National Science Foundation
Panel Report

on the

Final Design Review

of the

Ocean Observatories Initiative (OOI)

November 2008

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 Information removed has been replaced by the insertion of "[redacted]".

Executive Summary

An expert Panel on behalf of the National Science Foundation (NSF) conducted a Final Design Review (FDR) of the Ocean Observatories Initiative (OOI) at NSF on November 12 – 14, 2008. The Panel scrutinized the proposed baseline, design maturity, and the project readiness to undertake construction. Based on these evaluations, the Panel discussed its findings in executive session and generated the following summary observations and conclusions:

1. The Ocean Observatories Initiative (OOI) continues to demonstrate the potential for significant broader impacts and the intellectual merits are outstanding.

2. The OOI project team is to be congratulated on the excellent progress made since the Preliminary Design Review and the overall state of readiness of the project planning documentation.

3. The OOI scientific goals, requirements, and interfaces are mature and the designs are consistent with design requirements. The overall design maturity is adequate to start construction on the proposed schedule, July 2010. If construction funding is available earlier there are specific long-lead procurements and other opportunities identified that could be pursued to reduce project cost and schedule risk.

4. The capability and depth of the OOI project team is impressive. Almost the entire management and technical leadership team is in place and there is a record of successfully addressing the issues and challenges that have arisen so far during the development phase of the project.

5. OOI is ready to receive MREFC funds after some minor adjustments to the project baseline. The Panel identified a limited number of actions that should be completed prior to initiating construction. The detailed performance measurement baseline is generally well developed and should prove to be a useful tool for measuring progress and future planning.

6. The OOI project baseline should be revised in light of the NSF "zero cost overrun" policy for MREFC projects. The Panel recommends a project completion date that includes additional explicit schedule float following the early completion date and a larger contingency budget providing additional confidence that that the baseline scope can be successfully completed. Contingency plans should include both financial contingency and scope contingency.

7. The Consortium for Ocean Leadership (OL) is directly accountable to the NSF for the successful construction of the OOI project and delivering the approved scope, within budget and on schedule. Key responsibilities include selecting qualified staff to lead the OOI project, establishing effective project advisory bodies, and maintaining cognizance of project issues through ongoing oversight and support. OL has the additional responsibility to engage the ocean science communities, educators, and the public in OOI.

8. OL very recently selected a new OOI Program Director for the OOI construction phase. The new director should lead the process of revising and finalizing the project baseline completion date, contingency budget, and funding requirements. This effort should be well advanced within two months to support NSF's internal review and approval process.

9. OL should ensure that the OOI advisory committee mechanism is effectively used during preparation of the final baseline.

10. The OOI project team has developed project management processes well suited for the size and complexity of the project. These tools are ready to be used to manage future work and changes to the performance measurement baseline and project documentation.

11. Impressive progress was made following the Preliminary Design Review on the definition of design requirements, interface definition, and risk identification and management processes. The time available in the pilot phase leading up to release of MREFC funding should be used to make further improvements in these areas.

12. The engineering and technical plans are sufficiently mature to produce solid cost estimates, schedules, and identification of risk factors.

13. Operations are planned to begin in the first year of the OOI construction project and will ramp up to steady-state operations in 2016. This is an excellent approach as it ensures that elements of the OOI scope are brought into operation as they are complete, ensuring: a) on-going construction and operations activities are informed by actual operational experience; and, b) early exploitation of the construction investment for science, education, and public engagement.

14. The Operations & Maintenance (O&M) plans and cost estimates are reasonable and supported by relevant experience. Special process spares are procured with O&M funding during construction and stored for future deployment during maintenance.

15. Issues of critical interest to the scientific community are data availability and data lifetime. A valuable high level near term milestone would be an early demonstration of what this actually means in practice. The Panel recommends establishing this milestone as part of the final baseline.

1 Introduction

The National Science Foundation (NSF) requested a Final Design Review (FDR) of the Ocean Observatories Initiative (OOI) by a non-advocate, expert Panel. The review was conducted at the NSF on November 12 – 14, 2008. The FDR charge, agenda, and names of the Panel participants are provided in the appendices. The Panel scrutinized the proposed baseline, design maturity, and the project readiness to undertake construction. A major input to the Panel was the set of conclusions from an NSF Panel that reviewed the OOI project cost estimates and schedules during the week prior to the FDR. Some members of the FDR Panel also served on the cost and schedule Panel.

Written material provided in electronic form by the OOI project to the Panel in advance of the meeting was examined, oral presentations were heard, and subgroups of the Panel met with appropriate members of the OOI project team to assess all elements of the OOI project. The format of the review followed the pattern of reviews of other large projects with time devoted to plenary presentations followed by expanded breakout sessions with individual groups for in-depth discussions. In these breakout sessions, the details of progress and plans were examined. Based on these evaluations, the Panel discussed its findings in executive session and generated the written summary conclusions and observations given below. Details of the assessment of the progress on the OOI project are given in the full text of this report.

2 Response to Charge Questions

The Panel reviewed the major elements of the OOI Project and developed a response to the major questions included in the charge. The responses to the charge are provided below:

Is the OOI, as outlined by the OOI Project Execution Plan (PEP), ready to receive MREFC funds?

Panel Response: *The OOI is ready to receive MREFC funds following some minor adjustments to the project baseline. The OOI project baseline should be revised in light of the NSF "zero cost overrun" policy for MREFC projects. The panel recommends a project completion date that includes additional explicit schedule float following the early completion date and a larger contingency budget providing additional confidence that that the baseline scope can be successfully completed. Contingency plans should include both financial contingency and scope contingency.*

Has the project credibly defined what OOI will cost to construct and operate?

Panel Response*: The OOI cost estimates for construction and operations are reasonable and credible.*

Are the risk planning and budget and schedule contingency proposed sufficient, such that there is a sound basis for a future request by NSF to Congress to obtain construction funding for this project?

Panel Response: *The OOI risk planning is well advanced. The Panel concluded that contingency, targeting 30%, and schedule float on the overall project, on the order of 5-10%, is appropriate for the OOI project. This would provide a sound basis for a future request by NSF to Congress for the OOI.*

Has the project appropriately planned the activities from FDR to project construction start? Are there recommendations for further planning or risk reduction activities that should be accomplished before NSF makes MREFC construction funding available to its awardee?

Panel Response*: The OOI project is currently in a "Pilot Period' that began on October 1, 2008, and is projected to continue until June 30, 2010, after which MREFC funding is expected to be available. The activities in the Pilot Period are limited by the amount of pre-MREFC funding available and restrictions on the use of that funding. The Panel concludes that these activities are appropriately planned and prioritized. There are additional opportunities for further risk reduction if some MREFC funding is available before July 2010. If construction funding is available earlier OOI can pursue specific long-lead procurements and other opportunities that would further reduce the overall construction project technical, cost and schedule risk.*

Are engineering and technical plans sufficiently mature that they can be used to produce robust cost, risk, and schedule estimates?

Panel Response: *The engineering and technical plans are sufficiently mature to produce solid cost estimates, schedules, and identification of risk factors.*

Are the project management processes (systems engineering, quality assurance, configuration management, financial and project controls and construction safety) fully developed?

Panel Response: *The OOI project team developed project management processes well suited for the size and complexity of the project. These tools are ready to be used to manage future work and changes to the performance measurement baseline and project documentation.*

Is the proposed operations budget complete and reasonable? Are there risks not included in the plans that should be considered in projecting future operating costs? Has the project done a best effort in projecting uncertainties associated with extrapolating a future operating budget, so that there is reasonable confidence that OOI can be operated at $55M/yr (in 2015 dollars) when completed?

Panel Response: *The proposed overall operations budgets are reasonable and supported by relevant experience. The risks associated with operations are identified and the planning assumptions appropriate. Limited operations are planned to begin in the first year of the OOI construction project and will ramp up to steady-state operations in 2016. This is an excellent approach as it ensures that elements of the OOI scope are brought into operation as they are complete and longer-term operations plans are informed by actual operational experience. The anticipated steady-state operations budget of $55 million/year (2015 dollars) should be sufficient to maintain and operate the OOI infrastructure.*

Does the OOI continue to demonstrate intellectual merit and enable broader impacts?

