.
7. Post-refurbishment functional checkout and burn-in of vehicles are performed by TWR- and Hydroid-trained technicians per established protocols.

c. Limit materials movement and shipping costs.
   Shipment to/from TWR and Hydroid occur as close to the mobilization/demobilization port as practical.
   Global glider ports: Woods Hole, Seattle, Reykjavik, Punta Arenas.
   Coastal glider ports: Woods Hole (Pioneer), Corvallis (Endurance).
   AUV port: Woods Hole (Pioneer).

5.2 Operational Assumptions for Moored and Cabled Systems

Moored Systems:

a. Global: 12 month deploy/recovery cycle, with deploy/recovery dates governed by acceptable working conditions (wind and sea state statistics that define a 'weather window') at each site.
b. Coastal: 6 month deploy/recovery cycle, based upon expected impacts of bio-fouling on instrumentation under coastal conditions as well as the need for recalibrated instrumentation at the onset of spring and fall transitions in ocean conditions. Small ROV may be required for recovery of some anchors.
c. CSPPs are nominally turned every 3 months. We deploy/recover them from UNOLS ships when possible, but in between our semi-annual cruises we charter local vessels and we combine glider and CSPP cruises whenever possible.
d. Operational status monitored via alert/alarm system.
e. Operators provide annotations and data availability to users through OOI system software.

Cabled Systems:

a. 12 month deploy/recovery cycle, with deploy/recovery dates governed by acceptable working conditions (wind and sea state statistics) in the NE Pacific.
b. ROV required for maintenance of cabled instruments, platforms, and moorings.
c. Operational status monitored via alert/alarm system.
d. Operators provide status to users through OOI system software.

6 Operational Scenarios

6.1 Observatory User Services

OOI Operators use various methods from data entry pages to data uploads to enter data and/or documentation to report or comment upon system anomalies, data delivery issues, or data quality concerns. This data is then available to the user on both the Main OOI site and the Data Portal, dependent upon the data being sought. This data is organized by location, time interval, data product, platform, or instrument. Notification to all users of on-going engineering investigations occur through the Events and Updates page on the Main website .

When a user has a non-data questions or requests (e.g., website issues, documentation needs, technical or engineering topics), he/she submits the question or request to the OOI Help Desk via the ***Help Request*** button located on every page of both the Main website and the Data Portal. The Cyberinfrastructure group maintains the OOI Help Desk, and numbers the request, provides an acknowledgement of receipt of a request within one business day, and a response to the question or request as soon as possible. The OOI Data Delivery Manager reviews all tickets received and assigns them to the resource(s) best able to resolve the question or issue.

6.2 Routine Scenario for Coastal Gliders and AUVs

a. The OOI sustains missions (e.g., waypoints, sampling rates, dive patterns) that meet science objectives. Default coastal missions sample cross-shelf, along isobath, and upstream/downstream of dominant features, sustaining approved data sampling and delivery rates.
b. Deviations (beyond approved thresholds) from glider or AUV mission profiles (tracks, sampling, etc.) are logged by the system software or by the local operator. Platform and instrument configurations are documented and tracked.
c. Gliders and AUVs are received by WHOI/OSU. Vehicle configuration and functionality of flight and science systems are verified (e.g., ballasting,

sensors, control systems) and mission programs are installed, verified and documented per standard operating procedures (SOP) in advance of deployment and handoff to piloting.

d. OSU is responsible for sustaining the mission profiles for 6 Coastal Gliders in the Endurance Array. WHOI is responsible for sustaining the mission profiles of 5 Coastal Gliders, 2 Coastal Profiling Gliders (summer only), and 2 AUVs in the Pioneer Array.
e. Coastal gliders have batteries that last 3 months per the specification. Planned glider turns occur every three months. Three-month turn cycles for coastal gliders require effective power budget management. AUVs have rechargeable batteries that support 48 hours of continuous operation before recharging.
f. Planned redeployment of Coastal gliders occurs 4 times per year. Two deployments occur from the UNOLS vessels during mooring redeployment. The mooring deployment crew includes a trained pilot. The OOI and UNOLS technician pool deploy gliders with assistance from the mooring deployment crews and the mooring crew pilot hands off the glider controls to the shore-based pilot. The mooring crew, OOI, and UNOLS technicians secure and photograph recovered gliders. Oregon State University Ocean Observing Center is used OSU's storage site, the Laboratory for Ocean Sensors and Observing Systems (LOSOS) building is used as a storage site at WHOI. Twice per year, small vessels are used to recover and redeploy gliders.
g. Redeployment of AUVs for short term missions occur every 2 months. These deployments may coincide with mooring turns and glider cruises.
h. Reviews of glider and AUV operations and performance against metrics are continually assessed.

