CI PROJECT EXECUTION PLAN (PEP)

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ID-9.03	10/29/09	Throughout	M	Annual update

*A – Added, M – Modified, D – Deleted

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1   Project Purpose

Next generation studies of dynamic, interacting processes in the Earth-ocean-climate system require new in situ approaches to complement the more traditional ship-based, expeditionary science that has dominated oceanographic research for the past century or more. Routine, long-term measurement of episodic oceanic processes is crucial to continued growth in our understanding and predictive modeling of complex natural phenomena that are highly variable and span enormous scales in space and time. This access is enabled by innovative ocean observatory facilities providing unprecedented levels of power and communication to access and manipulate real-time sensor networks deployed within the ocean. These facilities empower entirely new approaches to science, and enable education and outreach capabilities that dramatically impact the general understanding of, and public attitude toward, the ocean sciences.

To accomplish this paradigm shift, ocean scientists require at least seven infrastructural capabilities they do not now have. They must be able to:

* fully and quantitatively characterize selected volumes of the ocean, the atmosphere overhead, and the lithosphere beneath;
* receive information about all interrelated components of the system simultaneously, in real-time;
* recognize departures from the norm and observe emergent phenomena;
* conduct interactive experiments within the environment;
* reconfigure observational-sampling systems in response to events;
* assimilate in situ data efficiently into models that expand the space/time view of the data and feed back onto the measurement protocols; and
* continue and expand this real-time interaction within the oceans for decades.

These functions can only be realized through the development of state-of-the-art Ocean Observing Initiative/Cyberinfrastructure (OOI/CI). The OOI System Engineering Management Plan, CI System Life Cycle Plan and CI Architecture documents contain further details on the information technology capabilities, structure and development plans required to integrate the three observatory components, the Coastal, Regional and Global Scale Nodes, of the OOI into a coherent system-of-systems. These documents are incorporated into this PEP by reference.

2   Project Structure

2.1   Organizational Structure

The organization for the Cyberinfrastructure Program (Figure 2.1-1) is designed to accommodate integrated product development, and utilizes Integrated Product Teams (IPTs) whose membership spans required engineering disciplines and functions to produce products and services for delivery. The team organization is integrated with the Cyberinfrastructure product hierarchy as defined in the WBS, with WBS development elements the primary responsibility of a single IPT. This enables IPTs to identify clear and measurable outputs plus necessary interfaces. Additional work teams have been constituted for cross-cutting functions like system engineering, system architecture, system test and system integration.

Each team is chartered and empowered to accomplish its assigned mission and has a corresponding budget, schedule, and performance requirements (technical specifications). Within the constraints of budget, schedule, and technical performance, the team has complete flexibility to meet mission requirements if its actions do not impact another team's performance.

The "best of academia and industry" teammates have been integrated into the team structure with the correct mix of experience, capable of delivering high quality products within cost and schedule, while actively partnering with the two marine IOs and the OL Program Office to lower project risk.
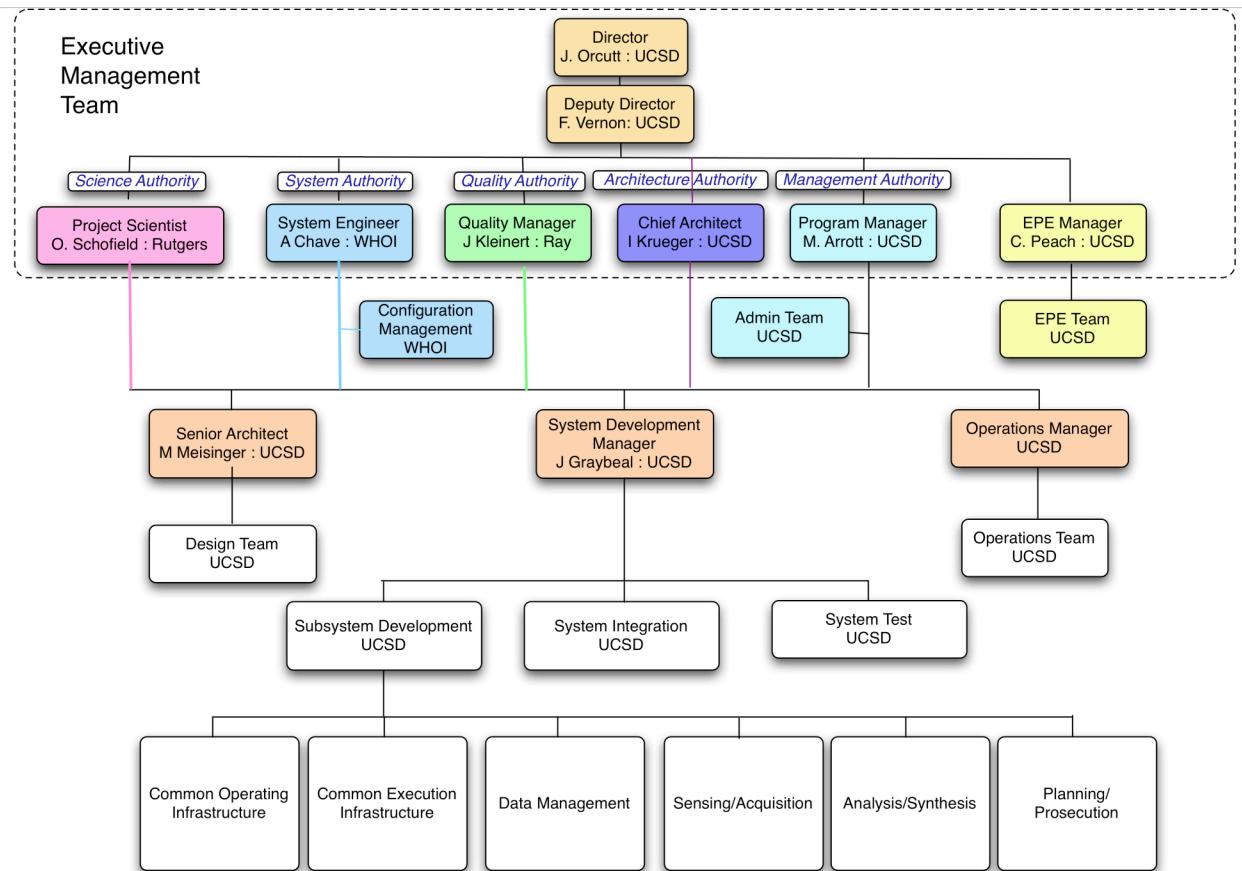
Figure 2.1-1 OOI/CI Project Organization

2.1.1 Executive Management Team

The Project Director (chair), Deputy Project Director, Project Manager, Project Scientist, System Engineer, Quality Manager, Chief Architect and EPE Manager are members of the Executive Management Team (EMT). The EMT meets weekly or as needed to discuss and seek consensus on IO management issues. The Project Manager presents a summary briefing that presents the current health and status of the project including (but not limited to) major accomplishments during the last period, major tasks scheduled for the next period, cost & schedule status, program risks, interactions with the two observatory IOs, and corrective actions. The System Engineer updates the group regarding system and subsystem engineering developments. Discussions also include customer relationships, opportunities to improve performance, issues that need executive level attention, and other strategic topics. In the event that consensus is not reached on EMT decisions, the Project Director makes a final and binding decision.

2.1.2 System Engineering Team

The System Engineer (chair), Senior Architect, System Development Manager, and Operations Manager constitute the System Engineering Team. This group meets weekly or as needed to keep abreast of developments at the system and subsystem levels of the project, along with the status of the two observatory IOs. The System Engineering Team seeks consensus on tactical decisions that cross-cut the project. In the event that consensus is not reached, the issue is elevated to the Executive Management Team.

2.1.3   Project Authorities

As shown in Figure 2.1-1, there are five overarching authorities that span the entire breadth and depth of the OOI/CI project, from the element to the system level.

- Management Authority is vested in the Project Manager, who is responsible for managing the entire project from cost, schedule, scope and risk perspectives.
- System Authority is vested in the System Engineer, who is responsible for the realization of a successful system that meets the technical requirements.
- Architecture Authority is vested in the Chief Architect, who is responsible for ensuring that a viable architecture is delivered.
- Quality Authority is vested in the Quality Manager, who is responsible for ensuring that the delivered CI meets quality standards.
- Science Authority is vested in the Project Scientist, who is responsible for ensuring that the system meets the needs of its stakeholder communities.

2.1.4   Roles and Responsibilities of Key Positions

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

Deputy Project Director: Reports to the Project Director with responsibility for oversight of internal project operations, and serves as the external point of contact in the absence of the Project Director. He approves plans and reports produced by the Project Manager, Project Scientist, System Engineer, Quality Manager, Chief Architect and Education and Public Engagement (EPE) Manager. The Deputy Project Director is the first point of contact for the Project Manager in resolving conflicts regarding resources not under his control and obtaining decisions beyond his authority. If these cannot be adjudicated by the Deputy Project Director, such issues are referred to the Project Director, and, if necessary, the OL Program Office for resolution.

Project Manager: Reports to the Deputy Project Director and has day-to-day responsibility for managing the project life cycle. He appoints the Senior Architect, Software Development Manager and Operations Manager. He is responsible for key project planning actions, including generation of all project-level plans. Other tasks include oversight of project activities to ensure timely correction of problems, convening regular meetings of the entire project team, assessing cost and work progress against plans and schedules including Earned Value Management, maintaining up-to-date projections of the project schedule and cost-to-complete/life cycle costs, and ensuring that the results of design reviews are incorporated into the project plans.

Project Scientist: Reports to the Deputy Project Director and has responsibility for the scientific integrity of the OOI/CI and communication with the scientific community on OOI/CI issues. The Project Scientist organizes a stakeholder team comprising representatives of interested user groups to develop use case scenarios. He is responsible for the OOI/CI science user requirements in consultation with working groups, the System Engineer and Senior Architect, the advisory committees and the Program Office as appropriate. He is also responsible for validation of the integrated OOI/CI.

System Engineer: Reports to the Deputy Project Director and is responsible for management of the system life cycle, integration of the CI with the observatory elements of the OOI and external observatories, and verification of the integrated CI and its deployment into the marine infrastructure. He is responsible for developing, verifying, and maintaining all system-level engineering policies and plans. Together with the Senior Architect, the System Engineer manages the definition of science user requirements, defines the system requirements, and specifies internal system hardware/software interfaces in consultation with subsystem IPTs. The System Engineer is responsible for establishing the external system interfaces with the other IO system engineers and/or non-OOI observatories.

Quality Manager: Reports to the Deputy Project Director and leads the Quality Assurance Team. Rather than acting as an audit process, quality management is an ongoing activity, and the Quality Team provides QA/QC across the system throughout the design/build cycles.

Chief Architect: Reports to the Deputy Project Director, and is responsible for oversight and guidance of architectural work in the Project.

Education and Public Engagement (EPE) Manager: Reports to the Deputy Project Director and is responsible for the development of education and outreach plans and for maximizing EPE opportunities for relevant communities at system-level reviews. He/she assists the Project Scientist with the development of user requirements, representing the interests of the EPE community. The EPE Manager coordinates and integrates activities with the OOI Program EPE effort.

Senior System Architect: Reporting to the Project Manager and leading the System Architecture Team, is responsible for the design, synthesis, and documentation of the OOI/CI system architecture, and oversight of its implementation by the subsystem IPTs.

System Development Manager: Reports to the Project Manager and oversees the development activities of the subsystem IPTs and System Integration Team. The SDM is responsible for delivering a quality integrated CI to the System Engineer for verification, deployment and stakeholder validation.

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

2.1.5   Work Teams

Six Subsystem IPTs (Figure 2.1-1) are responsible for the construction and delivery of their respective subsystems. A Subsystem IPT Lead reporting to the System Development Manager is responsible for delivery of a quality subsystem. A Subsystem IPT comprises the IPT Lead, a Subsystem Architect, Expert Users, Design Participants, Development Participants, and Technology Providers. A single individual may play multiple roles. The Subsystem Architect provides the architectural vision. To ensure the delivery of an end-user focused product, Expert Users work with each development team throughout the development life cycle. Design Participants assist the Subsystem Architect to produce the architecture documents relevant to their subsystem. Development Participants construct the subsystem. Technology Providers bring OOI/CI capabilities to the Development Team.

2.1.6   System Architecture Team

To achieve consistency across the project, an integrative System Architecture Team led by the Senior System Architect provides design and domain modeling expertise to each subsystem IPT.

2.1.7   System Integration Team

The System Integration Team reports to the System Development Manager and is responsible for Software Integration and Test (SWIT), the integration of all subsystems and technologies. After SWIT is complete, the System Engineer is responsible for verification against the system requirements. The System Integration Team also supports the Operations Manager and System Engineer in integration and deployment of the CI into the hardware and software provided by the marine IOs, as well as external observatory systems such as IOOS.

2.1.8   System Test Team

The System Test Team reports to the System Development Manager and is responsible for the formal testing of the CI.

2.1.9   Business Operations Support

The project office staff comprises the Project Analyst, Financial Analyst, Project Administrator, Project Scheduler, and other support personnel as required, and reports to the Project Manager. The Project Analyst supports the Project Manager in managing costs and schedules, and serves as the CAM for the subsystem IPTs. The Financial Analyst assists with project financial management activities, including Earned Value Management. The Project Administrator assists with general administrative activities.