Panel Response: *The OOI continues to demonstrate the potential for significant broader impacts and the intellectual merits are outstanding.*

3 Work Scope

3.1 Cyberinfrastructure (CI)

3.1.1 Findings

The CI team has made tremendous progress since the PDR in collecting and using requirements to develop a strong CI architecture and create a comprehensive set of documents outlining their plans for developing, testing and deploying the CI infrastructure. The CI team is strong and well focused, has a good management structure and appears to be in command of the overall CI architecture.

The Panel believes that the basic architecture developed by the CI team is well constructed and takes good advantage of open-source technologies. It provides ample opportunity for innovation and evolution. The team has done a thorough study of planned open-source technologies, including their future roadmaps. Together with the prototyping effort, this should help mitigate risk.

The CI team obtained user requirements and "use cases" from a series of user requirements workshops held during 2008 and successfully translated them into CI requirements. Still, many of the requirements are potentially somewhat open-ended, and areas where scope has been specifically limited (e.g. supplying computing power for modeling) are not documented. Since requirements growth is the most common cause of information systems project failure, this is an important area to address.

The uncertainty in CI requirements is not surprising given the inherent uncertainty in projecting user requirements so far into the future. However, the requirements that are documented have been triaged in the DOORS database to provide a prioritization. We expect that the plan for a two-year pilot will further clarify them, provided user feedback is properly incorporated. In addition, the spiral development process is designed to manage the risk of ill-defined requirements. Thus effective execution of the Pilot Program should put the CI team in a position to begin construction in 2010.

The Panel finds that there were insufficient performance criteria to evaluate the cyberinfrastructure end-to-end. These should be derived from the science requirements and additional user input as necessary. Particular criteria should include, but are not limited to, data latency, distribution throughput and computational requirements for creating standardized derived data products.

3.1.2 Comments

The Panel is concerned about the complexity and number of components planned for the eventual cyberinfrastructure. Other projects have found that these factors can make integration difficult and expensive and give rise to undesirable emergent behaviors that are difficult to predict and make the system difficult to test. While we do not have specific recommendations to offer, the Panel suggests that the CI team evaluate whether additional specific risks should be assigned at the higher levels of integration and verification.

The Panel feels that, given the rapid pace of technological evolution, the staffing level of 2.0 FTEs for development during the O&M phase limits the ability of the CI to keep up with the technology curve.

3.1.3 Recommendations

1. Identify requirements that are potentially open-ended and add specifics so that they are well bounded and testable. In some cases, language may be needed to clarify that potentially ambiguous requirements (e.g. supplying computing power for modeling) are deemed out of scope for the CI.

2. The CI project team should develop more complete performance criteria, taking into consideration science user requirements.

3. Incorporate and document *continual* user involvement in the Pilot Program (e.g., beta users) and the initial spirals, particularly with respect to clarifying user requirements to make them less open-ended.

3.2 Coastal/Global Scale Nodes (CGSN)

Direct charges to the CGSN FDR sub-committee:

Is sufficient information provided for non-standard construction components (e.g., non-COTS, high risk items) to provide a high level of confidence in the construction and deployment of these components?

Panel Response: *Yes, the planned engineering lifetime design, test, and evaluation tasks appear sufficiently mature to have confidence in the construction and deployment of these items.*

Has the CGSN IO reached parity with the other IOs with respect to integration, implementation and quality control?

Panel Response: *Yes, the FDR documentation and the experience of the CGSN team assure us that the CGSN IO is on par with the other IOs.*

3.2.1 Findings

The Panel found no fundamental planning or preparation hurdles preventing readiness for the CGSN to proceed to construction. There are some details that will be addressed during the Pilot Period. If MREFC funds become available earlier than otherwise anticipated, the Panel feels that the CGSN IO could begin construction at any time. The CGSN IO has assembled an outstanding team to direct the coastal and global components of the OOI. The team was very well prepared for the Panel and highly responsive to requests for additional information. The team demonstrated that numerous cutting-edge technologies are being incorporated into the CGSN that will help transform the nature of observational oceanography.

The CGSN IO team demonstrated substantial and appropriate progress since the PDR. The team's approach of utilizing Requests for Information from COTS developers along with technology oriented vendor workshops is ideal. White papers have been a particularly useful tool for documenting the progress of the CGSN IO in addressing high-risk components of their essential goals. The CGSN IO's plans for the Pilot Period, the construction phase, and transition to full operational status are appropriate and well developed. The Panel found the CGSN cost estimates to be reasonable and supported by relevant experience.

The panel has three main categories for comments and resulting recommendations directed toward the CGSN IO:

(i) Continue to update risk status and evolving system requirements;
(ii) Improve documentation describing the interface between CGSN and CI; and,
(iii) Improve the documentation, which would enable a fully informed competition for future operation of the CGSN by new IOs.

The panel believes that many, if not most, of these recommendations apply across the OOI.

3.2.2 Comments

CGSN IO representatives at the review noted that additional progress had been made on strategies for addressing risk-prone technologies since release of the white papers. For example, some CGSN subsystem design criteria continue to evolve as a result of Request for Information responses from potential manufacturers and now differ from those stated within the Level 4 Requirements (e.g., wind turbine power output capability and standard power system battery storage capacity.) Refinement of these requirements is an ongoing process that will continue through the Pilot phase and into construction. The Panel noted that the calculation of likely mooring loss did not include the recently destroyed Real-Time Seismic Monitoring Station mooring.

CGSN and CI representatives demonstrated a common vision for interfacing and releasing data and for the general functionality of software that will help control CGSN sensors. However, there was relatively little written documentation outlining the details of how this will work. In addition, the present Final Network Design document may overemphasize the role of Autonomous Underwater Vehicles (AUVs) in dominating CI's efforts to facilitate adaptive sampling. The Panel was also concerned that the openness for rapid data release and sharing expressed by the IO representatives was not adequately represented in written system requirements. Similarly, we did not see written documentation as to how the remote control of CGSN platforms and sensors would be managed. The Panel believes that the necessary documentation will be developed in the course of this project.

The Panel was concerned that sufficient documentation be available for other groups to fairly compete for future O&M opportunities. An example of the need for a level playing field in competing for the O&M was raised with regard to the impact of proprietary technologies (e.g., stretch mooring hoses). Another aspect of a complete documentation trail is to ensure a functioning and stable change control process, which is not currently in place. Also, the likely costs of moving the Pioneer Array have not yet been` estimated.

3.2.3 Recommendations

1. Continue to update white papers focusing on risk-prone and evolving technologies and periodically release new versions to document how risks are being addressed and how new and alternative technologies are evolving.

2. Periodically update top-level system requirements to ensure they reflect the current state of expectations for the various subsystems.

3. Compose and periodically document the technical interface between CGSN and CI summarizing the flow of data and metadata, the state of sensor control software, and the protocol for remote control of CGSN sensors essential to the interface between these two IOs.

4. Broaden discussion in future releases of Final Network Design and other overview documents and presentations to emphasize the adaptive sampling possible through control of all relevant platforms, not only or primarily AUVs.

5. Update system requirements to ensure completely open and real-time release of both un-calibrated and preliminarily calibrated data.

6. Create and routinely update user manuals describing how components of the CG are operated. Provide sufficient detail such that other IOs have the information needed to reasonably compete to operate components of the CGSN in the future.

7. Compose and periodically update a glossary for the CGSN.

8. Work with OL to develop and implement a clear policy on intellectual property, especially with regard to how it will affect the ability of other IOs to compete for operation of the CGSN in the future.

9. Start using the change control process.

10. Estimate and document the likely additional costs beyond normal annual O&M for moving the Pioneer Array to its next location and clarify which costs are included in the O&M estimate and which have to come from elsewhere (R&RA).

3.3 Regional Scale Nodes (RSN)

3.3.1 Findings

The Regional Scale Nodes (RSN) IO has made substantial progress, with the majority of the PDR issues now addressed. The Panel believes that the RSN Project Execution Plan is now sufficiently mature to allow RSN to receive MREFC funds.