6.3 Routine Scenario of Open Ocean Gliders and Global Profiling Gliders

a. The OOI sustains missions (e.g., waypoints, sampling rates, dive patterns) that meet science objectives. Default Open Ocean Glider missions' sample inter-mooring meso- and large-scale variability, sustain approved data sampling and delivery rates, retrieve and transmit data from moored instruments via acoustic telemetry. Default missions for Global Profiling Gliders sustain vertical profiles in the upper 200 m near the array Hybrid Profiler Mooring.
b. Deviations (beyond approved thresholds) from glider or AUV mission profiles (tracks, sampling, etc.) are logged by the system software or local operator. Platform and instrument configuration documented and tracked.
c. Gliders are received at WHOI. Vehicle configuration and functionality of flight and science systems are verified (e.g., ballasting, sensors, control systems, acoustic modem) and mission programs are installed, verified, and documented per SOP in advance of deployment and handoff to piloting.
d. WHOI is responsible for sustaining up to 2 Open Ocean Gliders and 1 Global Profiling Global Profiling Glider at each of the two Global sites.

e. Open Ocean and Global Profiling Gliders have batteries that last one year per the specification. Planned glider turns occur annually with each global mooring replacement. One-year endurance for Open Ocean and Global Profiling gliders require effective power budget management. Initial mission profiles are reviewed to examine power budgets (planned vs actual), and incorporate lessons learned to maximize mission endurance within the approved mission plans. Energy use is tracked for compliance with endurance limits and mission objectives.
f. Planned redeployment of Open Ocean and Global Profiling Gliders occur annually from global class UNOLS vessels. The OOI and UNOLS technician pool deploys gliders with assistance from the mooring deployment crews and shore-pilots. Shore pilots handle glider controls at all stages of deployment. When possible, the mooring deployment crews may include a trained OOI pilot who is assisted by a UNOLS technician. The mooring crew, OOI, and UNOLS technicians secure and photograph recovered gliders per SOP procedures. The LOSOS building is used as a storage site at WHOI.
g. Reviews of glider and AUV operations and performance against metrics are continually assessed.

6.4 Routine Scenario for Moored Assets

a. Operators review notifications from automated monitoring of deployed asset status and health conducted through programmed checks against operating parameters (e.g., voltage ranges, data telemetry throughput, etc.). Reports of anomalies and technical responses are compiled weekly by the lead engineer of each Engineering Group, and are reviewed by the OOI Principal Investigator and all O&M Managers during weekly management meetings.
b. O&M managers for Cabled and Uncabled Array Engineering Groups assign priorities to Engineering staff for technical responses to Help Requests, alerts and alarms, according to SOPs.
c. The technical response to critical (or high priority) alerts occur through the closest engineering center, under the authority of the OOI Principal Investigator.
d. O&M Managers validate pre-deployment, as-deployed, and post-recovery configuration in the Asset Tracking Database. Asset status in the database (lifecycle stage, current status (inventory, refurbishment, deployed, etc.) informs management actions, per SOPs, for scheduling of refurbishment/repair/replacement of assets.
e. O&M Managers assign priorities to technical responses to management, configuration and performance alerts/alarms related to OMC servers and software.
f. O&M Managers align workforce to meet the deploy/recover/refurbishment cycle, including scheduling, training, mission planning and review, and personnel performance assessment.
g. O&M Managers coordinate with OOI Cruise Planning office regarding scheduling of vessels, winches, ROVs for deployment/recovery cruises.

h. O&M Managers coordinate quarterly quality & safety compliance reviews, data delivery reviews and financial status reviews with OOI Principal Investigator.