Since the project and its personnel are housed at existing institutions, their human resources, property management, facility management, physical security, and supply chain management capabilities support project activities.

2.1.10   Relation to the OOI Program Office

CI Project personnel adhere to the policies and constraints laid out by the OOI Program Office in this OOI PEP. This includes, but is not necessarily limited to:

*   Participation in the cross-organizational structure defined by the OOI Program Office
*   Compliance with international and interagency partnership agreements
*   Compliance with the accounting system, including the Earned Value Management system, defined by the OOI Program Office
*   Adherence to a document control system consistent with document control at the OOI Program Office
*   Compliance with the program Data Policy
*   Submission of plans and reports for approval as required
*   Providing ex officio members of program advisory committees as required

2.2   Project Life Cycle

The OOI/CI project has elected the Spiral Development Model as the primary project life cycle because it:

*   Places the strongest emphasis on risk identification in the early stages of development where they can be reduced or eliminated in a cost-effective manner.
*   Is designed for projects where the user needs and enterprise requirements are not fully known at the start of the project, and must evolve as the community better understands the capabilities of the maturing system.
*   Allows the exploration of various design alternatives in a cost-effective manner.
*   Provides continual integration that uncovers functional, performance, and interface defects early in the life cycle where they can be removed in a cost-effective manner.

Figure 2.2-1 illustrates a tailored version of the spiral development model as described by Royce [1998] that has been selected for this project. It drives modification of the documentation and schedule requirements outlined in the OOI/CI RFP.

Figure 2.2-2 depicts a set of successive development spirals that are used to increase system definition from a concept to deployed products over time. The increasing definition typically occurs within four phases called inception, elaboration, construction, and transition [Royce 1998]. Anchor point milestones, called Life Cycle Objectives (LCOs), Life Cycle Architecture (LCA), and Initial Operating Capability (IOC) provide and manage criteria for progressing from one phase to the next. In practice, multiple overlapping development cycles are completed; for the proposed work, a total of five full cycles are planned. Further details may be found in the CI System Life Cycle Plan.

Cumulative Cost

Progress
Through
Steps

**Determine
Objectives,
Alternatives,
Constraints**

**Evaluate
Alternatives;
Identify, Resolve
Risks**

Risk Analysis

Risk Analysis

Risk
Analysis

R
A

Proto-
type 1

Prototype 2

Prototype 3

Operational
Prototype

**Commitment
Partition**

Requirements
Plan, Life
Cycle Plan

Concept of
Operation

Software
Requirements

Software
Product
Design

Detailed
Design

Development
Plan

Requirements
Validation

Integration
and Test

Design Validation
and Verification

Code

Unit
Test

Implementation

Acceptance Test

Integration & Test

B. W. Boehm, "A spiral model of software
development and enhancement," IEEE
Computer, copyright 1988, IEEE

**Plan Next
Phases**

**Develop, Verify
Next-Level Product**

Figure 2.2-1 Original Spiral Model

System Life Cycle Model

Life Cycle
Objective

Life Cycle
Architecture

Initial
Operational Capacity

Release

4 months

4 months

6 months

2 months

Inception	Elaboration	Construction	Transition

Viable Architecture Articulated
-
**Critical Requirements Satisfied
Critical Risks Prototyped
Key Technologies Selected**

Core Architecture Operational
-
**Critical Requirements Implemented
Critical Risks Mitigated
Key Technologies Integrated**

Planned System Operational
-
**All Requirements Implemented
All Risks Mitigated
All Technologies Integrated**

Planned System Deployed
-
**External Systems Integrate
User Training
Stakeholder Validation**

Validate

Test
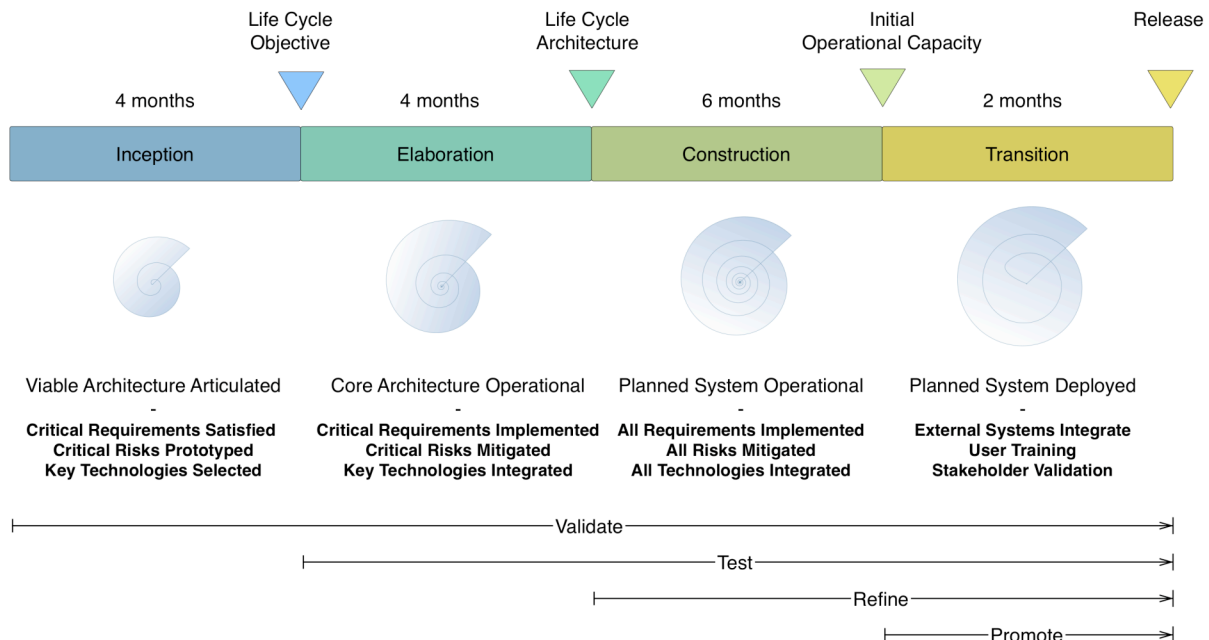
Refine

Promote

Figure 2.2-2 Incremental Spiral Development Life Cycle

The key activities during the inception phase are requirements discovery, critical risk mitigation and conceptual architecture definition based on negotiation with and among stakeholders. This culminates in the Life Cycle Objectives (LCO) anchor point milestone that produces stakeholder commitment to building the architecture. The elaboration phase focuses on defining the optimal system architecture and addressing its riskiest elements. It ends with the Life Cycle Architecture (LCA) anchor point milestone that commits the stakeholders to construction of the system. The construction phase is centered on building alpha and beta releases of the system. It terminates with the Initial Operating Capability (IOC) anchor point milestone that commits the stakeholders to deployment of the system. It is followed by transition to a deployed system.

As the spiral model has evolved, variants have been introduced, but all share several key properties. The system is defined, refined, and developed in multiple, risk-driven spiral iterations bounded by anchor point milestones. The details and impact of the risks (whether technical, management, operational, or stakeholder) drive the number of spirals and the level of detail and effort within each phase of a spiral. The riskiest elements are brought forward as early in the project as possible. Each spiral includes management, engineering, and support activities in proportion to the risks. Each spiral expands system definition and results in a deployed representation.

2.3   Key Deliverables

The key project deliverable is an integrated, verified, validated, and deployed OOI/CI. The OOI/CI is delivered in an increasingly advanced form every 12 months beginning 18 months after project inception. Interim releases that provide incremental capability improvement may also be released at the discretion of the Project Manager.

The project also delivers a range of plans, reports, and manuals. Planning documents are updated at least annually. Reports are provided on a schedule specified by the Program Office and consistent with the budget.

2.4   Metrics, Decision Analysis, and Reporting

An element of project execution is metrics, decision analysis, and reporting (Table 2.4-1). It encompasses the review and documentation of activities of the project.

Table 2.4-1 Metrics, Decision Analysis, and Reporting

Item	Description
Drivers	PM, SDM, SE, and IPT Leads
Participants	IPT Leads, Stakeholders, Software Architects, System Engineers, System Integrators, and QA Engineers
Entry Criteria	• End of a reporting period (e.g., end of month, preparation for a major review) • Need for a decision
Inputs	• Collected measurements • Facts for decision making • Prototyping results • Cost actuals
Tasks	• Decision making • Metrics – collection, analysis and reporting
Tools & Methodologies	• EVMS • Microsoft Project • Decision Trees • Ishakawa (cause and effect) diagrams • Prototyping • Microsoft Excel
Metrics	• Per metrics section of the PEP
Outputs	• Documented decisions • Recommended corrective actions • Metrics reports (including Earned Value and TPMs)
Exit Criteria	• End of Program

2.4.1   Decision Process

The OOI/CI decision-making process is a structured one focused on decisions that impact the programmatic, technical, cost or schedule baselines, and is designed to provide clear guidance to project personnel. Decision-making authority within the OOI/CI Project resides in individuals, working teams, IPTs, and review/control boards with proper involvement of key stakeholders.

Stakeholder involvement is critical to the integrity of formal decisions. The first step in stakeholder involvement is the identification of the stakeholders. The specific stakeholders needed for each decision depends on the type and functional (or discipline) area of the specific decision. For example, issues with requirements should involve system engineers, architects, and designers. The second step is the management of stakeholder involvement through formal inclusion in meetings or informal inclusion in follow-ups to meetings.

The type of decision to be made determines which method to use in evaluating action alternatives. The selected method considers the available data, the needed output, and the opportunity it affords to focus on issues and provide the required measurement data. The assumptions used in the analysis are compared to the evaluation criteria and the rationale for the assumptions is documented. The selected method is then used to evaluate the alternatives in reaching a decision. The results of the consideration are provided to the stakeholders along with the risks associated with the selected alternative and for confirmation of the decision. The resulting selection and stakeholder consensus is documented.

A variety of standard formal methods of decision making provide the foundation for solving complex challenges when there may be more than one solution option and more than one selection criterion to be considered.

Decisions that do not affect the cost, schedule, or technical baselines are made on a continuing basis by individuals during the normal course of carrying out their work. At this level, no management involvement or review is required. The results of such decisions become apparent via meeting minutes or other records from peer reviews, design reviews, or regular status reports and are communicated to the affected audience.

2.4.2   Project Metrics Strategy

The OOI/CI project metric strategy defines performance measurement processes to identify, collect, analyze, and track data needed for quantitative management by the OOI/CI work teams responsible for the design, development, integration, and delivery of the required system. The performance measurements are developed and accomplished throughout all phases of the project life cycle. Although the PM is responsible for ensuring sufficient planning, providing resources and management of these processes, implementation of the provisions of this plan is the responsibility of the entire OOI/CI Project Team.

Metrics are neither shelf data, used only for historical purposes, nor a set of predefined measures that never change during the life of the project. Instead, metrics help the stakeholder to make more informed decisions by identifying deviations from plans, thus enabling mid-course corrective actions when change is less expensive to implement. Additionally, the metrics must address the current issues at hand that may change with time or phase of the project.

Project performance measurements serve as indicators of process, activity status, and product quality and performance, providing positive and negative variance information for quantitative management of the OOI/CI team. These data, with the interpretive meaning provided by the associated measurements, are used to provide insight for management necessary in resource allocation and programmatic and financial decision-making.

The goal of the OOI/CI measurement process (Figure 2.4.2-1) is provision of accessible and timely measurements to project management, the stakeholders and all teammates to facilitate proactive, fact-based quantitative management. The measurements provide early indicators of where positive and negative variances occur in the program so that, in the case of negative variance, the appropriate corrective actions can be taken as early as possible. This course of action enables adverse trends/challenges to be reversed and minimized. If reports are positive, measurements enable

appropriate recognition to be given and, if necessary, the diversion of resources to places where need is greater.
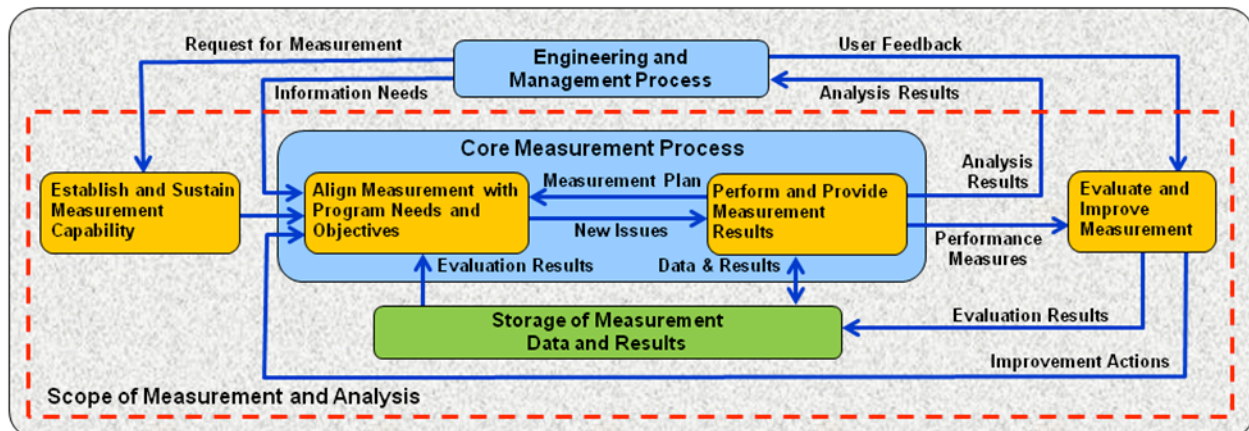

Figure 2.4.2-1 OOI/CI Measurement Process

The measurements are used and analyzed at all levels of the program by those who have responsibility for the day-to-day activities up to the Executive Management Team that has overall responsibility for the project's performance. Wide availability of data is accomplished through the integration of this plan into the overall project execution plan, providing execution planning and referenced by other program plans. Table 2.4.2-1 is a summary of project metrics.