The procurement strategy has matured and the RSN has completed the RFP process for the Primary Infrastructure contract. Initial feedback from the RFP process supports the cost estimates for this major element of the RSN. The Panel was encouraged to see that the RSN is taking the initiative to pre-lease cable station space and conditionally reserve, for the future deployment of the cable, landing station dark fiber and beach landing civil works. The RSN Risk register has been updated since PDR and accurately reflects the risks associated with a sub-sea cabled infrastructure installation.

Three “high” risks remain on the register (by order of negative project impact):

a. The Medium Voltage Converter (MVC) development;
b. Vertical Profiler technology; and
c. Limited Primary Infrastructure vendors.

Since PDR, the RSN Team has confirmed the existence of additional MVC developments that provide a broader pool of technology solutions that could fully satisfy the technical requirements. Additionally, the team has identified an existing, partially compliant, MVC solution that could be used in the event the primary MVC development encountered setbacks. This “fallback” solution would support the planned science at OOI commissioning but would have limited growth potential at certain science sites. There would be schedule impacts associated with the “fallback” MVC solution that have not been fully defined. There have also been positive developments in the vertical profiler technology that should be reflected in the Risk Register as mitigating the risk.

The RSN and the Panel recognize the limited vendors available in the marketplace for implementation of the primary infrastructure.

The FDR RSN Testing and Integration plan has changed significantly from PDR and now allows for the integration of the Primary and Secondary infrastructure and the related Cyberinfrastructure components prior to the deployment of the Primary Infrastructure. Additional resources have been allocated to ensure that the test and integration effort is complete and robust.

The transition plan from Implementation to O&M is logical and contains sufficient FTE resources to manage the expected workload. The steady state O&M projections were examined in detail and found to be reasonable and complete. RSN is establishing an asset management and workflow control system to support operations (Observatory Management System, OMS).

The RSN IO has identified a number of risk reduction activities for the Pilot Period. Should MREFC funds be released during the Pilot period, the following risk reduction tasks were identified:

a. “Intent to Proceed” for the Primary infrastructure contract to allow MVC development to start;
b. node site surveys to reduce the risk associated with extension cable specification and Secondary infrastructure installation; and,
c. contracting with a permitting agency to advance the permit application process.

The RSN confirmed that MREFC funded tasks completed in the Pilot period are part of the construction cost baseline.

The following risk reduction tasks were identified for R&RA funds during the Pilot period:

a. White Paper on ROV cable laying capability to reduce installation risk;
b. O&M processes development; and
c. Vertical Profiler development.

3.3.2 Comments

Requirements have been refined and a concerted effort has been made to ensure that technical specifications reflect the expected design life of the observatory elements. A review of the Level 3 and 4 requirements did, however, reveal some inconsistencies and instances of over-specification that need to be addressed.

A number of activities are underway that will help reduce the technical risk of the MVC and vertical profiler development but these are not captured in the Risk Register. The Risk Register does not highlight the impacts of the risk mitigation plans on the initial science plans nor on other IOs.

It was not clear to the Panel that a common commissioning process & standards exist within the OOI effort.

The O&M plan would benefit from a document that defines priorities of preventive and corrective maintenance activities. It was not clear to the Panel what the Ocean Leadership strategy was to mitigate the financial impact of a "catastrophic" failure of the RSN. The Panel was also concerned that the level of "recapitalization" of the RSN physical assets may be different from the other IOs. The Panel was unable to find a documented description of the Command and Control framework that governs the operational interactions between the RSN IO, CGSN IO and the CI IO.

3.3.3 Recommendations

1. Review all Level 3 and 4 requirements for consistency and ensure that requirements match the projected design life.

2. Examine the RSN Risk Register and confirm that it correctly reflects recent successful risk mitigation activities.

3. Ensure the RSN Risk Register reflects the impacts of the risk mitigation plans on the initial science plans and other IOs.

4. The RSN would benefit if monies are released in the Pilot Period that could be used to progress MVC design/development to help reduce this risk early in the construction phase.

5. Establish a common commissioning process and standards across the OOI and ensure that responsibility for commissioning is assigned to designated members of the respective System Engineering groups.

6. Establish a document that defines maintenance priority policies.

7. Ensure that Operations plans include "Catastrophic Event" mitigation plans.

8. Ensure the RSN annualized asset recapitalization approach is consistent with the other OOI elements.

9. Create the Command and Control framework documentation and drawings.

10. Continue to focus Pilot Period activities on risk reduction tasks.

3.4 Education and Public Engagement (EPE)

3.4.1 Findings

The Panel finds that EPE effort has made enormous strides since PDR. Overall the draft RFP provides adequate detail for bidders regarding drivers, requirements, management expectations and deliverables. The MREFC restrictions and budget ceiling are clearly described along with the need to leverage existing cyberinfrastructure. The RFP clearly lays out the articulation between the EPE effort and the rest of the project. The RFP should allow the OOI to select an IO with capabilities to build a robust EPE infrastructure, and some minor additions should ensure that the infrastructure is capable of delivering the education experiences that OOI envisions. As currently planned, the six- to nine-month RFP process brings the EPE IO into OOI as late as one month prior to MREFC.

Since PDR, a cross-organization team has done an excellent job integrating the EPE effort into the larger OOI project. Past concerns (expressed in the PDR report) have been laid to rest, and once the RFP is awarded and the interface agreements are in place, the EPE IO will be on a par with the other IOs. Specifically, the EPE effort has drivers, requirements and deliverables analogous to those of the other IOs. EPE drivers map to science drivers; user requirements integrate with cyberinfrastructure user categories and requirements. EPE has fleshed out a work breakdown structure including project management, education systems engineering, education subsystems development and implementation, and incorporated Level 2 EPE requirements in DOORS.

EPE goals and requirements are appropriately scoped for the available budget. Based on essential principles for ocean literacy and other earlier work, the EPE effort narrowed their scope to focus on two major audiences—post-secondary education and training including K-12 teachers and "free-choice" learners with an emphasis on increasing participation and diversity in the ocean science community. OOI acknowledges the need to leverage strengths and resources of other efforts, for example, COSEE that directly address K-12 students. The EPE team reviewed the budgets of several other cyber-based programs, i.e., IRIS, PRISM and COOL classroom, as a means of verifying the accuracy of their budget estimates.

3.4.2 Comments

Since PDR, OOI has made great strides in articulating the education drivers and education user requirements and in writing the EPE RFP. Positive steps towards broadening community involvement in the OOI include involving members of the larger ocean science education community in two development workshops and excluding existing IOs from the RFP competition.

Members of the other IOs show a genuine enthusiasm for and interest in EPE. This enthusiasm has translated into a number of activities that serve as examples for what is possible in OOI. The EPE liaisons and the fractional FTE funded in each of the other IOs indicate a real commitment to integrate efforts across OOI to accomplish the EPE goals.

Several issues emerged regarding MREFC and O&M. The cross-organization team needs clarification about the operating rules during O&M ramp up and the level of funding anticipated for EPE O&M and they also need to develop requirements for the O&M budget regarding staff responsibilities, both technical and educational—promoting the availability of the

EPE toolkit and the public databases particularly among diverse developers. An education user proposal process should facilitate developer access to what is most likely a new idea in science education, i.e., a user facility.

3.4.3 Recommendations

1. Include a brief vision, which includes a description of desired experiences for users in the EPE IO RFP. For example, there are various interpretations of "investigative learning." Clarity will guide the work of the IO to promote OOI interests.

2. Include some indication in the RFP and EUR of the responsibilities of the EPE IO during O&M to help ensure that the education toolkit is actually used. Just because it exists does not mean it will be used.

3. Add a user requirement to explicitly address toolkit adaptations that will allow users to work within IT constraints imposed by schools, libraries, museums and other institutions.

4. Develop an education user proposal process adapted from and integrated with the science user proposal process.

5. Clarify the amount and availability of O&M funds as EPE components are commissioned during the MREFC phase.

3.5 Systems Engineering (all components)

Direct charges to the Systems Engineering sub-committee:

Does the systems engineering process clearly and accurately define the OOI system and subsystem requirements and present a process for verifying compliance to those requirements?