6.5 Routine Scenario for Cabled Assets

a. The Regional Cabled Array O&M Manager manages the credentials of operators of cabled assets consistent with their authority for command and control and access to the cabled infrastructure, with notification to OOI Principal Investigator of those authorities.
b. Operators review notifications from automated monitoring of deployed asset status and health conducted through programmed checks against operating parameters (e.g., power distribution, data throughput, cable faults, etc.).
c. Operators assign priorities to technical responses to trouble tickets, alerts and alarms, according to SOPs.
d. O&M Manager coordinates the technical response to critical (or high priority) alerts.
e. O&M Manager validates pre-deployment, as-deployed, and post-recovery configuration in the Asset Tracking Database. Asset status in the database (lifecycle stage, current status, i.e., inventory, refurbishment, deployed, etc.) informs management actions, per SOPs, for scheduling of refurbishment/repair/replacement of assets.
f. O&M Manager assigns priorities to technical responses to management, configuration and performance alerts/alarms related to OMS server and software.
g. O&M Manager aligns workforce to meet the deploy/recover/refurbishment cycle, including scheduling, training, mission planning and review, personnel performance assessment.
h. O&M Manager coordinates quarterly quality & safety compliance reviews, data delivery reviews and financial status reviews with Observatory Director.
i. O&M Manager coordinates with OOI Cruise Planning office regarding scheduling of vessel, winches and ROV for annual deployment/recovery cruise to maintain the Regional Cabled Array.

6.6 Unusual Operations for Mobile Assets

a. Gliders and/or AUVs may get lost as a result of subsystem and system malfunctions, vessel strikes, vandalism, and environment. These occurrences are tracked through the OOI Trouble Ticketing System ticket system and engineering investigations conducted by relevant IOs.
b. If a Glider or AUV deviates from the mission profile beyond the normal variations created by local currents the operator uses a standard operation procedure to return the glider or AUV to its mission profile.
c. If a Glider or AUV mission is threatened by an extreme event (e.g., hurricane) the operator uses SOP to move the vehicle into a safe operational mode until the extreme event has passed.

d. Unplanned recoveries (and potentially redeployments) occur using procedures similar to the two annual small vessel deployments noted above.

6.7 Unusual Operations for Uncabled and Cabled Assets

a. Emergency mobilization for recovery of drifting coastal mooring, per SOP.
b. Emergency response to drifting mooring in international waters, per SOP.
c. Programmatic response to loss of coastal or global mooring. To be determined by OOI Principal Investigator, as advised by the OOI Program Manager and OOI Program Engineer.
d. Response to external impacts on Primary/Secondary Infrastructure, per SOP.
e. Emergency responses to fire, water, power threats or damage to Shore Station or cable storage facilities, per SOP.
f. Extended sequestering (> 30 days) of Hydrophone / Seismometer Data, per SOP.

7 User Needs

7.1 All Users

a. All Users can access OOI data and documentation through its Main website (www.oceanobservatories.org) which in turn will display information and/or directly link to the sites containing requested information. See section 2.3 for available websites and their functions.
    1. Users who visit the website to view data or learn more about the network do not require registration.
    2. Users who want to download data or subscribe to data are required to register and create a login password.
b. All Users need access to:
    1. OOI data policy and the statement describing appropriate attribution of OOI data usage.
        4 Glossaries and maps in order to understand OOI vocabulary and context.
    3. Sort, search and download OOI data. Users may download any data from OOI. Data includes all of the following:
        a. Metadata
        b. Shipboard
        c. *In situ* sampling
        d. Calibration data
        e. Real time data
        f. Delayed mode data
        g. Raw data
        h. Quality Controlled data
    4. OOI data quality and evaluation policies and procedures.
    5. System Performance Metrics.