Table 2.4.2-1 Summary of OOI/CI Program Metrics

Title	Description
COST	
Cost Performance Index (CPI)	Employs earned value to measure the cost efficiency with which work has been accomplished by showing the budgeted cost of work performed over a period of time versus the actual cost of the work performed.
To Complete Performance Index (TCPI)	Compares remaining work against remaining effort and indicates how efficient the future work must be to complete on budget by showing the budgeted cost of work performed over a period of time versus the actual cost of work performed
Cost Variance	Compares budgeted costs for the period to the actual costs
Estimate At Completion (EAC)	Provides best estimate for total cost at the end of the project and is a leading indicator of the project's cost status.
SCHEDULE AND PROGRESS	
Schedule Performance Index (SPI)	Employs earned value to measure the schedule efficiency with which work has been accomplished showing the budgeted cost of work performed over a period of time versus the reflected cost of budgeted work performed
Schedule Variance	Compares the planned schedule for the period to the actual schedule
Critical Path and Schedule Buffer Management	Tracks and provides status of the critical and near-critical paths. Tracks the burn rate of the schedule buffer.
Milestone Status	Provides summary of milestone status for various activities defined in the schedule (e.g., summary status of activities leading to preliminary design and to unit test)
SUBCONTRACTOR MANAGEMENT	
Subcontract Management	Tracks the performance (e.g., CPI, SPI, deliverables, risks) of the subcontractors
GROWTH AND STABILITY	
Requirement Volatility (Internal sources of change)	Provides a measure of the changes to requirements to ensure the timely recognition and analysis of impacts on scope, schedule and cost due to lack of clarity, completeness, and understanding of the requirements
Changes (External sources of change)	Tracks externally-driven changes by type (e.g., Class I impacts having cost and schedule impacts versus Class II that only have technical impacts), source, cause, and cycle time.

PRODUCTIVITY	
Staffing	Provides a measurement of the ability to maintain planned staffing levels for timely completion of the project. It also provides early insight to additional project staffing needs or staff reduction plans. Early management visibility and support of staffing changes provide for a more orderly staffing transition
Software Size and Growth	Provides a measurement, over time, of changes to the size and the code mix of the software development effort. Size metrics are reported in units of SLOCs split into New and Reuse categories. In addition, the code reuse factor is derived and the current ESLOC projections are compared to planned (software bid) ESLOC to provide software growth statistics.
Requirements Verified Against Plan	Measures the total number of requirements verified with respect to the total number of requirements.
Software Productivity	Provides a measurement of the effectiveness of the software development effort in meeting project commitments. SLOC is the primary input parameter for most software size estimates. ESLOC counts are derived from SLOC to define the effective scope of work and, combined with labor month projects, are used to forecast the software development team's productivity.
Development Environment Utilization	Tracks changes in the estimated and actual utilization and availability of computer resources in the development environment. Provides early warning if the limits or capacity of a resource are approached or if infrastructure challenges are impeding development effort
Test Environment Utilization	Identifies the readiness of the test environment. Criteria includes whether the test environment is configured as specified by the test plan and is under Configuration Management control such that the configuration of all required resources enables formal testing to proceed
Delivered Environment Utilization	Tracks change in the estimated and actual utilization and availability of computer resources in the delivered environment to provide early warning if the limits or capacity of a resource are approached.
QUALITY	
Defect Density and Containment	Provides a measure of the effectiveness of the process to identify and contain defects across the product life cycle. Analysis of defect containment characteristics also provide insight on where process improvements could provide the most benefits
Rework	Tracks the cost of poor quality in product engineering by identifying the cost of the rework incurred in fixing product defects detected during product reviews and product evaluations, across all development life-cycle phases.
Peer Reviews	Tracks the progress towards achieving work products peer review goals.
Quality Performance Index (QPI)	Indication as to the overall status of the program reflecting the Product Quality, Development Process Quality, Customer Satisfaction Rating, and overall Contract Compliance. The factors contributing to these four components of the QPI have a variety of sources and measurement attributes. The goal is to define these factors as completely as possible and express the attributes of these factors as objective measures where possible. The QPI serves as a predictive indicator of the program's final quality.
Assessments/Audits	Monitors adherence to defined processes by tracking the corrective actions developed because of non-compliance challenges determined during assessments/audits (external and internal)
Action Items (AIs) and Discrepancy Reports (DRs)	Shows the trend in open/close rates over a period of time and that the DRs and AIs are tracked through closure
PERFORMANCE	
Requirement Traceability	Measures the number of requirements that are completely traced from the top-level specification to the design component as compared to the total number of requirements. This provides identification of the degree of completeness between what is required of the system (requirements) and the actual design components specified in the implementation.
Technical Performance Measurements	Measures the actual performance as compared to required performance of key technical parameters.
RISK	
Risk Summary	Shows the status of the project's risk. Provides management an overview of how risks are distributed across the project and the primary impact category should the risk be realized.
Risk Mitigation	Shows the progress of implementing risk mitigation plans and the status of these plans in relationship to the planned schedule
Opportunities	Shows the status of the program's opportunities and the actions needed to realize these opportunities

2.4.3   Metrics and Decision Reporting

Metrics are more than collections of measurements for historical purposes, and must be analyzed and reported across the project. The analysis includes examining trends, preparing detailed reports as needed, causal analysis, and preparation of recommendations for corrective action. The analysis identifies each case in which a defined threshold has been reached, and highlights metrics whose trends point to the possibility of an imminent threshold breach. It is important that analysis be completed quickly to detect potential challenges as early as possible and/or predict the occurrence of future challenges.

Thresholds must be established to assist in the analysis of metrics. In most instances the thresholds are set with an upper and lower limit to provide an acceptable range of performance. Activity over a period of time is tracked to provide trending information that supports early identification of potential issues. Some metrics have no numeric thresholds and must receive management review for all changes.

There is a natural hierarchy of metrics reporting. Each IPT lead reports metrics to the System Development Manager and reviews any necessary recovery steps with him. The System Development Manager combines the subsystem metrics into a summary IPT metric and transmits it to the System Engineer. He in turn adds system-level metrics and sends the result to the Project Manager.

Reporting is at a summary level with more complete information generated "by exception" (e.g., an anomaly or issue that needs to be reviewed). The term "exception" refers to metrics that have reached their thresholds, metrics whose trends predict they may reach a threshold within the next reporting period, metrics that show significant changes (positive or negative), process changes, and the effect of previously implemented corrective or preventive actions. If thresholds are not used for a given metric, the metric is always reported.

The majority of reporting is directed to the individuals performing work related to a given measurement. These individuals can often resolve issues or correct negative trends without the need to refer to the next higher level. These reports are usually detailed metrics reports focused on the individual's work scope.

The next level of reporting is summary and management-oriented. Weekly IPT reviews cover schedule progress. The weekly Executive Management Team meeting receives a top-level summary of metrics as objective confirmation of the progress reporting provided by the IPTs and discipline leads.

On a monthly basis, the Project Manager reviews both the collected metrics and the effectiveness of the metrics program. This review uses summary reports to assess the overall progress and quality of program. Stakeholder representatives participate in this review similarly to how stakeholder IPT representatives participate in other reviews.

Review of the generated reports is the source of recommendations for action items or corrective actions and identification of process improvements. Action items or corrective actions are assigned to the appropriate individual and tracked through closure. In the cases where risk is changed, the risk identification process documented in the CI RMP is followed.

Process improvements may be identified through comparison of the same metric across IPTs. For example, reports at an IPT level may show that one sub-IPT has made a significant improvement in a metric such as requirements volatility while another sub-IPT has not. As the reason for the improvement is discussed, effective measures and proven process improvements can be shared. As with any process change, these improvements must be managed through the change control process.

Response consists of the implementation and tracking of corrective actions that have been agreed upon to achieve the desired result. Management involvement is required since response involves tracking the progress of actions. Therefore, the effectiveness of the metrics process itself is considered and may lead to actions to improve it.

2.4.4   Earned Value Management

The OOI EVMS is designed to provide meaningful program performance information to CI and OOI program management, and ultimately to NSF. It is used as a tool for planning and monitoring program cost and schedule performance. The EVMS objective is to integrate cost and scheduling throughout the life of the program; take a performance management approach to cost and schedule management; and

achieve cost performance within targets by effective control through "up-front" detailed planning. The implementation of the IMP/IMS schedule management process is an essential part of EVMS. The IMS is directly tied to the development of the Performance Management Baseline (PMB), and provides an input to an integrated cost and scheduling tool set for the program. Both data and tools reside in a collaborative work environment that integrates costs and scheduling throughout the life of the program, and enables consistent implementation across IPTs.

2.4.5　Technical Performance Measurements

The OOI Cyberinfrastructure Program has established a Technical Performance Measurement (TPM) process that identifies Key Performance Parameters (KPPs) used to determine the success of the CI system, portion thereof, or across the entire OOI System and to receive management focus and be tracked using TPM procedures. The OOI TPM process continuously tracks the TPMs assigned and/or allocated to the Cyberinfrastructure from the OOI Level and those internally identified to ensure they are considered in the design, properly addressed in the implementation, and thoroughly tested before the products are incorporated into the OOI System Baseline.

TPM is the continuing verification of the degree of anticipated and actual achievement of technical parameters. TPM is used to identify and flag the importance of a design deficiency that might jeopardize meeting a system level requirement that has been determined to be critical. Measured values that fall outside an established tolerance band require proper corrective actions to be taken by management. The management of TPMs (including selection, monitoring, and reporting) is the responsibility of the System Engineer following the process documented in the SEMP.

2.5　Project Reporting/Status

Project reporting and status (Table 2.5-1) is the timely and comprehensive measurement of project progress against the plan to determine the potential seriousness of uncorrected variances.

Table 2.5-1 Program Reporting/Status

Program Reporting/Status	
Drivers	PM and Work Team Leads
Participants	Work Team Leads, Stakeholders, Software Architects, System Engineer, System Integrators, and QA Engineer
Entry Criteria	• Metrics indicating potential issues or improvement opportunities • Issues identified
Inputs	• Lessons learned • Metrics • Results from demonstrator or previous builds
Tasks	• Cost performance and contract fund status reporting • Metrics reports • Action items and discrepancies
Tools and Methodologies	• Microsoft Excel • Change management software
Metrics	• Per metrics section of the PEP
Outputs	• Cost Performance Report (CPR) • Contract Fund Status Report • Metrics Analysis • Action Item/Discrepancy Status
Exit Criteria	• End of Program

2.5.1　Cost Performance and Contract Fund Status Reporting

Schedule data are integrated with the program budget baseline to provide accurate Cost Performance Reports (CPRs) and Contract Fund Status Reports (CFSRs). Earned value data from the CI team members is electronically transmitted for consolidation into a single report. Schedule analysis is performed using Microsoft Project.

Status is based on completed tasks, not percentage of tasks completed. Schedule variance is expressed as dollars expended and explained in terms of impact to the critical path.

Variance thresholds are established for internal and externally reportable variances. Every month, each work team provides updated schedule status. This information from responsible engineers is provided to the business management organization, where actual expenditure levels are combined with earned value status. Variance analysis is performed for each cost account and formally documented if exceeding the pre-established threshold. Internal variances are summarized to the external reporting levels, as required. Internal reports for project work teams and external reports for the OOI Program Office are generated from the same database.

The CPR is provided monthly and the CFSR is provided quarterly.

2.5.2 Metrics Report

Measurement and metrics data, analysis results, and actions planned or taken from all Teammates are integrated into a monthly metrics report.

2.5.3 Action Items and Dependencies

Both the formal (contract-related) and the informal (routine) action item logs are continually updated as new actions are defined and old actions are closed.

An external dependency log (giver-receiver items) is addressed monthly for additions, deletions, or changes. Due dates are reviewed and, on delinquent items, the dependency is addressed at Core Management Team status meetings.

3 Planning and Control

Project planning and control parameters include all information needed to perform planning, organization, staffing, directing, coordinating, reporting, and budgeting functions. These include requirements imposed by NSF and/or the OL Program Office; the scope of the project as defined by science user, system requirements, and the system architecture; the spiral project life cycle; the deployment schedule; and build-to-cost constraints. Task and work product identification and their conversion to costs are based on prior experience in related projects.