Panel Response: *Yes. There were a number of systems engineering and related project management processes reviewed that are based upon industry standards. The requirements flow-down has been captured systematically in the DOORS database that will enable systematic flow-down checks on requirements. Detailed requirements can be traced back to high-level requirements. Some of this has been done, while others have pointed out some potential disconnects. These disconnects will be easy to find and trace with the system that has been set up. The overall plan for verification is also sound and can be used in conjunction with the DOORS database for testing and verification planning ranging from component, to sub-system- to system and finally overall commissioning.*

Are there reasonable interface agreements for the project to succeed? Are the agreements appropriately defined? Are there significant risks that have not been accounted for within the interfaces that remain to be defined?

Panel Response: *Yes, at the top level, but more detail or references to the detail needs to be added. Short concise Interface agreements exist between each of the performing organizations that detail who is responsible for what aspect of the major interfaces among these groups. We found some evidence of interface details in various design or other project* *documentation, but they are not easy to trace for the purpose of clearly seeing all of the critical interface decisions. There are also placeholders for interface details in a variety of documents that are blank at this time. We cannot tell which ones are critical, though most seem that they will be easy to fill out and largely be relatively simple in the end. We have a recommendation below to evolve this more completely during the pilot phase over the next two years, which we believe is adequate time and a good opportunity to clarify and document the critical interfaces.*

Systems Engineering leadership was able to articulate a clear vision for their role in the program and, in general, provided specific examples to demonstrate implementation of the documented processes. The team contains an excellent cross-section of key, talented people from the various organizations, including several members that represent the science community, which support and make up the OOI team. They appear to communicate well and often within this Integrated Product Team.

The Systems Engineering Team is staffed at the appropriate level and has been successful in developing and documenting Systems Engineering processes for the project; including populating the DOORS database with system requirements.

Examples of plans in which Systems Engineering led or played a key role include:

a. Systems Engineering Management Plan
b. Change control
c. Well-documented escalation plan with identified responsible individuals
d. Risk control
e. Configuration control
f. Testing and verification organization and plans
   - component to sub-system and sub-system to system
   - culminating in overall commissioning plans
   - detailed plans to be developed during early construction phase
h. Earned Value Management Plan
i. WBS (basis for tying schedule, cost and work descriptions in a consistent manner)

The team has made good progress working with project scientists to convert science goals into requirements. We do have two areas, Risk Management and Interface Control, with specific observations, comments, and recommendations:

3.5.1 Risk Management Plan

3.5.1.1 Observation

The Risk Management Plan developed by the project is well thought out, thorough and follows industry wide best practices. The many risks have been reduced through prototyping done to date. The pilot program over the next two years will offer a good opportunity for risk reduction prior to the construction program start. Given this plan, we do believe the program is well positioned for the start of construction from a risk perspective. There are some minor adjustments outlined below, with one of them viewed as an immediate action (comparing risk exposure to contingency).

3.5.1.2 Concern

There is a minor inconsistency between the wording and figure 2-1 describing the overall flow, which is an industry standard method, and the remainder of the document. The figure refers to "Opportunities" but there is no reference to this elsewhere in the plan.

We suggest adding "Opportunities" to the risk management process and plan:

a) Add short discussion of Opportunities to encourage active efforts to look for cost savings. This is a simple addition that is already referred to in Figure 2-1 in the Risk Management Plan. Re-title to "Risk and Opportunity Management".
b) Add candidate opportunities to the risk list. The team has already presented a candidate list of reductions in scope, some of which may not impact the scientific scope, which would be a start. These had decision dates already determined.

Following the plan as written can be a large job and may be too large of a cultural shift to implement in a practical manner, though the intentions are admirable. Reviewing all risks every two weeks, for example, will be very time consuming and may tend to result in a loss of focus on the key risks and culling for changes. Generating a mitigation plan for each of these is not practical. Suggestions to simplify implementation of the risk management plan include:

a) Review "high" and/or "medium" risks, or "top ten" risks and opportunities and any items changing on the bi-weekly schedule proposed.
b) Review complete list on longer time scale (quarterly is suggested?)
c) Eliminate the programmatic risk category (out of control of the team)
d) Track the Operational and Support risk separately as these apply to risk of the operations performance and cost.

The risk ratings are not quantified in terms of the cost impact. There is a discussion of contingency needed for high risks, but it is not directly related to the impact and likelihood ratings, making it impractical to sum up the total risk exposure (probability weighted risk). We suggest:

a) Convert technical and schedule risk into cost impact using the existing ranking table (Table 4.2 from the RM Plan). Add cost impact for any items not yet analyzed. Refine for mid to high exposure numbers as appropriate. Add reasonable opportunities.
b) Eliminate programmatic, support or operations risks that are out of the control of the program (operations/support risks and opportunities can be summed separately to assess operations cost risk).
c) Work to develop mitigation plans for any risks at or above the medium level, if a cost effective mitigation plan can be developed.
d) Mitigation plans should be implemented where the cost of mitigating is less than the probability-weighted risk (risk exposure – see next comment).
e) Risk Submission Forms should be reviewed to ensure consistency between proposed risk mitigation strategies and project execution plans (e.g. the designated high risk RSN mooring profiler risk reduction strategy calls for design/prototyping/testing a deep water system while the PEP calls for purchasing a COTS product and relying on factory acceptance testing).

Risk ratings should be more fully assessed for their impact to other systems and overall science implications. For example, the high voltage power system for RSN is identified as a high-risk item with the mitigation plan to provide a low voltage lower power supply with a future upgrade. There is limited discussion as to the impact the loss of available power has on the ability to perform science or its potential impact to other systems such as AUVs and sensors, although the OOI Project Team indicated that there is no initial impact to RSN capability or forecasted power requirements at the commissioning date. The potential impacts for all risk mitigation actions should be more thoroughly defined and timelines established for critical decision points to be fully incorporated into the project plan. Once certain systems are procured or constructed, it could be time and cost prohibitive to make alterations to accommodate system mitigations.

3.5.1.3 Recommendations

1. Complete the risk exposure analysis (impact x likelihood in terms of dollars).

2. Sum the total of Risk and Opportunity exposure (probability weighted) for technical, schedule and cost.

3. Compare to contingency. Assess additional “head room” required for unknown-unknowns. Use this to verify or adjust committee recommendation of 30%.

3.5.2 Interface Control

3.5.2.1 Observations

The Systems Engineering Management Plan (SEMP) indicates that Interface Agreements (IA) contain the requirements between subsystems. A review of the IAs indicates that although they are a good collection of definition of responsibility between subsystems, they fall short on specific interface details and requirements. There was little indication that ICDs or inclusions of additional details in the IAs are key elements of the pre-construction plan. More broadly, the review committee as a whole recognized that, although the subsystems understood their own requirements, there was little documented evidence that the interface requirements had been agreed upon between subsystems. It is apparent that a number of the interface requirements are distributed in the various subsystem documents and therefore the complete set of interface requirements is not easily identifiable for subsystem developers.

3.5.2.2 Concerns

The concern is that the interface requirements between subsystems need to be agreed upon and accurately and easily identified to minimize incompatibilities and integration issues when hardware, software and networks are integrated during the construction phase. Additionally, the responsibility for subsystem performance needs to be clearly delineated and resources identified for resolving issues during the construction phase.

Major or common interfaces such as to instrumentation that would be subcontracted should be emphasized. Separate Interface Control Documents are recommended for these, though they may reference other standards/documents. Use of the N2 diagram to define major hardware, software, or other interfaces that should be documented is encouraged.

3.5.2.3 Recommendations

These should be completed during the pilot phase and prior to construction.

1. Complete or create Interface Control Documents for organizational responsibilities and key/common subsystems or components (such as instrumentation) prior to the start of the construction phase. Systems engineering must take ownership for interfaces, working with the subsystems to ensure agreement on all sides.

2. Prior to construction, SE should complete the CI Interoperability Plan as outlined in paragraph 4.1.4.2 in the SEMP to document the "interfaces between all system and subsystem elements internal to the CI, between the CI and the OOI marine observatories, and between the CI and external entities".