    6. A Help Request system for posing questions, reporting performance issues.

c. All users should have the ability to submit requests for assistance and receive a timely response.
    1. All visitors to the website can enter a question or issue into the Help Request system.
    2. External user Help Requests are assigned to the proper person for review and for provision of an answer. External users are required to indicate their email as the method of response. Any emergency information should be provided to the phone numbers provided on the OOI infrastructure.
    3. Project team members have the ability to enter project-specific Help Requests.
    4. Project Managers at the Marine IOs manage the assignment of appropriate staff to respond to items assigned by the Help Request manager within CI.

7.2 Science Users

a. Science users need access to OOI data and interfaces required to script and download data via the ERDDAP server and other machine-to-machine interfaces, which require accepting the data policy before access is granted.
b. Science users require receipt of all metadata associated with their data product requests. Metadata can be within data product or in a separate file associated with the science data.
c. Science users need access to CTD casts from mooring turn cruises, laboratory analyses of water samples, and shipboard meteorology and underway data from cruises.
d. Science users need access to OOI documents (e.g. mooring drawing) and reports (e.g. cruise report) that would be associated with a specific data product and/or sensor.
e. Science users need to understand data provenance. The OOI must fully describe data, including all transformations, analyses, and interpretations. This includes the historical record of all calibration factors for each instrument, cross calibration actions, and observatory configurations for each deployment.
f. Science users need access to the description of algorithm codes, input parameters and quality flag limits, as well as any records of configuration change.
g. Science users need access to all OOI data evaluation and associated observatory actions being taken to address data quality. At the observatory level this ties directly to the calibration history for instruments/sensors and the service records. Observatory actions include flagging suspect data stream and opening a Help Request for service/calibration.
h. Science users need to plot and display data through the user interface, from one or more instruments, including support for the scalable display of the following:

1. Single Instrument Time Series
2. Multiple overlaid Instrument Time Series
    a. same type, same platform
    b. same type, multiple platforms
    c. different type, same platform
    d. different type, multiple platforms

i. Scientists need information about how to write proposals for the OOI for any additions to the observatory (instruments, moorings, other cabled or uncabled platforms, etc.).
j. Science users need to receive regular updates about observatory configuration changes.

7.3 All OOI Operations Users

a. System Health: All operations users need to:
    1. Obtain and review status for instruments, platforms, components, data flow, and data storage.
    2. Track and manage specific instruments or infrastructure problems, as required.
    3. Submit trouble tickets for assignment, review and tracking (Internal, external, quality matters).
    4. Retrieve history, per asset or process, of alert or alarm thresholds and history of occurrences for all instruments, moorings, AUVs, gliders and profilers.
    5. Access to functional status and telemetered data from to-be-deployed platforms during burn-in.

b. Data Entry
    1. IO Project Managers authorize which employees can enter data into OOINet and provide system access for those employees. All authorizations are subject to configuration control, with control overseen by the OOI Principal Investigator. Non-project employees are not authorized to enter observatory data into the system.

7.4 Configuration and Observatory Asset Data Management

a. Enter authorized configuration data into the Asset Management Database for instruments and/or platforms and edit information when configuration changes occur (e.g., at time of calibration, build, deploy, recover, refurbish).
b. Users need to retrieve history of configuration status for any instrument or platform
c. Users need access to the history of, lifecycle status for, and current disposition of any asset
d. Users need to create, edit, submit, or reference approved mission plans for instrument or platform, prior to as well as during deployment.
e. Configuration Access
    1. Configuration Managers identified by the Project Managers

2. OOI engineering centers at UW and WHOI retain and manage the configuration of the OOI drawings at their home institutions.
3. All project documentation (historical and other non-drawing documents) are electronically archived.

7.5 Marine Operation Staff

a. Work with the IO Project Managers to align workflow and labor workforce for scheduled deployments.
b. Request vessel and necessary supplemental equipment
c. Arrange pre- and post-cruise logistics
d. Obtain and renew approvals or permits for work in marine sanctuaries, fishing zones, other nations' Exclusive Economic Zone (EEZ).
e. Facilitate pre-cruise access to regional weather information, including weather and ocean state conditions.
f. Ensure compliance with USCG and U.S Naval rules and regulations.