3.1 System Breakdown Structure (SBS)

The CI System Breakdown Structure (SBS) is shown in Figure 3.1-1. Based on the System Requirements, these are the components of the system that consume resources in their production. These CI Subsystems and the Elements within each Subsystem determine the basic structure for the CI Work Breakdown Structure (WBS). The names of the CI Subsystems are self-descriptive; additional technical detail can be found in the OOI SEMP and the CI System Design Documentation.
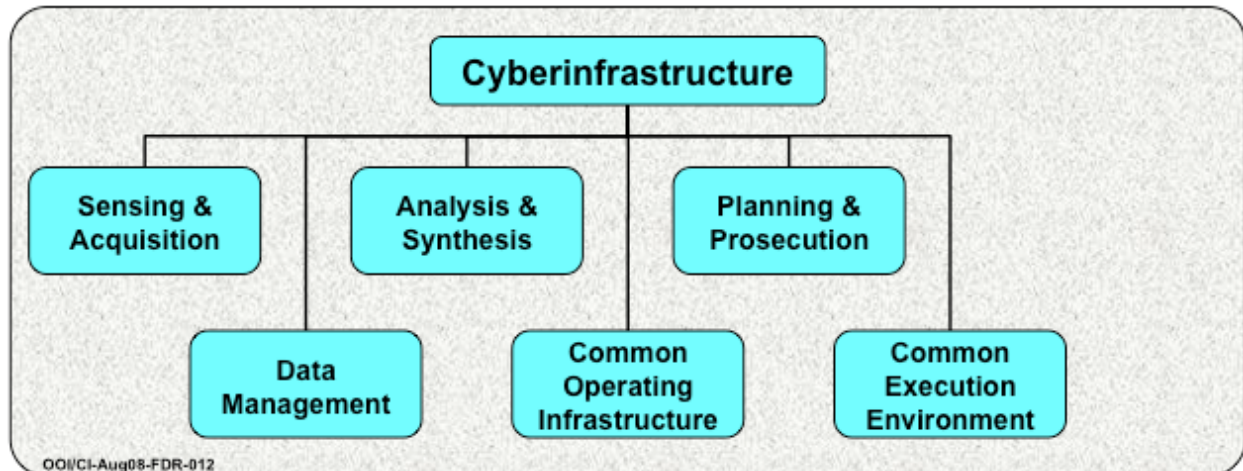
Figure 3.1-1 CI System Breakdown Structure

3.2 Work Breakdown Structure (WBS)

The OOI Work Breakdown Structure (WBS) derives its structure from the OOI System Breakdown Structure (SBS). The major products (i.e., subsystems) that comprise the system correlate to the cornerstone WBS Elements to create a product-based WBS, which is augmented with a program management branch, a system engineering branch, a system integration and test branch, and an operations branch.

The cornerstone WBS elements have been decomposed to reflect hardware sub-products / assemblies and software that comprise the CI Subsystems. This is combined with the Events, Significant Accomplishments (SAs), and Accomplishment Criteria (ACs) from the IMP that represent the life-cycle phases of the OOI project. Decomposition is continued until the WBS elements identify applicable tasks that can be accomplished by a team of two or three people in one or two months following organizational procedures with specific entry and exit criteria.

The result is a robust WBS, which along with the WBS Dictionary establishes the individual elements of work that are managed. Because of its size, the OOI WBS is maintained as a separate document that is subject to configuration control.

3.3 Cost Work Breakdown Structure (CWBS)

With a robust WBS and WBS dictionary established, technical estimators can properly estimate the amount of labor, appropriate methods and tools, required facilities, materials/equipment, training, travel, and other direct costs required to complete defined tasks and meet event exit criteria for each WBS element and hence, the total cost for each WBS element. The estimator also identifies applicable or potential technology constraints and develops an approach for overcoming each constraint by using an appropriate mitigation approach and by technology insertion at the appropriate time in the enterprise-based life cycle. The final step is to estimate the risks associated with producing the required products on time and on budget so that contingency funds can be estimated and set aside. Results of the estimating exercise are captured in Technical Description/Basis of Estimates (TDBOEs) documentation.

With the costs associated, the WBS now becomes a Cost Work Breakdown Structure (CWBS) with established cost objectives (e.g., ownership, acquisition, operating, support, and disposal) that can be used in tradeoff analyses. Tradeoffs may be required if the total cost obtained by summing up the individual WBS element cost estimates exceeds the budget for the system. The CWBS provides a framework for defining the scope of the program, and is the cost tracking mechanism for the Cyberinfrastructure project. It provides the structure for control and management of the project throughout its period of performance.

The CWBS, WBS Dictionary, and Cost Book that detail the efforts of each WBS task are maintained by the Program Office as part of the Earned Value Management System. A change can be requested by a CAM or driven by a scope change. However, the PM is the authority to approve changes to the CWBS.

3.4 Integrated Master Plan/Integrated Master Schedule

The project uses the Integrated Master Plan/Integrated Master Schedule (IMP/IMS) as the basis for the CI management and scheduling approach.

Integrated Master Plan (IMP): The Cyberinfrastructure IMP, depicted in Figure 3.4-1, identifies contractual events, Significant Accomplishments (SAs), and Accomplishment Criteria (AC) that must be achieved by those events to complete the technical effort. The Cyberinfrastructure IMP is a time-independent architecture for the project by which successful performance is defined and measured. It clearly reflects the CI Iterative Life Cycle and how the efforts of the development groups are integrated to satisfy the required accomplishments and is the primary management tool used to understand, define, plan, bid, and execute the project.

Each of the IMP accomplishments, which can also be referred to as a life-cycle phase, culminates with a Formal Management Review for which specific work products are expected to be produced and reviewed. Each of the Formal Management Reviews has measurable exit criteria for successful completion of the review, which provides a definitive measure or indicator that the required level of maturity or progress has been achieved and also denotes the successful completion of that life-cycle phase. The events, significant accomplishments, and accomplishment criteria directly relate to WBS elements.
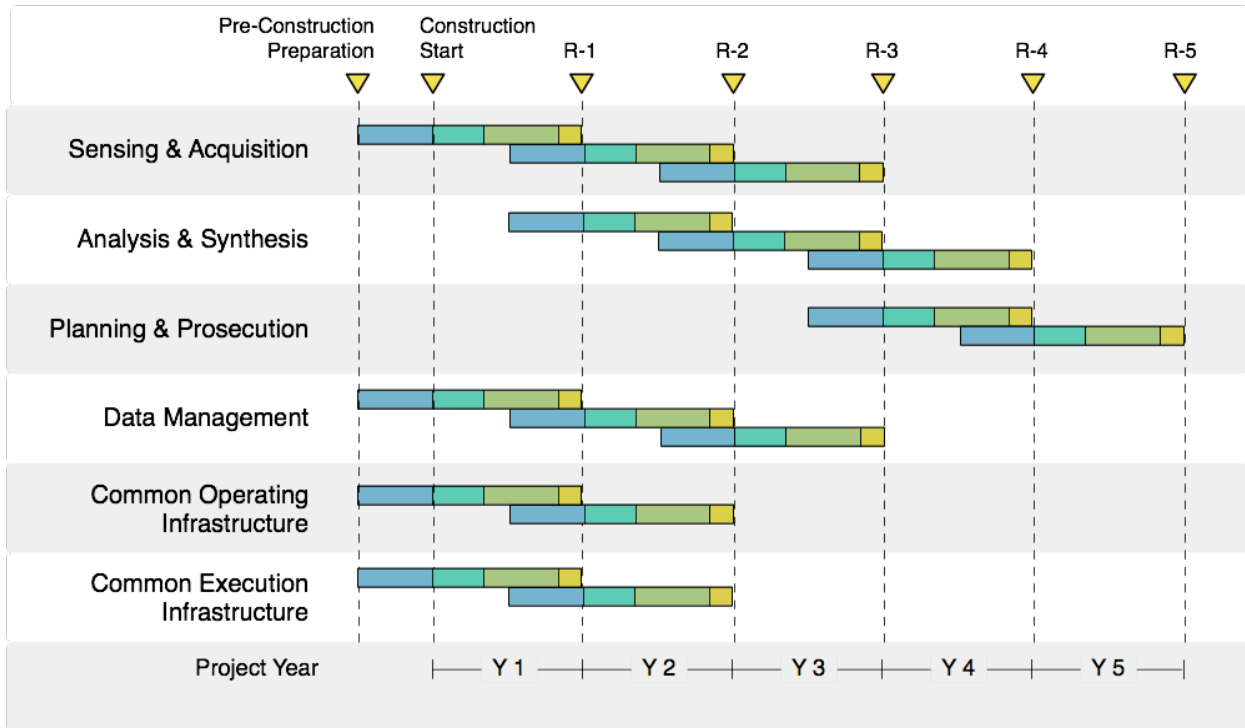
Figure 3.4-1 CI Integrated Master Plan (IMP)

Integrated Master Schedule (IMS): The Cyberinfrastructure IMS time-phases and connects the tasks and activities (work details) necessary to successfully execute the IMP. The IMS is the primary time-dependent management tool used to define and integrate project tasks, track them, and report on progress. The IMP/IMS integrates all project management aspects including project structure (IPT structure, project architecture, work breakdown structure), capture activities (estimating, pricing), and execution considerations (e.g., stakeholder roles, schedules, risk management, and earned value management).

The IMP/IMS hierarchy lends itself to alignment with the EVMS hierarchy (Figure 3.4-2) to provide a solid EVMS framework. In essence, the IMP SA is aligned with the EVMS Control Account (CA), and the IMP AC is aligned with the EVMS Work Package (WP). This permits ready identification of the EVMS CA and WP in the resource-loaded IMS.

After initial approval of the IMP/IMS, any potential changes are first reviewed internally by the Executive Management Team and then reviewed by the OL Program Office for approval before changes are incorporated.
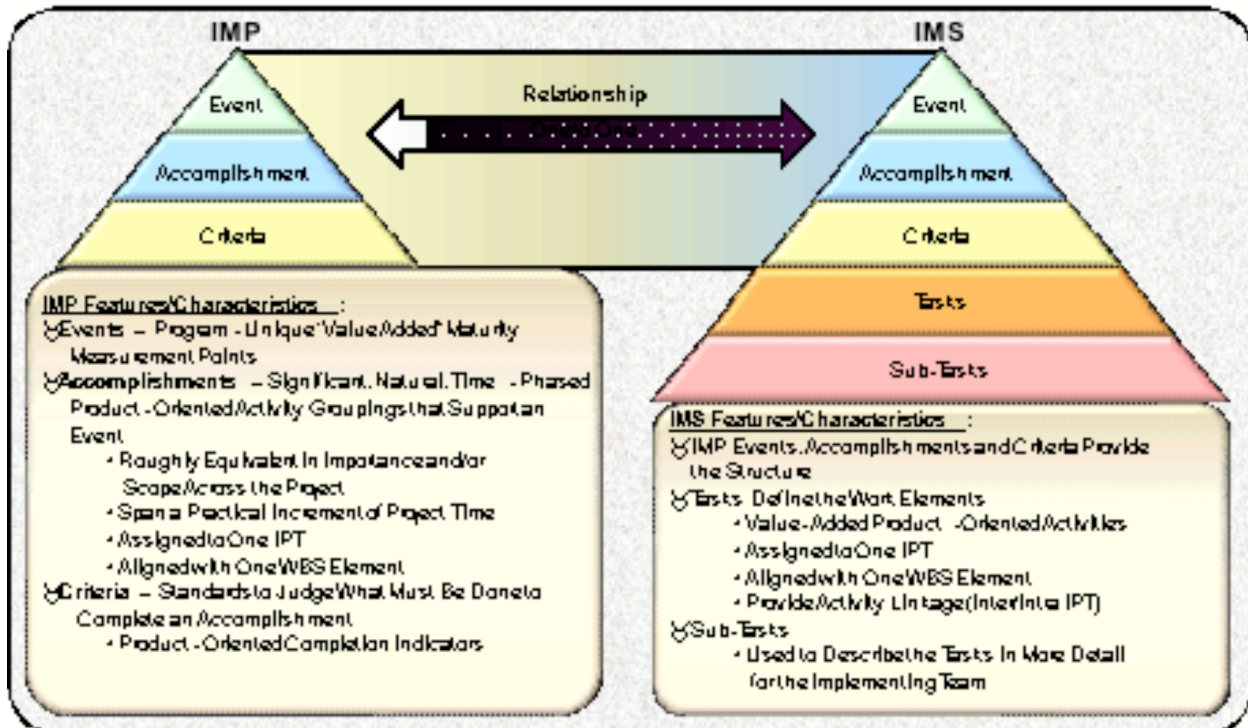
Figure 3.4-2 IMP to IMS Relationships

3.4.1   Contingency Management

When estimating the effort and associated costs for each of the WBS Elements, a risk evaluation is performed. Each of the WBS elements are evaluated for technical, cost, and schedule risk and assigned factors in each category following the guidelines in Table 3.4.1-1, which is based on the amount of perceived risk. The risk factors are algorithmically combined and multiplied against the total budget for each WBS element to determine the percentage of additional funds that should be included as part of the total project budget but set aside as contingency funds. Additional contingency flows from specific risks identified and quantified in the CI Risk Register.