4 Cost Estimate, Schedule, and Funding

See Appendix C, OOI Cost and Schedule Review Report – November 2008

5 Project Management and Operations

5.1 Findings

Overall Readiness to Proceed to Construction - From a project management perspective, the OOI project is ready to proceed to start of construction following some minor adjustments to the baseline. The design is well developed for this stage of the project and is consistent with the presented schedule and budget. The project management control systems are ready for full implementation. The Consortium for Ocean Leadership (OL) organization appears prepared to meet NSF expectations to deliver the facility construction phase within plan while also appropriately managing ocean science community expectations for this long-awaited project. The OOI project key leadership staff is largely in place and reflects the depth and breadth of experience needed to successfully manage this complex project. Risk management, including mitigation activities underway in the pre-execution pilot phase, is on-going within a methodology that provides management with generally useful information upon which to manage contingency needs and make decisions and tradeoffs during the construction phase. Required environmental health, safety and permit planning is on track. The project team has responded effectively to the major concerns raised during the Preliminary Design Review. Some recommendations are noted below.

Project Organization, Governance, and Oversight - The OOI Project Execution Plan (PEP) for the OOI facility identifies that construction is managed through a cooperative agreement between the NSF and the Consortium for Ocean Leadership (OL), a not-for-profit Limited Liability Corporation of member institutions. OL acts for NSF in managing all aspects of the OOI project. The NSF-OCE Program Manager for OOI, who provides overall program oversight and funding through the Major Research Equipment, leads the NSF organization for OOI (Figure 1) and Facilities Construction (MREFC) and OOI project associated O&M accounts, and whom the NSF Large Facilities Office supports in planning the OOI project. The OL organization for OOI (Figure 2) is led by the Program Director for Ocean Observing Activities, who has been approved for this position by NSF and has primary responsibility to NSF for executing the OOI project.

A Director of Engineering and other OL staff who interface with the IOs on engineering, business, and contract administration activities support the Program Director. The PEP states that a Project Advisory Committee for OOI reporting to the Executive Board of OL will provide overall strategic planning and science leadership for the OOI facility.

OL has made competitive awards to 3 of 4 planned Implementing Organizations (IOs or “sub-awardees”) who will perform the OOI scope of work. IOs currently exist for the Cyber-infrastructure (CI) at the University of San Diego; the Regional Scale Nodes (RSN) at the University of Washington; Coastal Global Scale Nodes at the Woods Hole Oceanographic Institute; with a future IO for Education and Public Engagement to be awarded later in FY2009. The OOI project scope at each IO is managed by a Principal Investigator (PI) and a Program Manager (PM) and associated support staff. Plans for managing the subprojects are flowed down from the OL –level plans to each IO through the sub-award contract.

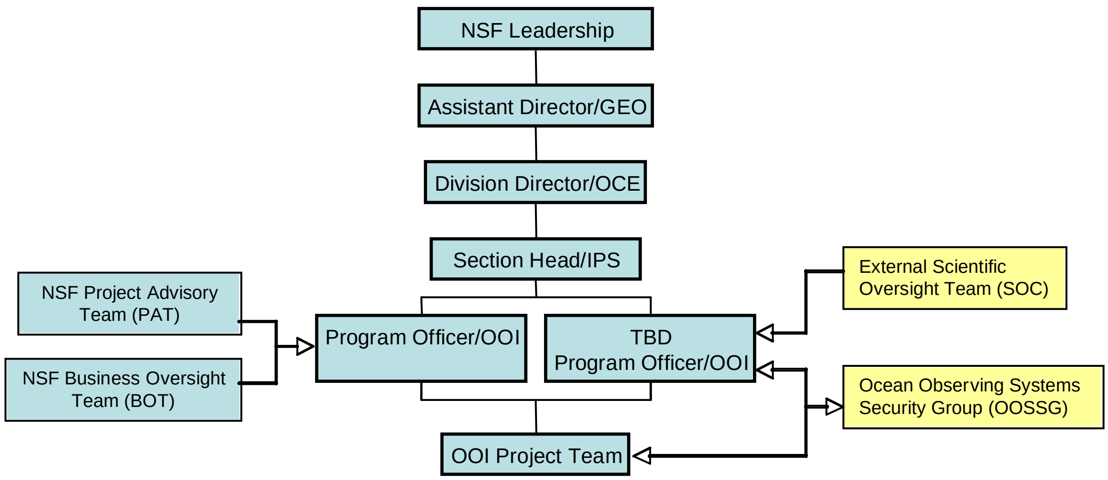

Figure 1. NSF Organizational Chart for the OOI
(Blue boxes are NSF; yellow boxes are external personnel)

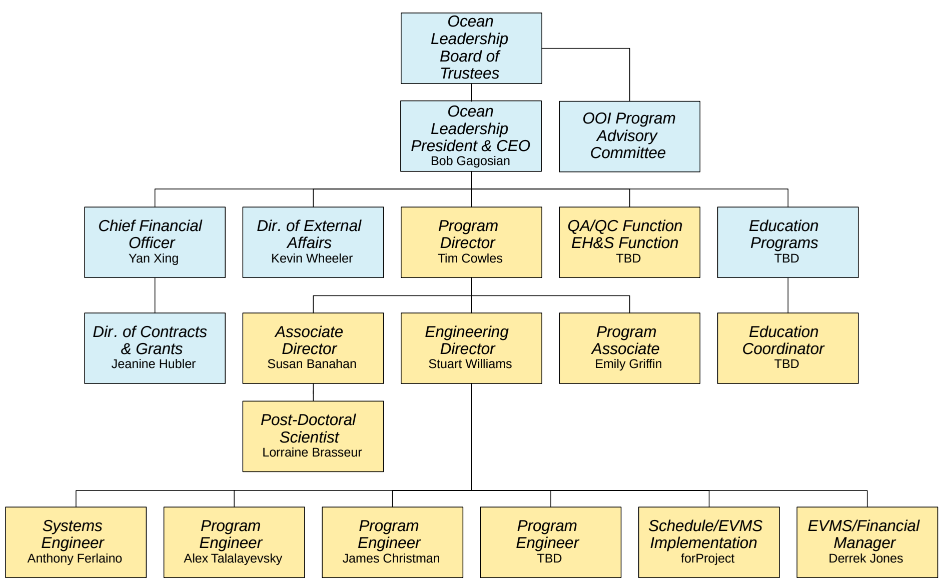

Figure 2. OOI MREFC Organizational Chart (Blue boxes are OL personnel working part-time on OOI; yellow boxes are OL personnel working full-time on OOI)

Sub-awardee Management - OL manages the IOs through cost reimbursement, no fee sub-agreements based on 1-year periods of performance with annual renewable options through the end of the 5-year project construction schedule and extending through 5 years of operations. Sub-awards in execution will be incrementally funded for MREFC and O&M activities from OL based on OL-approved annual work plans and paid to IO invoices that are reconciled to project milestones throughout each annual performance period. The IO subcontract contains provisions for the IOs to notify OL when incremental funding reaches 75% and to request additional needed funding. The sub-agreement also provides for the ability of OL to withhold funds in the event of non-performance or deficiency in deliverables. The OL Program Director is in frequent contact with senior managers at the IO institutional hosts to coordinate resource support and issue management.

Staffing - OL and the IOs have developed an integrated staffing plan consistent with the resource loaded schedule for the duration of the project; this plan includes the staff required to execute the MREFC construction as well as the O&M associated aspects that begin very early in the OOI project (Figure 3).