7.6 OOI Engineering Groups

a. Manage configuration of the OOI in compliance with the Configuration and Quality Management Plans.
b. Manage and support the lifecycle of OOI data and infrastructure
c. Provide technical input for supported PI requests for additions, or modifications to OOI infrastructure, or operating schemes.
d. Enable safe operations by responding to alerts and alarm and via access to status and health.
e. Resolve Help Requests, log the resolution action, and communicate the resolution.
f. Manage the operational capacity of deployed infrastructure, including the power budget for deployed systems.
g. Maintain capability for Command and Control of deployed Platforms
    1. Execute command and control for deployed instruments, either indirectly via telemetry or directly via the cabled system.
    2. Specify, record, and retrieve pre-deployment configurations for each array, including as-deployed sampling rates for all instruments.

h. Maintain capability for Refurbishment and Command and Control of deployed Gliders
    1. Specifies parameters and conditions to create, edit, and submit approved mission plans for vehicles, prior to deployment and while deployed.
i. Records all data for Glider workflow including:
    1. SOPs including pre-deployment checklists
    2. Deployment templates
    3. Vehicle mobilization documents
    4. Deployment and recovery photos
    5. Post-recovery vehicle evaluation

6. Generation of itemized refurbishment list.
7. Coordinates vehicle fleet operations and maintenance.

7.7 Cyberinfrastructure

a. The CI Data Delivery Manager is responsible for all aspects of the Cyberinfrastructure and resources responsible for delivering services.
    1. Management of CI Systems Project Manager
    2. Management of CI Software Administration
    3. Management of CI Development
    4. Software licensing management
    5. Strategic planning
    6. Cyber security
    7. Communications to program and end users
    8. User support in conjunction with the MIOs to support the Help Desk function
    9. Application of data quality standardization across organizations
    10. Coordination of Development, Systems and the MIO Data Teams
b. The CI Systems Project Manager monitors/manages:
    1. The acquisition and distribution network.
    2. The status and capability of the hardware through technical refresh, licenses renewals, etc.
    3. The configuration and status of interfaces between Network, software packages and Data Portal.
    4. Monitoring of all OOI CI-specific hardware environments
    5. Data Center administration
    6. Permissions for access to systems and software residing on those systems
c. The CI Software Administrator is responsible for User Support through management of:
    1. Software build management
    2. Monitoring of software environments
    3. Patching, upgrades and implementations of new packages

7.8 Data Management

Data Management staff at the Marine IOs:

a. Collect, edit, verify, and submit and update metadata and instrument calibration data
b. Upload, store, and ingest all available data records (either telemetered or recovered) and maintain visibility of data custody and quality from point-of-acquisition to final-delivery to the CI and the public.
c. Implement standardized community best practices for data QC and data flagging
d. Manage and report data quality evaluations, including trends, instrument stats, metrics, quick look visualizations, etc.

e. Review and update annotations relevant to instrument performance in the field and make these visible and available to all users
f. Upload and transform any cross-calibration data following each deployment/recovery cruise.
g. Chief Scientists, technicians and engineers are authorized to upload OOI cruise data and water sampling data.
h. Coordinate with research scientists and the OOI team to resolve Help Request issues within the data management domain (algorithms, equipment set up questions, etc.).
i. Collect and apply lessons learned to improve observatory data and operations quality.

7.9 OOI Principal Investigator

a. Establish/verify configuration of observatory following approvals by NSF and resolution of technical and scheduling issues.
b. Manage and implement OOI (and institutional) safety, quality, security and configuration management requirements. Amend and control all SOPs, software, infrastructure per the approved plans and specifications.
c. Provide the research community access to all project documentation to assist in answering questions (as permissible by institutional and security policies).
d. Plan and manage to the Annual Work Plans and OOI project documents per award terms and conditions.
e. Review OOI Performance Metrics.
f. Develop, document (via the Configuration Management Plan) and assign approved permissions to the observatory. This includes authorities for remote access to power and operational settings for instruments, platforms, etc.
g. Assure that O&M managers respond to safety incidents in accordance with the Safety Plan.
h. Manage/verify that fixed, mobile and seafloor platforms, and associated instruments, retain approved configurations (e.g. sampling rates, mission plans) within OOI performance guidelines.
i. Assure, through annual assessments, that OOI procedures are compliant with the established OOI Quality Plan
j. Assure that the OOI is managed according to baseline standard operating procedures.