Table 3.4.1-1 Risk Evaluation Factors and Guidelines

Risk Area	Factor	Evaluation Guidelines
Technical	1	Existing design and off-the-shelf system
	2	Minor modifications to an existing design
	3	Extensive modifications to an existing design
	4	New design within established product line
	6	New design different from established product line. Existing technology
	8	New design. Requires some R&D development but does not advance the state-of-the-art
	10	New design. Development of new technology which advances the state-of-the-art
	15	New design far beyond the current state-of-the-art

Risk Area	Factor	Evaluation Guidelines
Cost	1	Off the shelf or catalog item
	2	Vendor quote from established drawings
	3	Vendor quote with some design sketches
	4	In-house estimate for item within current production line
	6	In-house estimate for item with minimal company experience but related to existing capabilities
	8	In-house estimate for item with minimal company experience and minimal in-house capability
	10	Top down estimate from analogous programs
	15	Engineering judgment
Schedule	2	No schedule impact on any other item
	4	Delays completion of noncritical path subsystem item
	8	Delays completion of critical path subsystem item

Contingency funds are designated as Management Reserve (MR), which is the amount of the total project budget withheld for management control purposes rather than being allocated for a specific task or tasks. A major portion of the management reserve is typically allocated to risk mitigation and corrective action activities. The total project budget is not changed unless authorized written changes, whether contractual or managerial, are received.

3.4.2   Performance Management Baseline (PMB)

The Performance Management Baseline (PMB) is the time-phased budget plan against which contract performance is measured. The PMB is the total project budget minus the management reserve. The PMB is formed by the time-phased budgets assigned to cost accounts and time-phased applicable indirect budgets. The project office and the CAMs jointly develop the budgets.

The Cyberinfrastructure budget process establishes work team task-specific responsibility and associated cost account funding. The Project Analyst serves as the CAM for the subsystem IPTs. As budgets are distributed and established, an agreement is reached with work team leads on responsibilities and associated budget. This negotiation/coordination ensures a clear understanding of work team responsibility, accountability, and authority. Agreements with teammates are negotiated and agreed to. Final detailed work packages, or other agreed processes for measuring earned value, are created during this process.

The SOW and work team staffing requirements, including teammates' tasks, are captured for the life of the Cyberinfrastructure Project, and address resource budgeting, personnel skill mixes, and phasing of project personnel. The staffing plan provides practical personnel transitions and identifies difficult staffing challenges and needs. The task definition and associated budgets drive short- and long-term staffing forecasts that are coordinated with the functional organizations for practicality and implementation. Tasks and associated cost and schedule budgets for teammates are also completed.

Concurrently, the subcontract management process completes estimates for subcontracted material. These costs are included to complete IPT budgets and provide an overall project budget.

3.4.3   Earned Value Rolling Wave Development

The CAMs use work packages and planning packages to divide their cost account into manageable and measurable units of work. The CAM assigns a budget value in hours or dollars to each work or planning package. The sum of the work and planning packages must equal the total budget assigned to the CAM in the cost account level of work authorization. Earned value is claimed only on work packages. CAMs select appropriate earned value techniques for each created work package.

Cyberinfrastructure CAMs plan both work packages and planning packages for work beyond the design period. Periodic detail planning (the rolling wave) is used to subdivide the work from planning packages into work packages. As the tasks and schedule requirements in the planning packages become better

defined, the CAM converts the near term tasks into work packages. The pre-planned periodic conversion of planning packages to work packages usually includes six to twelve months of tasks.

Earned value techniques used in work packages include 0/100, Percentage of Work Completed, Milestone Weights, Milestone Weights with Percentage Completed, Units Completed, and (minimally) Level of Effort.

Earned value budgets and progress are captured in Microsoft Project. Time and materials are captured in Deltek T&E.

3.4.4   Work Authorization

Work authorization is an iterative process throughout the life of the project. It is the official means of communication to initiate early planning and to place controls on the accomplishment of work. Work authorizations represent the commitment by the project team to perform the required work scope and to provide the budgeted resources to support the defined schedule and technical goals.

Project personnel do not begin work on a contract without authorization. Verbal authorization (from any management level, including the COL Program Office) is normally not sufficient, and the Contract Organization must initiate a formal process.

Issuance of the primary work authorization (PWA) authorizes the PM to commence the necessary effort relative to the agreed upon SOW. When appropriate, the Project Manager modifies the PWA to reflect any scope, schedule, or budget changes assured by original contract negotiations or by contract change orders and their associated negotiations. The PM issues Secondary Work Authorizations (SWAs) that communicate the scope, schedule, and budget to the program CAMs to authorize CA level planning and commencement of work. Advance or interim authorizations are based on estimates submitted in the proposal in response to the RFP, as modified by any scope, schedule, and/or budget changes to the program approach that may have taken place between the bid submittal and contract award.

While the contract is being finalized, functional management/work team leaders and CAMs continue to plan their detailed near-term work. This process authorizes and enables the Project Office to establish a baseline for measuring performance almost immediately following contract award.

Final authorizations formally establish the scope, schedule, and budget baseline for the project. They supersede any interim/advance authorizations that may have been issued and reflect contract negotiations that could result in budget reductions from prior interim authorizations. The Project Office follows through by reviewing and updating of all the requisite contract records to reflect the approved baseline.

Final authorization may occur immediately upon receipt of a fully negotiated contract award without the need for interim authorization. In these cases, the initial authorizations would also be the final authorizations.

Internal CAM Authorization

CAMs are given the responsibility of managing the technical, cost, and schedule aspects of the defined scope of work. Items for consideration include:

- Control account aligned to one WBS element and organizational element
- Discrete scope of work
- Time frame for scope of work
- The lowest level for typical work accomplishment
- Authorized resources
- Responsible individual(s)

3.5   Financial and Contracts Management

The Project Manager is responsible for implementing an accounting system that complies with the requirements for EVMS. The accounting system and its products are made available for audit as required by the OL Program Office or NSF.

The Project Manager is also responsible for negotiation of subcontracts with design partners at other academic institutions, federally funded research and development centers (FFRDC) and industry as appropriate, and for procurement of items that exceed the prime institution's policies for a no-bid process. Guidelines are instituted that delegate procurement below a threshold value to the System Engineer, Senior Architect, System Development Manager and Operations Manager, and require approval by the Deputy Project Director for procurements above another threshold level. The Project Manager is responsible for monitoring and controlling all subcontractors, and has the authority to modify or revoke subcontracts as needed.

The scope of OOI requirements for the CI IO demands that it employ a broad range of technical expertise and deploy infrastructure over a very wide geography at a time of significant disruptions in how technology is acquired. The CI IO strategy for acquiring the necessary capabilities is to build core unified design, integration and operation teams that contract with specific institutions and vendors that have the specific expertise, technologies and/or services required for execution. The CI IO has three categories of supplier relationships. Two are strategic classes of relationships and the third is a straightforward product/service relationship with COTS vendors.

The first and most critical class of supplier relationship is the Construction Partnership. These partners bring specific domain knowledge, expertise and technologies to the program. This type of partnership takes two forms. First, the Development Partner provides engineering manpower coupled with specific core technologies for including in the OOI Integrated Observatory Network, ION. Second, the Design Partner brings specific domain knowledge and experience in the development of an aspect of the ION. Contracts with Development Partners are on the order of thirty to sixty months of effort and with Design Partners they are on order of six to twenty months. In both cases, the contracts are scoped only to the development cycles the Partners are materially contributing to the program. This is either two or three release cycles in all cases. There are twelve Construction Partners. All were qualified and selected as a part of the OOI IO proposal process and the NSF ITR grant, LOOKING, that assessed the current architectures, technologies and future trends of existing observatory initiatives.

The second class of 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 the one that provides high bandwidth network connective (order 10Gbps) nationally with international links. Candidates for all the relationships 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 occur in the latter half of the OOI construction program, when detailed information on OOI's capacity requirements are available and the costs/benefits of on-demand computing infrastructure have been established.

The CI IO deployed infrastructure within the Marine IOs' operations environment, the acquisition point and marine management CyberPoPs, are straightforward acquisition of COTS computing, storage, and networking equipment. The procurement and build out of this infrastructure starts in year-one and continues through year-five with the deployment of the High Bandwidth Data Stream Processor CyberPoP at the shore end of the Regional Scaled network.

The Project Manager is responsible for obtaining necessary permits and insurances. Given the scope of the project, it is anticipated that standard prime institution and subcontractor insurance provisioning is sufficient, and that no permits are going to be necessary.

3.6   Risk and Opportunity Management

The CI risk and opportunity management approach (Figure 3.6-1) is an organized process to identify and categorize situations so that undesirable risks may be mitigated and advantageous situations may be exploited throughout the project life cycle.

The OOI Risk Management Plan specifies a program-wide process for controlling risk with which the project complies. The CI Project Manager is responsible for preparation and implementation of the CI Risk and Opportunity Management Plan. He serves as the CI Project Risk and Opportunity Manager, and is a member of the OOI Risk Management Team. The CI risk management process is modeled after that described in the OOI RMP. Interface points include the following:

- All risk identification, risk analysis, planning for risk handling, and decisions on how much risk budget, if any, is allocated to each risk are a joint effort with the OOI Program Office.

- A trade study will be conducted to select the appropriate risk management tool, which will be used by OOI and the IOs. The trade criteria include where the tool should be installed and how members of the OOI community access it. Should the tool be installed at UCSD with everyone accessing it (e.g., the DOORS model) or should each IO and OL have their own copies? Some of the potential COTS Risk management tools include:

  - Risk + (C/S Solutions)
  - Pertmaster Risk Project/Risk Expert (Pertmaster Ltd.)
  - Active Risk Manager (Strategic Thought Group)
  - Risk Radar (Integrated Computer Engineering)
  - Risk Track (Risk Services and Technology)

- The OL Contracting Officer's Technical Representative (COTR) is a member of the CI Risk Management Board and attends its bi-weekly meetings.

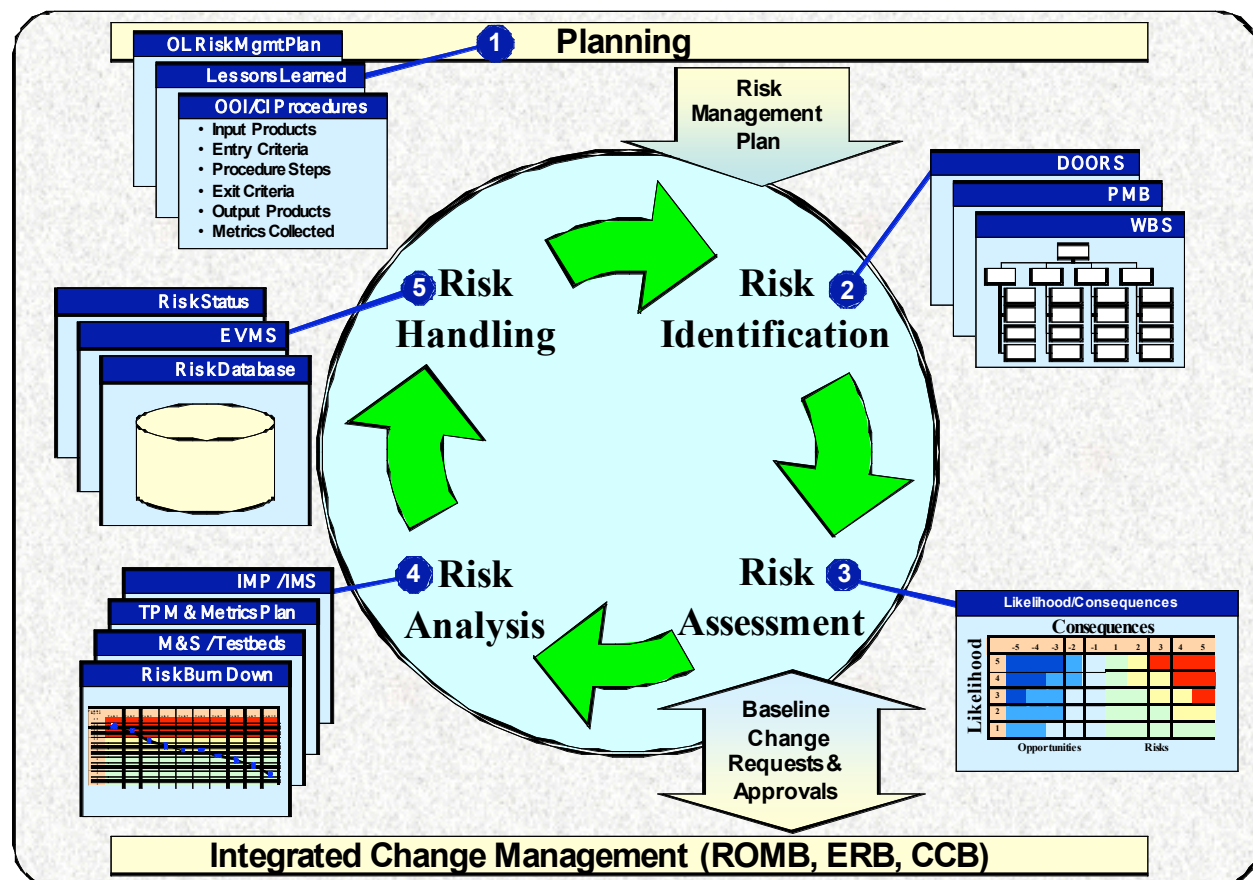- OL level risk management forums and configuration control boards are supported as requested.