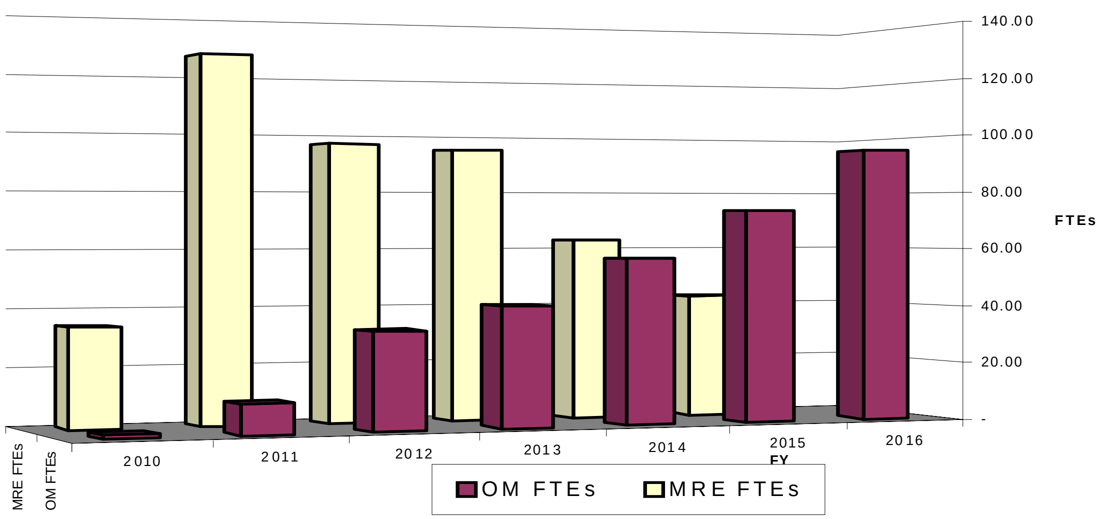

Figure 3. OOI Labor for MREFC and O&M

The review panel discussed the potential risks associated with achieving the sometimes aggressive staff ramp-ups needed in some areas of the project and the OL-IO team explained their strategies, including recent experience that gives them confidence that they can acquire and bring on-board the needed assets quickly and make them productive rapidly. The IO PIs noted a principal strategy is to use a number of fractional staff that can be quickly converted to full-time when funds are made available to the OOI project, which appears flexible in the current situation where the project start has been delayed based on federal funding. The impending transition of the OL Program Director was noted, and the newly selected Program Director participated in this review. Some positions in the OL hierarchy remain unfilled pending receipt of federal funds, and the project has adopted a strategy, supported by Program R&R funds, that focuses the core team on risk-reduction activities during a pilot period before start of construction, now planned for July 2010.

Management Plans and Systems - In accordance with their PEP, OL has procured, tailored and implemented an ANSI-748 standard-based commercial EVMS that integrates with the project scheduling tool (MS Project) and is capable of providing all needed functionality to measure progress and identify variances to budget and schedule plans. Control Account Managers, who will provide the first-line control of budget and schedule within the IOs, have not yet been identified. The project management control systems being implemented for OOI appear to be of standard form familiar to experienced project managers and PMCS staff. There exists a formal OOI Quality Assurance and Quality Control Plan for OL, the requirements of which are nested with and flow down to the IO QA/QC plans. The OL QA Manager role (when filled) will report directly to the President of OL to maintain independence in the function. The OL QA plan lists a number of specific QA and QC activities that require the involvement of the QA Manager, with significant emphasis on audits and process evaluation. The OL Acquisition Plan is also a formal document that prescribes specific strategies for major IO acquisitions plus processes for OL to provide risk-based monitoring and oversight of the performance of the IOs as they execute their acquisition strategies through the procedures in place at their host institutions. A formal Configuration Management Plan (CMP) exists and defines the roles, responsibilities and authorities of the OOI project team in the configuration management process. The CMP addresses IO needs for drawing/software standards, software versioning and control, documentation assurance and Configuration Management. The CMP describes the contents of the technical data packages associated with each system from Final Design through the "as-built" and commissioned stages. The CMP also includes procedures for the important areas of requirements management and design reviews plus Change Control Board (CCB) roles, responsibilities and membership. The CCB process as described considers all effects of technical changes on cost and schedule as well as design. Thresholds guiding approval authority of the CCBs are established.

Environmental Health & Safety - A formal EH&S plan exists, is under document control and provides procedures for OOI EH&S as a means to identify, eliminate or control environmental health and safety risks throughout the OOI lifecycle of design, construction and operation. The OL EH&S Manager (yet to be hired) will be independent of the OL Project Director and will report to the President of OL. The PI and PM at each IO have responsibility by the plan for the total safety performance of their subproject. For the most part, the existing safety programs at the IOs, such as the marine safety standards governing operation of the UNOLS fleet, require no modifications for OOI specific requirements. ES&H milestones that affect permits are included in the schedule. NEPA actions for OOI have been addressed through a programmatic Environmental Assessment and are planned to be followed up at specific OOI sites.

Risk Management and Contingency - The PEP Risk Management Plan describes a useful approach to identifying and dispositioning risks to the OOI project technical, cost and schedule baselines. The project team has developed an extensive list of potential risks and determined the potential impacts and contingency budgets required to mitigate the risks of high concern. Contingency has been determined for discreet WBS elements for budget, schedule and performance related risks. These risks were developed bottom-up through template algorithms that classify risks by consequence and impact as "low," "medium" and "high." Contingency funds are held and managed centrally by OL. The PEP states that the project will maintain a nominal contingency balance of 25% of the work-to-go within each annual work plan. An anticipated risk-based profile of contingency use has been developed by OL and appears appropriately balanced across the project duration (Figure 4.). [Figure 4 redacted]

The project risk-based contingency budget presented for the review totals [redacted] approximately 21.7% and 24.8% (with NSF Management Reserve) of the Total Estimated Cost of construction. The project integrated master schedule critical path currently shows one month of float on the project completion date.

Operations - Initial planning for operations has been extensive, given the need to initiate some O&M funded activities very soon following start of construction. NSF plans to commit extensive O&M funding during the execution phase (Figure 5) [Figure 5 redacted] in order to ensure that O&M spares and other maintenance needs are acquired most efficiently and ready to support commissioning and full operations upon systems turnover. Following the PDR, the OOI design was released from non-technical constraints with the caveat to be supportable on an initial O&M budget of $55M (in dollars escalated to 2015). The committee explored the sensitivity of the final design to this expected funding level and determined that the final design has not incorporated any undue risks based upon this O&M cap. An Operations and Maintenance Plan exists and describes the O&M processes being implemented by the IOs and includes the methods for adding proposed future instruments. Maintenance will be prioritized through annual work plans for planned activities that will be endorsed by a Facilities Operations Group; emergency maintenance is foreseen as event-driven, but with some pre-planned quick-response scenarios. The maintenance plan accounts for modified designs post-CDR and as a result of recent experience (MARS medium voltage converter).

5.2 Comments

Project Organization, Governance and Oversight - The PEP calls for annual (at a minimum) reviews of the OOI project by NSF and OL. With the significant scope, associated cost estimate, the very distributed management of the OOI project and the extensive degree of separation of the funding agency (NSF) from the performance of the work in the IOs, a process (consistent with the expected fast pace of construction) for NSF to assess overall project as well as OL performance is essential but not in place. The membership of the current PAC does not include expertise on project management, procurement, industrial or other non-scientific aspects of large construction project execution. The reports needed from the management systems to allow effective management assessment of performance metrics and trends require further development to be fully effective in the execution phase. The roles of some current ad hoc but useful management groups, including key line managers at OL, the IOs and perhaps NSF who may constitute the Integrated Project Team, have not been formally defined within the organization.

Sub-awardee Management - The NSF Cooperative Agreement with OL requires that any new, i.e., not already in an approved annual procurement plan, subcontract exceeding $250,000 must be reviewed by the NSF Program Official and permission given to proceed to award; however, this requirement is not included in the sub-awardee contracts. There are no terms within the sub-award statements of work that specify formal organizational arrangements for the host institution oversight of the OOI work at the IOs. OL managers plan to provide full funds annually for approved IO annual work plans, an approach that may reduce OL flexibility in shifting funds to match the pace of work across the project or to accelerate schedule.

Management Plans and Systems - OL has recognized that the extensive involvement of research institutions in the OOI project in non-traditional (for them) project management roles within the IOs indicates a strong need for OL to ensure high-quality selection and training of capable support staff (e.g., Control Account Managers) on the application of the PMCS across the project. The OL Quality Plan does not specify specific OL QA involvement in the critical process of vendor qualification that will largely be carried out in the IOs. The CMP does not require Program Director involvement or participation in the CCB, including for those changes that require referral to NSF for decision. This top-level OL presence is also desirable to ensure that the top management of OL can appropriately balance the impacts of proposed technical, cost and schedule changes.