8 Configuration Management

The OOI employs approved procedures, documented in the OOI Configuration Management Plan, to manage the configuration of all hardware and software elements that constitute the data path in order to fulfill the end-to-end data delivery objectives of the observatory. The initial configuration state of hardware and software elements is documented within the “as-built” Technical Data Package (TDP) of each array and the TDP of the OOI system software. The “as-built" and any subsequent approved changes to that configuration, are maintained within the OOI Asset Management system.

Management responsibility for configuration maintenance/control of the cabled assets and shore-side hardware resides at University of Washington, while responsibility of configuration maintenance/control of the uncabled assets and OMC hardware resides at Woods Hole Oceanographic Institution and Oregon State University. Woods Hole Oceanographic Institution has responsibility for the configuration maintenance/control of the network, supporting hardware and software.

9 OOI Workflows

System Health

System health monitoring is a distributed responsibility. The marine Ios have responsibility to monitor and maintain their assigned infrastructure. Specific workflows stem from monitoring the infrastructure position, power consumption, operating status, and data transmission from the instrument to the shore-based OMC or OMS. Specific workflows are contained in operational documentation maintained at the IOs.

Workflows for CI system health stem from monitoring and maintaining the OOINet operational status, data ingest and availability, data quality checks, QC flagging, data download, and transfer of data to the OOI archive.

Mooring Turns

a. Refurbish, Build, integrate, test the mooring and subsystems
b. Conduct conformance testing of received instruments
c. Functional checkout of instruments and subsystems
d. Verify operational configuration for deployment (e.g., sampling rates)
e. Update asset management system to reflect configuration to be deployed
f. Pack for shipping and deployment
g. Deploy
    1. Platforms per approved procedures
    2. Execute at-sea calibration procedures
    3. Update asset system with as-deployed configuration
    4. Determine calibration and offset corrections
h. Operate –
    1. Execute operational activities, including:
        a. Monitor system status
        b. Sustain sampling rates, adjust per procedures
        c. Respond per procedures to alerts, alarms
        d. Update, and maintain operational status reports
i. Recover

    1. Execute at-sea calibration procedures
    2. Verify configuration on recovery
    3. Determine calibration and offset corrections
    4. Conduct data quality control and assurance procedures

j. Download data
    1. Incorporate at-sea cross-calibration results into processing pipeline

k. Update asset management system to record status of recovered assets
l. Pack for transport or shipping to home institution
m. Unpack, replace materials and worn parts, calibrate sensors
n. Align build schedule with next deployment cruise
o. Go to step#1

Cabled infrastructure Turns

a. Refurbish, Build, integrate, test each cabled subsystem to be deployed
    1. Low-voltage junction box
    2. Medium-voltage junction box
    3. Deep profiler
    4. Shallow profiler
    5. Platform Interface Assembly
    6. Benthic Experiment Package

b. Conduct quality conformance testing of each instrument
c. Conduct functional checkout of #1 [a-d], #2
d. Verify operational configuration for deployment (e.g., sampling rates)
e. Update asset system to reflect configuration to be deployed
f. Establish ROV work plan for maintenance cruise
g. Pack for shipping and deployment
h. Deploy
    2. Execute at-sea calibration procedures
    3. Update asset system with as-deployed configuration
    4. Determine calibration and offset corrections

i. Operate
    1. Execute operational activities, including
        a. Monitor system status
        b. Sustain sampling rates, adjust per procedures
        c. Respond per procedures to alerts, alarms
        d. Update, and maintain operational status reports

j. Recover
    1. Execute at-sea calibration procedures
    2. Verify configuration on recovery
    3. Determine calibration and offset corrections
    4. Conduct data quality control and assurance procedures

k. Download data
    1. Incorporate at-sea cross-calibration results into processing pipeline

l. Update asset system to record status of recovered assets
m. Pack for transport or shipping to home institution
n. Unpack, replace materials and worn parts, calibrate sensors

o. Align build schedule with next deployment cruise
p. Go to step#1

Code, algorithm, instrument/platform driver maintenance

a. Compile performance information on code
    1. User comments
    2. Periodic load tests
b. Evaluate options for code performance
c. Implement code improvements within budget
d. Same sequence for algorithms
e. Same sequence for drivers