Figure 3.6-1 CI Risk Management Process

The CI risk and opportunity management is tightly coupled with contingency management. With the approval of the CI Deputy Project Director, the CI Project Manager is responsible for administering the Management Reserve (MR) funds held by the project, applying MR to mitigate project risk, and replenishing MR when opportunities are realized. The Project Manager is also responsible for coordination with the OL Program Office regarding MR funds, debiting or crediting MR only after formal approval of scope or design changes by the project and/or program Change Control Boards, or NSF if required.

The Cyberinfrastructure's risk management approach incorporates team experience and insight for early identification and mitigation of critical risks to provide a system with low overall system development risk. Leveraging completed risk mitigation demonstrations and an incremental system development approach provides a lower risk profile throughout the project life cycle. Key features of the risk program include the following:

- Proven, structured, and highly visible risk management process ensures successful system implementation within target schedule and budget
- Risk processes proven in an iterative system development life cycle
- A robust risk mitigation infrastructure spanning the entire development life cycle for known risks as well as the flexibility to address future "unknowns"

As illustrated in Figure 3.6-1, the CI risk management process includes five major elements (Planning, Identification, Assessment, Analysis, and Handling), each of which is highlighted in the following paragraphs.

3.6.1   Risk Planning

The Risk Planning Process includes development and tailoring of a Risk Management Plan (RMP) that provides the detailed Risk and Opportunity Management procedures and work instructions and is compliant with the Ocean Leadership Risk Management Plan. The CI RMP is published as a separate standalone document that is included as part of this PEP by reference.

3.6.2   Risk Identification

The Risk Identification Process includes a combination of unstructured approaches, such as brainstorming and expert opinions, and structured approaches. Structured approaches include WBS analysis, interviews, risk taxonomy analysis to create Risk Breakdown Structures (RBS), and detailed requirements analyses. In addition, meticulous examination of the IMS is conducted to assess schedule network nodes of convergence, divergence, and critical/near-critical paths. TPMs and metrics are selected and monitored project execution to serve as indicators that help identify shortfalls. This process encourages potential risks to be identified at any time by any stakeholder.

3.6.3   Risk Assessment

The Risk Assessment Process step determines the probability (likelihood), consequence for each risk, and prioritizes the risks based on criteria definitions provided in the CI Risk and Opportunity Management Plan.

3.6.4   Risk Analysis

The Risk Analysis Process determines the optimal approach for handling specific risks and develops a detailed execution plan. A handling method is selected from four options:

1. Assumption (accept the risk without mitigation)
2. Avoidance (change the baseline approach)
3. Transfer, or
4. Control (reduce the consequence severity or the likelihood)

When control is the chosen handling strategy, a burn-down plan is developed that defines who is responsible, the specific mitigation tasks, task start/end dates, predecessor and successor tasks (including relationships to major project events), task closure criteria and the overall risk retirement event. The burn-down plans are treated as specific work packages, included in the IMS, and managed with the same priority as other elements in the program baseline.

3.6.5   Risk Handling

The Risk Handling Process authorizes a risk handling plan for the most critical risk items, provides management reserve funds for execution of these plans, and regularly monitors actual progress against the plans. In addition, the Risk Handling Process provides a systematic evaluation of all risk items. An important element is the tracking of key assumptions, including those for medium and low level risk items even though they may not have authorized and funded risk handling plans. All risks are maintained on the watch list, their status is updated on a regular basis, and the current status of all risk items is reviewed by the Risk and Opportunity Management Board (ROMB) on a regular basis.

3.7   Communication Management

Communications Management is the means by which CI team members, the COL Program Office, and other stakeholders gain insight into program activity. This includes the monitoring, tracking, gathering, and dissemination of information. The objectives of an effective system are:

*   Open communication – up, down, and laterally
*   Influence morale and team spirit
*   Determine current and upcoming activities
*   Verify status
*   Forums for escalating issues and provide resolution

3.7.1   Communication Strategy

Good communication is the primary focus of visibility and is the principal enabler for execution of multi-system/subsystem project integration. Effective project coordination, as well as interface management processes and techniques, are enabled through a robust Electronic Data Interchange (EDI) using a variety of COTS collaboration tools. Communications include project direction, baseline and data control information, status inputs from all project areas, and external communications.

A strong communication strategy recognizes the challenge of ensuring that information is effectively shared in a timely manner within a large, geographically-dispersed team. Well-defined communication channels within the team, with the marine IOs, with the Program Office, and the external community is a necessity. The work teams have charters defining their meetings (including membership and frequency), and working groups are established to facilitate coordination on specific issues (e.g., subsystem interfaces). Other forms of communication within the team include all-hands, technical interchange meetings, and formal/informal reviews.

Communication channels with the OL Program Office are defined based on role. The Project Director is the primary contact point with the Program Office, with contractual issues handled by the Project Manager. Other interfaces with the Program Office occur through involvement with their working groups.

There are also established communications channels with the external community. Some of these channels are the result of teammates participating on standards boards and industry associations. Other channels may be the result of past performance on other contracts or may be newly established ones to gain more understanding of a peering network.

3.7.2   Sources of Information

Information is gathered from multiple sources. Table 3.7.2-1 lists the major sources of information for the OOI/CI Program.

Table 3.2.7-1 Multiple Sources of Information

Sources		
Organizational Charts	Corrective Actions	Program Announcements and News
Work Team Charters	Action Items	CDRL Repository
Decisions	Discrepancy Reports	Program Calendar
Program Information	SE Artifacts	Presentation Archives – TIMs and Reviews
Metrics	Software Engineering Artifacts	Personnel Directory
Schedule (IMP/IMS)	Board/Meeting Agendas and Minutes	Plans, Processes, and Work Instructions
Risk Tracking	Project Orientation	Contractual Documentation
Reference Library	Training Material and Records	OCI Training/Refresher

3.7.3   Communication Techniques

An important element of effective communication is the techniques used. The selected technique must account for the subject being communicated, its priority, and its audience. Common techniques are:

- E-mail
- WebEx
- Video conferencing
- Teleconferencing
- Face-to-face interactions
- Meetings
- Project reviews and events
- Internal reviews
- Project announcements/news
- Project plans/processes/work instructions

Of these, meetings, project reviews/events, and conferences are discussed further in the following paragraphs.

The CI Project Office has defined its regularly scheduled meetings on a monthly cycle as shown notionally in Figure 3.7.3-1, and uses the CI project calendar to manage them and ensure that conflicts between attendees are minimized.

The CI Project Office has defined its regularly scheduled meetings and working groups. These include, but are not limited to, weekly Executive Management and System Engineering Team meetings, weekly Cross-IO systems engineering work sessions, weekly status meetings for the individual work teams, bi-weekly Risk Management and Change Control Boards, and ad hoc working groups discussing intra-IO topics. Additionally, technical interchange meetings (TIMs) and user workshops are scheduled on an as needed basis.
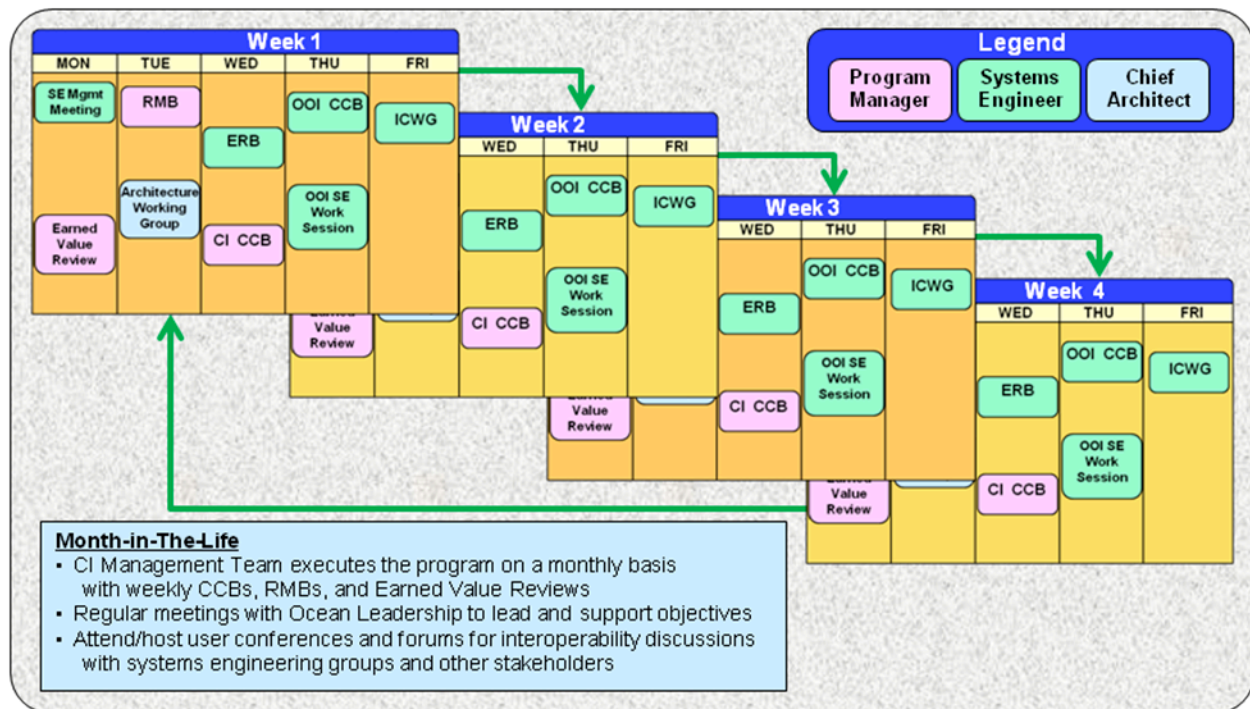
Figure 3.7.3-1 Monthly Cycle of CI Meetings

Ocean Leadership and marine IO personnel are invited to participate in CI meetings as necessary and CI personnel reciprocate as requested.

3.7.4   Technical and Management Reviews

Technical and Management Reviews are formal activities led by either the CI Program Office, the CI Systems Engineering Team, or the OL Project Office. Formal reviews are included in the IMP as events, and through the associated Significant Accomplishment and Accomplishment Criteria, implicitly define the entry and exit criteria for each. These reviews are summarized in Table 3.7.4-1.

Table 3.7.4-1 Summary of CI Project Reviews

Review/Meeting	Purpose	Chair and Key Participants	Frequency
Subcontractor Project Management Review	Review of subcontractor status and metrics to determine if effort is on track. Leading indicators (e.g., CPI, SPI, earned value, risk,) are reviewed to determine what corrective actions need to be planned. Existing action plans and action items are reviewed.	PM (chair), SE, SA, IPT leads	Monthly
Executive Management Team Review	Review of the project's health and status, discussion of external impact, and impact to OOI/CI, and resolution of inter-IO issues	PD(chair), DPD, PM, PS, SE, QM, EPEM	Monthly
Life Cycle Objectives	*Goal:* Definition of what the Cyberinfrastructure design will accomplish • *Focus:* Ensuring that at least one architecture choice is acceptable to the stakeholders • *Stakeholder Commitment:* Building the identified architecture	CI management and work team leads, Program Office, 10 invited stakeholders. SE is chair.	Once per design spiral
Life Cycle Architecture	*Goal:* Definition of the software architecture and technologies needed to implement the Cyberinfrastructure design. • *Focus:* Committing the project to a single viable design of the system. • *Stakeholder Commitment:* Supporting initial	CI management and work team leads, Program Office. SE is chair.	Once per design spiral

Review/Meeting	Purpose	Chair and Key Participants	Frequency
	deployment of the Cyberinfrastructure design.		
Initial Operating Capability	*Goal:* Integration of first production release. • *Focus:* Assembly of a viable system. • Stakeholder Commitment: Going into production.	CI management and IPT leads, Program Office. SE is chair.	Once per design spiral
Preliminary Design Review (PDR)	Review to confirm that the total system detailed design approach satisfies the functional baseline and the total system is ready for detailed design • Conducted to confirm that the total system detailed design approach satisfies the functional baseline and the total system is ready for detailed design. This event captures all the lower-level PDRs in the OOI/CI Segment. • Formal technical review of basic design approach for SIs and HIs • Audit trail from SDR	CI management, Marine IO management, Program Office	Once
Final Design Review (FDR)	Review to demonstrate that the total system detailed design (as an integrated composite of people, product, and process solutions) is complete, meets requirements, and that the total system is ready • Captures all the systems and subsystems FDRs in the same manner as the PDR captures the systems and subsystems PDRs. Conducted to demonstrate that the total system detailed design (as an integrated composite of people, product, and process solutions) is complete, meets requirements, and that the total system is ready for manufacturing and coding • Formal technical review of each HI and SI's design • Audit trail from PDR	CI management, Marine IO management, Program Office	Once

The System Engineer is responsible for organizing, documenting, and reporting all internal project reviews (e.g., LCO, LCA, and IOC during each development spiral). The PM is responsible for incorporating the findings from treviews into the development process. With approval of the Deputy Project Director, all reports are submitted to the Program Office. The project also supports program-level design reviews. The Project Manager is the principal point of contact for that purpose.