Risk Management and Contingency - The risk-based contingency budget is considered adequate but not generous. The risk analysis indicates that known, higher category risks if they materialized in large numbers could significantly deplete the contingency budget leaving little headroom for the inevitable unknown issues. Some impacts associated with a potential "marching army" associated with schedule delays were not included in the plan. The distributed and diverse nature of the project indicates that some level of "unknowns" likely exists within the project construction estimate and integrated schedule. The NSF has adopted a "no cost overrun" approach to the OOI project. All of these factors indicate that the project should take all reasonable steps to closely review the cost estimate against requirements in order to increase the centrally controlled budget contingency and explicit schedule float prior to construction start. [Note: See recommendation from the Cost/Schedule report.]

Operations - The O&M plan and the ultimate readiness for commissioning and turnover is very dependent on the O&M funding provided during the construction period.

5.3 Recommendations.

5.3.1 Organization and Oversight Recommendations

1. Institute a non-advocate, external review process to assess on at least a semi-annual basis the performance of OL and the broader OOI project in meeting the cost, schedule and performance objectives of the OOI project.

2. Assess OL PAC membership, expertise and structure to provide the project management, procurement, industrial and technical experience needed to assist in oversight during construction and preparation for operations.

3. Define the membership, roles and responsibilities of the Integrated Project Team.

4. Include the OL Program Director appropriately in the CCB structure.

5. Include within IO sub-award contracts any flow-down requirements on limitations of authority and provisions to ensure formal institutional oversight of OOI work.

5.3.2 Contingency Recommendation

1. Take steps to increase the budget contingency balance prior to starting construction, with a target of 30%. Assess the schedule risks in conjunction with the program establishment of a project complete date to provide 5-10% explicit float to the end-of-project milestone.

Appendix A. Final Design Review Charge

Charge to the Ocean Observatories Initiative
Final Design Review
November 12-14, 2008
National Science Foundation

The National Science Foundation (NSF) is conducting a Final Design Review (FDR) of Ocean Observatories Initiative (OOI) to ensure that the OOI project plans are fully ready for construction, and that there is a high degree of confidence that the facility scope proposed can be delivered within the parameters defined in the project baseline. NSF has implemented a "zero cost overrun" for its MREFC projects, so that the baseline budget defined must be sufficient to cover the needs of the project. Any unanticipated project needs will be dealt with through project scope reductions. NSF requests the external review committee advise NSF on the sufficiency of the baseline planning to meet this policy and provide assistive recommendations in the panel review report. This review will take place at NSF from November 12-14, 2008.

The FDR Panel will scrutinize the projected readiness of the project to undertake construction, assessing project management and the technical status through this stage of development, planning for conducting the remaining work, including work during the intervening time between this review and anticipated construction start (anticipated mid-2010 pending NSB approval), network construction, deployment, and commissioning and eventual operation of the network. Note that a full operational readiness review for the OOI will be conducted at a later date as the OOI moves to full operation. The Panel will also review progress made by the OOI Project Team in response to directions and recommendations given to the project by NSF following the Preliminary Design Review.

Specifically, the FDR Panel will review the major elements of the OOI Project as fully elaborated in enclosures (1) and (2). Considering the stated criteria, the panel should answer the following questions:

- Is the OOI, as outlined by the OOI Project Execution Plan (PEP), ready to receive MREFC funds?
- Has the project credibly defined what OOI will cost to construct and operate?
- Are the risk planning and budget and schedule contingency proposed sufficient, such that there is a sound basis for a future request by NSF to Congress to obtain construction funding for this project?
- Has the project appropriately planned the activities from FDR to project construction start? Are there recommendations for further planning or risk reduction activities that should be accomplished before NSF makes MREFC construction funding available to its awardee?
- Are engineering and technical plans sufficiently mature that they can be used to produce robust cost, risk, and schedule estimates?
- Are the project management processes (systems engineering, quality assurance, configuration management, financial and project controls and construction safety) fully developed?
- Is the proposed operations budget complete and reasonable? Are there risks not included in the plans that should be considered in projecting future operating costs? Has the project done a best effort in projecting uncertainties associated with extrapolating a future operating

budget, so that there is reasonable confidence that OOI can be operated at $55M/yr (in 2015 dollars) when completed?
- Does the OOI continue to demonstrate intellectual merit and enable broader impacts?

NSF has organized a separate cost/schedule review and panel for the OOI Project on November 6-7, 2008. The cost review panel will evaluate the OOI project construction cost and schedule elements at a detailed level and the cost/schedule panel chair will report their findings to the FDR panel on Day 1 of the review. Operations costs will not be reviewed by the cost and schedule panel and are included as part of this FDR charge. This review, along with guidance from the OOI Program Officer and Deputy Director for Large Facilities Projects in the BFA office, will assist the FDR panel in answering the following questions:

- Is the proposed OOI total project budget complete, reasonable and appropriately described? Is there a sound basis of estimate that was informed by a thorough understanding of market conditions? Is there a sound basis for all escalation factors used?
- Are there any outstanding risks and uncertainties? Is the risk management plan reasonable, and do you have high confidence that the budgeted contingency is adequate to deliver the proposed project scope within the planned schedule and budget?
- Is the proposed project schedule reasonable, and does the proposed schedule contingency provide the project with sufficient schedule float to manage schedule risks?
- Do the proposed plans represent an optimally cost effective approach to construction? For example, is the proposed funding profile technically limited by the rate at which the project can accomplish technical work? Is the critical path optimal to the needs of the project?

Additionally, NSF requests that the FDR panel address the following specific questions related to successful project completion:

Project Management

- Is the project optimally organized to place authority, accountability and responsibility in appropriate positions? Is the project governance structure reasonable and does it include adequate community representation?
- Has the design been reasonably developed to define a final cost and schedule for the OOI project?
- How well are the project risks identified, analyzed and mitigated?
- Have Configuration, Quality and Safety (ES&H) Management Plans for this construction effort been properly developed with sufficient staffing plans?
- Is there a sufficient plan for integrated environmental compliance and regulatory management? Is the permitting effort for the project appropriately scoped and scheduled, with sufficient schedule contingency?
- Is there a reasonable system developed for project control and financial management including contingency and change management, particularly across interfaces?
- Do project team members understand how to use the developed project management systems and are they working in a transparent mode of team operation?
- Has the project responded to the recommendations provided by NSF from previous reviews?

Systems Engineering (all components)

- Does the systems engineering process clearly and accurately define the OOI system and subsystem requirements and present a process for verifying compliance to those requirements?

- Are there reasonable interface agreements for the project to succeed? Are the agreements appropriately defined? Are there significant risks that have not been accounted for within the interfaces that remain to be defined?

Cyberinfrastructure (CI)

- Is the workscope for construction fully identified, quantified and prioritized?
- Is there a workable plan for tracking and assessing the construction of CI to assure that it satisfies planning estimates?
- Is the CI development sufficiently integrated/coordinated with the construction/deployment of the marine assets?
- Is the budgeted contingency for CI appropriately derived and matched to the needs of the project? Is anything significant missing?
- Is end-to-end CI performance and maintenance sufficiently addressed?

Coastal/Global Scale Nodes (CGSN)

- Is sufficient information provided for non-standard construction components (e.g., non-COTS, high risk items) to provide a high level of confidence in the construction and deployment of these components?
- Has the CGSN IO reached parity with the other IOs with respect to integration, implementation and quality control?

Regional Scale Nodes (RSN)

- Are risks unique to the RSN sufficiently identified, analyzed, and mitigated?
- Do RSN integration, testing, deployment, and commissioning plans accurately reflect the challenges of the infrastructure?

Education and Public Engagement (EPE)

- Do the EPE effort and the draft EPE IO RFP provide sufficient information to optimize the capabilities of the OOI for EPE efforts as well as adhere to MREFC restrictions?
- Are the EPE drivers, requirements, and objectives appropriately integrated into the larger OOI project?
- Are the EPE goals and requirements appropriately scoped for the available budget?