OOI Mobile Assets

Table 1. Workflow for Gliders

Operation	Location	Work execution	Pioneer	Endurance	Globals
TWR delivery of factory repairs	Glider receipt	N/A – LOE	WHOI	OSU	WHOI
Glider Integration and Testing	Integration locations	Per SOP – LOE w/ inst. Tech or tech pool	WHOI	OSU	WHOI
Gliders transferred to ship	Docks	Per SOP Ship time labor costs	WHOI	Newport	PORT DEPENDENT
Gliders deployed	Ships	Per SOP – Tech pool and glider/mooring crew person co-trained (part of ship time cost)	WHOI		WHOI
Gliders retrieved	Ships	Per SOP -Tech pool or mooring crew	WHOI		WHOI
Document & download	Ships & shore if needed	Per SOP -Tech pool, mooring crew or TWR	WHOI	OSU	WHOI
Evaluate need for in-house vs factory refurbishment	Lab	Coordinated for most cost-effective and reliable solution	WHOI	OSU	WHOI

Operation	Location	Work execution	Pioneer	Endurance	Globals
Ship components or gliders to TWR			WHOI	OSU	WHOI

The workflow for AUVs is similar to that of gliders with maintenance and calibration work performed by the vendor.

Glider Turns

a. Receive material from vendor factory refurbishment, or in-house stock
b. Verify conformance of vendor-refurbished parts
c. Build, integrate, test the gliders and subsystems
d. Functional checkout of instruments and subsystems
e. Verify operational configuration for deployment (e.g., sampling rates)
f. Update asset management system to reflect configuration to be deployed
g. Pack for shipping and deployment
h. Deploy
    5. Gliders per approved procedures
    6. Execute at-sea test procedures
i. Operate -
    2. Execute operational activities, including:
        e. Monitor glider status
        f. Sustain sampling rates, adjust per procedures
        g. Respond per procedures to alerts, alarms
        h. Update, and maintain operational status reports
j. Recover
    5. Verify configuration on recovery
k. Download data
l. Update asset management system to record status of recovered assets
m. Pack for transport or shipping to home institution
n. Unpack, evaluate condition and send gliders and glider-sections to vendor for factory refurbishment or allocate to MIO in-house refurbishment,
o. Replace worn parts, calibrate sensors
p. Align build schedule with next deployment cruise
q. Go to step#1

Help Requests and OOI Data Forum

a. CI Help Desk reviews daily submissions
    1. User receives acknowledgement of submission
    2. Help Desk personnel initiate action on the request
    3. Help Desk personnel send response to requestor, with intervention by CI manager, if necessary.

b. Designated CI personnel moderate the OOI Data Forum on an as needed basis
    1. Data Forum moderator responds the same day to easily answered questions and concerns
    2. Difficult data issues referred to Data Manager for resolution and response via the Data Forum

10 Administrative Processes

Annual Work Plan: The OOI Principal Investigator provides the National Science Foundation with an Annual Work Plan each year. The Annual Work Plan contains the work to support the approved and scheduled configuration of the OOI for the next program year.

Budgeting for OOI is conducted via a clear activity-based estimate that connects drawings and bills of materials to the number of hours of labor and the staff required to conduct the work. These estimates should also address the build campaigns that tie similar equipment to their deployments, e.g., refurbish and rebuild several wire-following profilers within one build campaign.

Institutions utilize their support functions to execute procurement, travel, financial accounting, etc., as fulfilled under other OCE research agreements (ship operations, etc.).

The OOI Project Management Office (PMO) oversees annual assessments of operational Cybersecurity, Safety and Quality at each of the subaward institutions. The OOI Principal Investigator provides summary reports of those assessments to the OOI Program Officer at NSF and the assessments are included within the review materials for the external Annual Review of the OOI.