3.7.5   Electronic Data Interchange (EDI)

A robust EDI is an important part of project communication strategy. The chosen EDI, Atlassian Jira coupled to Confluence, provides an efficient information distribution method through a Web-based data management system and digital environment. This enables every activity to cost-effectively create, store, access, manipulate, and/or exchange data digitally. It provides collaborative teaming components, interacting with the tools and data resources within the program network. Customizable web-based windows (portlets) present data to the user based on authorization and assigned roles. The environment enables internal and external users to use web-based tool interfaces in order to participate in the team activities in a near real-time manner.

Program data that may reside within the EDI includes contract correspondence, reports, presentations, memos, documents describing the program, lessons learned, management reviews, results of measurement activities, performance reports, change packages, risk information, and project life-cycle data. The EDI is available to all teammates, upon authorization from the Project Manager, to foster collaboration across the team. The EDI is managed and coordinated by the Project Office IPT.

3.7.6   Issue Escalation/Conflict Resolution

The organizational structure facilitates clear communication channels to resolve conflicts and obtain needed information. A standard escalation process is used by every member of the CI Project. When an issue arises, stakeholders at the lowest possible level are involved to resolve it, and the resulting status is provided to the next level work team. When an issue is not readily resolvable, it is escalated to the next higher organizational level until resolution is achieved. This process enables primary stakeholders to be involved with and be informed of issue resolution, and minimizes the number of participants in the resolution process. Management oversight is provided through existing status-reporting channels, which keeps the Executive Management Team informed, and enables it to take action only when necessary. The key is the appropriate balance of management control, team efficiency, and technical expertise.

Issues between the Prime and a subcontractor are resolved by the Project Manager through negotiation with the subcontractor's lead.

If the conflict is not resolved at this level, it is escalated to the Project Director, whose decision is final.

3.8   Configuration Management

Management of changes to the CI requirements, architecture, design, schedule, cost, software, COTS, documentation, and process baselines enables the controlled evolution of the project baseline to better serve the needs of users and stakeholders, and in parallel maintain cost, schedule, and technical quality. The following paragraphs summarize the change management process used by the OOI/CI Project to effectively manage change.

The OOI/CI Project manages all changes to the baseline and artifacts to ensure consistency, traceability, and proper authority. The CMP establishes several control boards (Table 3.8-1) with responsibility at various levels. Those at the project-level (Level 1) are focused on changes beyond the authority of an individual work team, including recommended changes that have impact on other work teams. Work teams at Level 2 use these control/review boards to manage changes within their scope of authority. Details of the change process can be found in the OOI/CI Configuration Management Plan (CMP).

Table 3.8-1 Project-Level Control/Review Boards

Board	Purpose	Chair and Key Participants
CI Change Control Board (CI CCB)	• Overall project authority • Decisions affecting work allocation among team members, and budget and schedule issues • Approves/rejects all changes to the approved program baseline • Focal point for coordination and review of Program Office-initiated changes	PM, PS, EPEM, SE (chair), CA, QM, SSE, SDM. OM, PD and DPD
Risk and Opportunity Management Board (ROMB)	• Authority for evaluating, rating and managing all project risks • Tracks status of each risk and opportunity item and monitors the risk reduction points in the IMS to ensure timely completion	PM (chair), SE, IPT leads (as needed), QM, CA, OM, PS, EPEM, SSA, SDM, Program Office representative

The board with the highest level of authority is the CI Change Control Board (PRB, chaired by the SE. It is the responsibility of this board to approve or reject all changes to the requirements, cost, and schedule baselines. It also approves changes that have an impact between IPTs. Terms of reference for the CI CCB are defined in the CI CMP. The PRB membership includes the Project Scientist and EPE Manager (who represent the stakeholders), the System Engineer, Senior System Architect, System Development Manager and Chief Architect (who represent the system), the Operations Manager (who ensures that changes have minimal impact on operations and maintenance), the Project Director, Deputy Project Director and the Project Manager. Proposed changes may also be submitted to the SL and OOI Change Control Board, and NSF, as specified in the OOI Configuration Management Plan, depending on the impact of the change.

Another project-level board is the Risk and Opportunity Management Board (ROMB). This board is responsible for reviewing all identified risks, status of mitigation plans, and current probability of occurrence. All recommendations for changes to a risk's severity, probability, and mitigation plans require the approval of this board. The RMB is a single board conducted at the project-level. The ROMB is chaired by the PM.

The scope verification effort for the OOI/CI Project begins with the PM, SE, SSA, SDM and IPT leads reviewing the Level 2 Requirements for the OOI System-of-Systems that include:

- L2 Science Questions
- L2 Science Requirements
- L2 Cyber-User Requirements
- L2 Educational Requirements
- L2 Operational Requirements
- L2 Common Requirements

In parallel with this effort the OOI Level 2 Requirements are entered into the Dynamic Object Oriented Requirements System (DOORS), a premier requirements management tool that provides a database for the requirements and their attributes and traceability to subsystems, products, and the teammate assigned responsibility for satisfying the requirement.

A requirements analysis and allocation process examines the Level 2 requirements and allocates them into the Level 3 Requirements for the three systems that comprise OOI that include:

- L3 CG System Requirements
- L3 RSN System Requirements
- L3 CI System Requirements
- L3 CG-RSN Interface Agreement
- L3 CI-CG Interface Agreement
- L3 CI-RSN Interface Agreement

The formal approval of the three Level 3 requirements documents that apply to CI are updated and baselined at each IOC, when all requirements are presented and reviewed, and concurrence is obtained from the stakeholders on them.

The other aspect of scope management is control, which is the responsibility of the PM. The primary source of scope changes is from RFCs or other contract actions issued by the OL Program Office. These are formal, controlled change requests that define the nature of requested changes, documents affected, changes to delivery dates, and any other appropriate information. These RFCs are transmitted through the COTR to the OOI/CI PM. The processing of RFCs and subsequent ECPs is defined in the OL SEMP.

The PM is also responsible for controlling unauthorized scope increases, otherwise known as "scope creep". It is critical to the success of the program that unauthorized or extra requirements be closely managed or eliminated from the work authorization program conduct. The mechanisms for controlling this are via the requirements allocation and management processes, the PRB, the ERB, work team meetings, and design and code walkthroughs. In addition, the milestone reviews provide formal points for assessing and re-baselining the OOI/CI project scope.

The scope control process begins with the review of an RFC or other change request by a work team. Following the technical analysis of the change request, an impact statement is prepared by the SE or designee, and the change request is brought to the ERB for formal review and impact assessment. If the ERB concurs with the assessment, the ROMB reviews the change request for risk impact. After both reviews are completed, the change is forwarded to the PRB by the SE for review and concurrence.

If the PRB agrees with the validity and scope of the change request, a cost estimate is prepared for submittal to the Program Office. Depending on the nature of the change and any specific directions from

them, this estimate can range from a coarse Rough Order of Magnitude (ROM) to a formal quote submitted with full pricing back up.

If the Program Office subsequently approves the change, a formal contract modification must be issued and funding authorized before any work can proceed.

3.9 Education and Public Engagement

A well executed education and public engagement (EPE) program that makes the OOI accessible to a wide range of observatory users is critical to the long-term success of the OOI. The CI IO will play a pivotal role in creating the bridge between observatory data acquisition and delivery systems and a diverse array of audiences envisioned for the OOI. Target EPE users include scientists less familiar with accessing and using online data and databases, graduate and undergraduate students, K-12 and informal educators, and the public.

The CI IO will provide a wide range of resources and services in support of both science and education OOI users. In some instances, these resources and services will be the same for both user audiences. In others, the (TBD) EPE IO will need to create another layer of infrastructure (often a specific user interface) that provides easy access and usability for non-scientist users. The EPE IO's purpose is to enable education projects by designing and building essential infrastructure that will leverage the larger investments in cyberinfrastructure and marine infrastructure. Thus the primary focus of the CI EPE efforts is supporting the EPE IO as it designs, develops and implements infrastructure that will enable users to conduct education and public engagement activities based on data, products, and knowledge generated by the OOI integrated observatory network. Developing EPE infrastructure will occur concurrently (starting in Year 2) with the development and implementation of OOI CI for the research community and requires close coordination between the CI IO (both the EPE team and the CI IPTs) and the EPE IO.

In addition to supporting the EPE IO, the CI IO EPE Team will also work with the OOI Project Office and other IO EPE teams to:

- *Develop Educational Prototypes* including educational games, animations and visualizations that serve as foundational components for future EPE activities and proposals.
- *Participate in Community Workshops* for scientists and/or educators that introduce the OOI and the CI to target user groups.
- *Contribute to the OOI EPE web presence* by developing and updating web products that promote the OOI (e.g. Wikipedia, You Tube, Google Earth).
- Document the development and deployment of the OOI infrastructure including Observing System Simulation Experiments (OSSEs).

The CI EPE team comprises an EPE Manager, a (TBD) EPE liaison between the (TBD) EPE IO and the CI IO, a Communications Manager and an EPE programmer. The EPE Manager is responsible for planning, coordinating and facilitating all CI IO EPE activities, interfacing with the education leads at the OOI project office and other IOs, and establishing connections with external Earth and ocean science education organizations (e.g. COSEE; science centers). Pending NSF/COL allocation of EPE funding to CI, the CI will also designate an EPE liaison who will be responsible for establishing a framework for collaboration between the (TBD) EPE IO and CI including linking the CI and EPE requirements, establishing an interface agreement between the CI and the EPE IO, overseeing communication between IPTs and appropriate EPE IO personnel and facilitating interaction on technical issues. The CI Communications Coordinator will oversee development and updating of the CI website, establish and update the CI web presence (wikipedia, Google Earth, YouTube etc.) and collaborate with the OOI communications team on the intersection between the above tasks and the overall OOI communications efforts. The education programmer will create educational prototypes and other products (e.g. educational games; Google Earth products; animations illustrating the OOI and CI function, etc.)

With approval by the Deputy Project Director, the EPE Manager develops and implements the EPE Plan that provides a roadmap for EPE activities during the project life cycle. The EPE Plan is compliant with the OOI EPE Plan.

4 Project Execution

4.1 Annual Work Plan

With the assistance of other project team members as required, the Project Manager is responsible for completion of an Annual Work Plan that:

- Defines the next year's major planning activities, engineering goals, engineering activities, and milestones through the identification and definition of:
    - "Events" – Program unique value added maturity measurement points such as anchor point milestones (i.e., Life Cycle Objectives, Life Cycle Architecture, and Initial Operating Capability) and increment deliveries
    - "Significant Accomplishments (SA)" – Significant, natural, time-phased, product-oriented activity groupings that support an event such as inception, elaboration, construction, and transition phases
    - "Accomplishment Criteria (AC)" – Standards to judge what must be done to complete an SA
- Includes a master schedule that uses the events, SAs, and ACs as a framework (i.e., the IMS) to integrate tasks and sub-tasks into a Resource Loaded Network (RLN) that states the required budgets and resources to complete the tasks and accomplish the project goals.

The Annual Work Plan is used to modify the scope, schedule, and cost baselines, and hence define the annual Performance Management Baseline (PMB).

The Annual Work Plan is approved by the Project Director and submitted to the COL Program Office for final approval.

4.2 Status Reports

The Project Manager is responsible for preparation of an Annual Report that:

- Gives the key accomplishments in the prior year
- Provides a comprehensive financial report
- States project changes that occurred during the year, including but not limited to, schedule variance, cost variance, schedule adjustments, management reserve allocations, and adjustments to the PMB.
- Summarizes major risk handling activities accomplished in the prior year and identifies the current risk status.

The Project Manager also submits Monthly and Quarterly Status Reports to the OL Program Office. Both of these reports document major accomplishments and project changes, and the quarterly report also includes a financial report.

The monthly and quarterly status reports are approved by the Deputy Project Director and submitted to the OL Program Office for final approval. The Annual Report is approved by the Project Director and submitted to the OL Program Office for final approval.

4.3 Detailed Project Schedule

The Integrated Master Schedule (IMS) structure has Integrated Master Plan (IMP) Events at level 1, Significant Accomplishments at level 2, and Accomplishment Criteria at Level 3. The Detailed Project Schedule consists of the tasks and subtasks from level 4 and lower. Product inception, elaboration, construction, and transition phase activities are laid in at level 4 with the leaf tasks having resources allocated to them and against which earned value is collected.

The Detailed Project Schedule provides a time-based view to support the activities in the Integrated Master Schedule (IMS) and Annual Work Plan, and hence is produced before beginning a development spiral. Because of schedule volatility, the Detailed Project Schedule at and below level 5 is only populated for the immediate future, usually for the next six months. Just before the end date for the current detailed project schedule is completed, it is extended by another six-month period, a continuous "Rolling Wave."

The Project Manager is responsible preparing the Detailed Project Schedule and the Deputy Project Director approves it before delivery to the OL Program Office.

4.4   Performance Management Baseline

The Performance Management Baseline (PMB) defines the performance capabilities required to meet the mission, and is used for Earned Value Management. It is comprised of three elements: scope, schedule, and cost baselines.