11 External Proposals for New Work within the OOI

Proposals from users of the OOI are submitted to the NSF core programs for review and consideration for funding. Funding sources may be external to NSF; however, the request to add instruments, infrastructure, and/or reconfigure sampling still go through NSF for consideration. It is expected that the proposals are one of three different types:

- Data Analysis: investigator proposes to use the OOI data to address a particular set of science questions, or to test a hypothesis.
- Addition of new instruments: investigator proposes to add a new type of instrument to the OOI infrastructure.
- Reconfigure or supplement the infrastructure at the array or system level: investigator proposes to alter the sampling rates of particular instruments or

sets of instruments, or to alter the mission plans of selected mobile assets, or to supplement an array with additional instances of OOI instruments or platforms.

The OOI website provides investigators and authors of proposals with information about OOI infrastructure and processes to support preparation of proposals.

An important feature of OOI Cyberinfrastructure is the representation of the power and data communications 'headroom' (used versus available capacity) as part of system status and health. Proposing entities should know the actual power and bandwidth/data communications headroom for the observatory.

12 Performance Assessment and Evaluation Metrics

The OOI PMO is responsible for aggregating, and compiling infrastructure performance data collected by each of the sub awardees. Observatory performance against defined metrics is assessed monthly by the Program Engineer and reported to the OOI Project Manager and the OOI Principal Investigator. Recommendations for corrective steps to performance issues are communicated to the IO PM's.

a. Performance Metrics (actual versus planned)

1. Number of science sensors deployed as compared to the AWP.
2. System Uptime: The percentage of time OOI infrastructure is operational.
3. Expected science data: Percentage of science data from deployed instruments that is telemetered on schedule, or predicted to be available upon platform recovery.
4. Mobile Asset functionality: The amount of days Mobile Assets are on station and collecting data.

b. User Statistics

1. Number of Data Portal users, and number and volume of downloads.
2. Most downloaded streams
3. Most active users
4. Website statistics regarding user behavior and demographics for both Data Portal and Main OOI website
5. Number of Help Requests and time to close.
6. Number of Proposals submitted.

NSF conducts annual reviews of facility performance relative to budgeted scope with the Annual Work Plan.

References

1. Committee on Guidance for NSF on National Ocean Science Research Priorities; Ocean Studies Board; Division on Earth and Life Studies; National Research Council. 2015. *Sea Change: 2015-2025 Decadal Survey of Ocean Sciences.* Washington, D.C. The National Academies Press.

2. National Science Foundation. 2001. *Ocean Sciences at the New Millennium*. Arlington, VA.

3. NSTC Joint Subcommittee on Ocean Science and Technology. 2007. *Charting the Course for Ocean Science in the United States for the Next Decade: An Ocean Research Priorities Plan and Implementation Strategy.* Washington, DC. [Online] Available: http://ocean.ceq.gov/about/sup_jsost_prioritiesplan.html.

4. ORION Executive Steering Committee. 2005. *Ocean Observatories Initiative Science Plan*. Joint Oceanographic Institutions, Inc. Washington, DC. Online: http://oceanleadership.org/files/OOI_Science_Plan.pdf

5. ORION Executive Steering Committee. 2007. Ocean Observatories Initiative (OOI) Scientific Objectives and Network Design: A Closer Look. [Online] Available: http://oceanobservatories.org/science-plan/

6. Schofield, O. and M. Tivey. 2005. *Ocean Research Interactive Observatory Network: A Workshop Report*. Joint Oceanographic Institutions, Inc., Washington, DC. [Online] Available: http://oceanleadership.org/ocean_observing/workshops/SanJuan.

7. Smith, L.M., Barth, J.A., Kelley, D.S, Plueddemann, A., Rodero, I., Ulses, G.A., Vardaro, M.F., and Weller, R. 2018. The Ocean Observatories Initiative. Oceanography 31(1):16-35, DOI:10.5670/oceanog.2018.105.

8. Trowbridge, J., R. Weller, D. Kelley, E. Dever, A. Plueddemann, J. A. Barth, and O. Kawka. 2019. The Ocean Observatories Initiative. *Frontiers in Marine Science.* 6:74. doi:10.3389/fmars.2019.00074