*   The scope baseline is defined by the Science User Requirements and the System Requirements that circumscribe the intended purpose of the OOI/CI System, the System Architecture (DoDAF) Documents that define the functionality of the OOI/CI System, and additional scope modifications contained in the Annual Work Plan.
*   The schedule baseline is the Detailed Project Schedule.
*   The cost baseline defines the total cost of providing the necessary capabilities in the Detailed Project Schedule. The Annual Work Plan defines the annual cost baseline.

With approval by the Deputy Project Director, the Project Manager is responsible for preparing and maintaining the performance baseline.

4.5   System Engineering

The system engineering framework used by the project is a tailored version of that defined in the System Engineering Handbook, Version 3 (SEH) issued by the International Council on System Engineering. The SE framework also incorporates the DoDAF standards that define a common approach for software architecture description, development, presentation, and integration that is especially suitable for systems that are implemented in stages.

Fulfilling the anchor point milestones in the spiral model is a key system engineering responsibility. Use of the spiral management model does not alter the function of system engineering, and in fact it becomes the key activity that binds the cyclically-growing system into a coherent whole.

4.5.1   System Engineering Management Plan (SEMP)

The Ocean Leadership SEMP for the OOI Program addresses the subjects traditionally addressed by a SEMP and also addresses subjects traditionally addressed by a Software Development Plan (SDP). The Ocean Leadership SEMP serves as an integrated roadmap for developing and delivering the entire OOI System so the individual IOs are not required to maintain a separate subordinate SEMP. The Ocean Leadership SEMP for the OOI program addresses a series of questions regarding the system deliverables for OL and the IOs:

*   What system will be delivered?
*   What tasks must be accomplished to deliver it?
*   When must each task be started and finished?
*   What is the order in which the tasks must be completed?
*   What are the task dependencies?
*   What are the final acceptance criteria?
*   Who will be responsible for each task?
*   How will each task be carried out?

The SEMP describes all stages in the system life cycle from requirements definition through integration to deployment. The SEMP includes reliability, maintainability and availability criteria. The OL SEMP for the OOI System is incorporated into this PEP by reference. The CI System Engineer is responsible for developing and implementing the OL SEMP as it applies to the CI IO. The SEMP is updated at least annually, and can be expected to evolve through successive development spirals. The CI System Life

Cycle Plan provides a simplified presentation of the spiral development system life cycle and system engineering processes that is intended for CI work team members.

4.5.2   Interoperability Management

The Interface Requirements Specifications in DOORS describe the interoperability of the OOI/CI with the hardware and software elements produced by the two observatory IOs and key external entities, notably IOOS. It links to Interface Control Documents (ICDs) that describe the interfaces with the OOI/CI and the two OOI observatories, and between the OOI/CI and external entities. Interfaces internal to the OOI/CI are negotiated between the System Development Manager and subsystem IPT leads and documented in architecture documents with System Engineer approval. The Interface Requirements Specifications also includes Interface Agreements (IAs) negotiated between the project and the two observatory IOs that establish interface responsibilities. The IAs are negotiated between, and signed by, the cognizant IO system engineers subject to approval by the cognizant IO Project Managers. The Program Office has final approval authority, and resolves any conflicts that may arise. Finally, IAs may be negotiated between the project and external entities under similar conditions.

4.5.3   Integration and Verification Management

The Integration and Verification Plan (IVP) establishes sequences and schedules for integration of the subsystems with each other, with the existing OOI/CI, and with the observatory and external elements at successive development spirals. It also establishes criteria to verify the system by asking "was the system built right?" through establishing that the system requirements have been met. ISO 9126 serves as a framework of verification attributes and criteria. The IVP subsumes test plans (with the exception of the elements in the Validation Plan), and is the responsibility of the System Engineer with approval of the Deputy Project Director. The IVP is implemented by the System Development Manager for internal OOI/CI elements, and by the Operations Manager and System Engineer for final integration and verification. At the end of each integration and verification phase, the System Engineer submits an Integration and Verification Report to the Executive Management Team that includes a Requirements Verification Compliance Matrix.

4.5.4   Concept of Operations and L3 CI System Requirements

With approval of the Deputy Project Director, the System Engineer is responsible for the CI Concept of Operations, Level 3 CI System Requirements, L3 CI-RSN Interface Requirements Specification, and L3 CI-CG Interface Requirements Specification. A Requirements Traceability Matrix maintained in DOORS links the SRD to the Level 3 OOI System-of-System, or Acquirer Requirements. The system requirements are divided into four major categories (functional requirements, performance requirements, common requirements and interface requirements), and then further sorted into categories that are consistent with the OOI/CI architecture and its subsystems to yield Level 4 Subsystem Requirements. The Level 3 CI System Requirements and the L3 Interface Requirement Specifications serve as the top level description of desired OOI/CI capabilities, and are key guides to software developers as the project moves forward.

4.5.5   DoDAF System Architecture Documents

The system architecture is specified using the DoDAF framework. With approval of the Project Manager, all system and subsystem architecture documents are the responsibility of the Senior Architect. The Enterprise Architect tool is used to capture the architecture. This document set replaces the usual System and Subsystem Specifications Documents.

4.5.6   User Documentation

The System Development Manager is responsible to the System Engineer for the production of user documentation for the OOI/CI. He/she may be assisted by selected members of the subsystem IPTs for this activity.

4.6   Validation Management

The Validation Plan establishes criteria to validate the system by asking "was the right system built?" It must include evaluation of the system in the context of the use scenarios that help define the science user requirements, and serves as final stakeholder acceptance of the OOI/CI at each deployment. With approval of the Deputy Project Director, the Project Scientist is responsible for development and implementation of the Validation Plan with support from the System Engineer. At the completion of each validation, the Project Scientist submits a Validation Report to the Deputy Project Director.

4.7   Quality Assurance and Quality Control

With approval of the Deputy Project Director and in coordination with the COL Program Office, the Project Manager is responsible for preparing a Quality Management Plan. He is also responsible for staffing a qualified Quality Assurance Team that audits the engineering deliverables and oversee the quality assurance and quality control process throughout the system life cycle. The Quality Manager is responsible for implementing the Quality Plan.

5   Security Management

The System Engineer is responsible for preparing and implementing a Security Plan that covers all aspects of operational and OOI/CI security for the system, including defining the software and hardware "best practices" (e.g., firewalls, one-time passwords, anti-virus software) that is used to protect against intrusion on a real-time basis and the processes used to define and manage reportable incidents both within the program and at the federal level. It also describes the authorization and auditing policies for the OOI/CI at different levels of access and the ongoing process for ensuring that repositories remain free from external aggression. Compliance with national security requirements is also described. The Security Plan incorporates any additional requirements imposed by the Program Office and NSF.

6   Transition to Operations

6.1   Integrated Logistics Support

Integrated Logistics Support (ILS) defines all of the elements required to support the system throughout its life cycle. It is usually divided into ten components:

- Maintenance planning.
- Supply support.
- Test equipment/equipment support.
- Manpower and personnel.
- Training and training support.
- Technical data.
- Computer resources support.
- Facilities.
- Packaging, handling, storage, and transportation (PHS&T).
- Design interface

The ILS process is fully described in the OL SEMP for the OOI System.

6.2   Operations and Maintenance Management

Operations and maintenance (O&M) management is the process that governs post-deployment operations and maintenance of the OOI/CI. It is governed by the O&M Plan that is effectively a project execution plan for the post-deployment phase extending to the end of the ocean observatory life cycle. The Annual Operations Plan is an annual work plan for operations and maintenance. With approval of the Deputy Project Director and support from the Operations Manager, the Project Manager prepares the

O&M Plan and the Annual Operations Plan. The Operations Manager is responsible for implementing both plans.

6.3 Deployment and Acceptance Management

With approval of the Deputy Project Director and Operations Manager assistance, the System Engineer is responsible for developing Transition to Operations and Commissioning Plans (TTOP and CP) that define the process for OOI/CI deployment at the end of each development spiral and the criteria for its acceptance and commissioning by the OOI Program Office. The Plans describe the documentation that allows the system to make the transition to operations and specify the training required for operations personnel. The acceptance process complies with requirements imposed by, and is overseen by, the OL Program Office, which has ultimate responsibility for commissioning the OOI/CI. The deployment and acceptance process follows on the integration, verification and validation processes described in the Integration and Verification Plan and Validation Plan, respectively. Deployment is carried out by the Operations Team and the System Integration Team, with oversight by the System Engineer. The System Engineer is responsible for delivering a deployed system to the Project Manager at the end of each development spiral, and prepares a Deployment and Acceptance Report for submission to the OL Program Office with approval of the Deputy Project Director after each development spiral.

Appendix A-1.   Glossary of Abbreviations and Acronyms

Acronym	Definition
AC	Accomplishment Criteria
ACEIT	Advanced Cost Estimating Integrated Tools
ACWP	Actual Cost of Work Performed
AI	Action Item
ATP	Authority to Proceed
AUW	Authorized Un-priced Work
BAC	Budget At Completion
BCR	Baseline Change Request
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
C&A	Certification and Accreditation
CA	Control Account
CAIV	Cost as An Independent Variable
CAM	Cost Account Manager
CAP	Contractor Acquired Property
CCB	Change Control Board
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CFE	Customer Furnished Equipment
CFP	Customer Furnished Property
CFSR	Contract Fund Status Report
CI	Configuration Item (Do Not Use – See HWCI, HI, CSCI, or SI)
CI	Cyberinfrastructure (Do Not Use – See OOI/CI)
CIO	Chief Information Officer
CLIN	Contract Line Item Number
CMMI®	Capability Maturity Model Integration®
CMP	Configuration Management Plan
CMT	Core Management Team
COE	Common Operating Environment
COL	Consortium for Ocean Leadership
CONOPS	Concept of Operations
COTS	Commercial Off The Shelf
CPI	Cost Performance Index
CPR	Cost Performance Report
CSCI	Computer Software Configuration Item
CWBS	Cost Work Breakdown Structure
DID	Data Item Description
DOORS	Dynamic Object Oriented Requirements System
DR	Discrepancy Report
EAC	Estimate at Completion
ECP	Engineering Change Proposal
EDI	Electronic Data Interchange
EMD	Engineering and Manufacturing Development
EMT	Executive Management Team
ERB	Engineering Review Board
EV	Earned Value
EVMS	Earned Value Management System
FAR	Federal Acquisition Regulation
FOC	Full Operational Capacity
FQT	Factory Qualification Test
FY	Fiscal Year
HI	Hardware Item
HWCI	Hardware Configuration Item

Acronym	Definition
I&T	Integration and Test
IA	Information Assurance
IAP	Information Assurance Plan
IBR	Integrated Baseline Review
ICD	Interface Control Document
ICWG	Interface Control Working Group
ILS	Integrated Logistics Support
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IOC	Initial Operational Capacity
IOOS	Integrated Ocean Observing System
IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
IS	Information Systems
IT	Information Technology
KPR	Key Program Reviews
LCA	Life Cycle Architecture
LCC	Life Cycle Cost
LCCE	Life Cycle Cost Estimate
LCO	Life Cycle Objective
LRE	Latest Revised Estimate
MA	Mission Assurance
MOSA	Modular Open Systems Approach
MP	Metric Plan
MPP	Master Phasing Plan
NSF	National Science Foundation
O&S	Operations and Sustainment
OOI/CI	Ocean Observing Initiative/Cyberinfrastructure
PCB	Program Control Board
PDR	Preliminary Design Review
PEP	Project Execution Plan
PIA	Program Independent Assessment
PKI	Public Key Infrastructure
PM	Project Manager
PMB	Performance Management Baseline
PMP	Program Management Plan
PMR	Program Management Review
POC	Point of Contact
PSM	Program Subcontract Manager
PSRR	Pre-Ship Readiness Review
PWA	Primary Work Authorization
QA	Quality Assurance
QAP	Quality Assurance Plan
QFD	Quality Function Deployment
QPI	Quality Performance Index
RE	Responsible Engineer
RFC	Request for Change
RFP	Request for Proposal
RMP	Risk Management Plan
ROM	Rough Order of Magnitude
ROMB	Risk & Opportunity Management Board
SA	Significant Accomplishment
SAT	Site Acceptance Test
SCA	Subcontract Administrator
SCM	Supply Chain Management

Acronym	Definition
SDP	Software Development Plan
SDR	System Design Review
SDRL	Subcontractor Data Requirements List
SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SI	Software Item
SMP	Subcontract Management Plan
SMT	Subcontract Management Team
SOO	Statement of Objectives
SOW	Statement of Work
SPI	Schedule Performance Index
SRR	System Requirement Review
SSDR	System/Segment Design Review
SWA	Secondary Work Authorization
TCPI	To Complete Performance Index
TIM	Technical Interchange Meeting
TPM	Technical Performance Measurement
TRD	Technical Requirements Document
TRR	Test Readiness Review
TVP	Test and Verification Plan
UB	Undistributed Budget
UIS	User Interface Specifications
VDT	Visual Display Terminals
WBS	Work Breakdown Structure
WG	Working Group
WLI	Watch List Item
WP	Work Package