Operations (all components)

- Is the commissioning and transition to operations clearly and sufficiently described? Is the scope, budget, duration, and process for commissioning and transition to operations appropriately defined?
- Does the project have an reasonable final concept of operations and is this supported by the operations budget?

Panel Report

The FDR panel report will inform NSF's future request for project funding. The report should respond to each section of the charge and we request that a draft of the report be submitted at the end of the review (November 14th) to the Project Team for fact checking. Any comments on the draft must be submitted to NSF by November 19 through the OOI Program Manager who will distribute them to the Panel. The final FDR report from the panel should be submitted to NSF by December 1, 2008.

Enclosure 1
Final Design Review Criteria as refined from the NSF Large Facilities Manual

1. Final construction-ready design: delivery of designs, specifications and work scopes that can be placed for bid to industry-requires:
    a. Key functional (science, system and sub-system) requirements and performance characteristics, including internal interfaces and interconnections
    b. System architecture and equipment configuration-including how the OOI will interface with other systems
    c. Operational concept
    d. Reliability criteria, analysis, and mitigation
2. Tools and technologies needed to construct the project
    a. technical maturity of critical components (including core sensors)
        i. Industrialization of key technologies needed for construction (made consistently-not necessarily COTS)
    b. Overall development and production schedule (within resource loaded schedule) of outstanding components in pre-construction phase, including
        i. Milestone reviews
        ii. Design reviews
        iii. Major tests
3. Project execution plan including
    a. Project organization/governance including
        i. Organizational structure (tied to WBS-roles, responsibilities, reporting)
        ii. Governance, including advisory structure
        iii. Completion of recruitment of key staff and cost account managers needed to accomplish the project
        iv. Managing sub-awardees
    b. Acquisition-Acquisition plans, sub-awards and subcontracting strategy-includes
        i. Competition strategy
        ii. Types of contracts to be awarded
        iii. Contractor(s) responsible for developing and implementing the system, where feasible
    c. Internal and institutional oversight plans, advisory committees, and plans for building and maintaining effective relationships with the broader research community that will eventually utilize the facility to conduct research
    d. Education and outreach plans
    e. Environmental compliance (NEPA)
    f. Plans for transitioning to operational status
    g. Configuration control plans
    h. Working with interagency and international partners
        i. Finalization of commitments with interagency and international partners
4. Fully implemented Project Management Control System, includes:
    a. Baseline version of resource-loaded schedule
    b. Mechanisms to generate reports-using EVMS-on monthly basis and use as a management tool
    c. Path dependencies, schedule float, and critical path are defined

5. Updated budget and contingency, including risk analysis, presented in a detailed WBS format with WBS dictionary defining scope of all entries
    a. Refined bottom-up cost and risk estimates and contingency estimates
    b. Refined description of the basis of estimate for budget components
        i. Majority of cost estimates derived from external information
        ii. Basis of estimates integrated in WBS dictionary/cost book
    c. Refined project risk analysis and description analysis methodology
        i. Risks include cost escalation and volatility in OMB escalators, etc.
    d. Refined contingency and contingency management (budget, scope, schedule)
        i. Prioritized scope
        ii. Integration of prioritized scope in schedule and cost (including O&M for upscope)
6. Fit-up and installation details of major components and commissioning strategy
    a. Systems integration
    b. Testing and acceptance
        i. Number of tests
        ii. Criteria for entering into testing
        iii. Exit criteria for passing test
        iv. Where test will be conducted
    c. Commissioning
    d. Operational readiness criteria-by component and by project
7. Plans for QA and ESH-reporting and mitigation
8. Updated operating estimates

Enclosure 2
Project Execution Plan requirements per NSF Large Facilities Manual
Appendix 3 of http://www.nsf.gov/pubs/2007/nsf0738/nsf0738.pdf

PROJECT MANAGEMENT COMPONENTS OF A CONSTRUCTION-READY PROJECT EXECUTION PLAN

Essential components of a construction-ready Project Execution Plan, common to most plans for construction of large facilities, are listed below, as an example of the extensive nature of the pre-construction planning that should be conducted prior to expending MREFC funds to execute the project. Additions or alterations to this list are likely, due to the unique nature of each specific project. While many of the listed topics cannot be substantively addressed at the earliest stage of project planning, it is important that project advocates are aware, at the outset, of the full scope of pre-construction planning activities that should be undertaken and the consequent pre-resources required. As the project matures through Conceptual Design, Preliminary and Final design, these topics become correspondingly well defined.

- Description of the research objectives motivating the facility proposal
- Comprehensive statement of the science requirements to be fulfilled by the proposed facility (to the extent possible identifying minimum essential as well as desirable quantitative requirements), which provide a basis for determining the scope of the associated infrastructure requirements;
- Description of the infrastructure necessary to obtain the research objectives
- Work breakdown structure (WBS)
- Work breakdown structure dictionary defining scope of WBS elements
- Project budget, by WBS element
- Description of the basis of estimate for budget components
- Project risk analysis and description analysis methodology
- Contingency budget and description of method for calculating contingency
- Project schedule (and eventually a resource-loaded schedule)
- Organizational structure
- Plans and commitments for interagency and international partnerships
- Acquisition plans, sub-awards and subcontracting strategy
- Project technical and financial status reporting, function of the PMCS, and description of financial and business controls
- Project governance
- Configuration control plans
- Contingency management
- Internal and institutional oversight plans, advisory committees, and plans for building and
- maintaining effective relationships with the broader research community that will
- eventually utilize the facility to conduct research
- Quality control and quality assurance plans
- Environmental plans, permitting and assessment
- Safety and health issues
- Systems engineering requirements
- Systems integration, testing, acceptance, commissioning and operational readiness
- criteria
- Plans for transitioning to operational status
- Estimates of operational cost for the facility

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Appendix B. Final Design Review Agenda

November 11, 2008

PM

6:00-7:30	Pre-review panel meeting	Westin Hotel Lobby

November 12, 2008 — ***Room***

AM

8:00–8:30	Morning refreshments	*NSF-555(II)*
8:15-9:00	Executive Session I	*NSF-555(II)*
9:00–9:15	Welcome and Introductions (NSF/Panel Chair) • Meeting agenda; goals of review	*NSF-555(II)*
9:15–9:30	NSF Presentation • OOI History • Funding Status and Projection	*NSF-555(II)*
9:30-10:30	OOI Network Overview (OOI Project Team) ▪ Scope ▪ General cost and schedule ▪ Governance-internal and external ▪ System engineering and requirements	*NSF-555(II)*
10:30-10:45	Break	
10:45-11:30	OOI Network Overview (OOI Project Team) ▪ Scope ▪ General cost and schedule ▪ Governance-internal and external ▪ System engineering and requirements	*NSF-555(II)*
11:30-12:00	Report out by Cost/Schedule Panel Chair	*NSF-555(II)*

PM

12:00–1:00	Lunch - Executive Session II	
1:00-4:00	Breakout Session I-Network Design (break within breakout session)	
	▪ Cyberinfrastructure o Sub-system Requirements o Architecture o Maturity assessment o Implementation-high level cost, schedule, management	*NSF-390*
	▪ Coastal/Global Scale Nodes o Sub-system Requirements o Scope	*NSF-380*

        - Maturity assessment
        - Implementation-high level cost, schedule, management
    - Regional Scale Nodes *NSF-370*
        - Sub-system Requirements
        - Scope
        - Maturity assessment
        - Implementation-high level cost, schedule, management
    - Education and Public Engagement *(Lisa Rom)* *NSF-791*
        - Scope
        - RFP Assessment
        - Integration
    - Project Management *NSF-555(II)*
        - Project organization/governance/oversight
        - Sub-awardee management
        - Staffing
        - PMCS
        - Acquisition/Quality
        - ESH
        - Configuration control
    - Systems Engineering *NSF-310*
        - Testing and Acceptance
        - Commissioning
        - Quality Control-technical
        - Change Management-technical
        - Risk Management-technical
        - Interfaces

4:00-4:45 Executive Session III *NSF-555(II)*

4:45-5:30 Plenary Session: Panel to present questions and concerns to the project *NSF-555(II)*

team to be addressed at the start of day 2

November 13, 2008

AM
8:00-8:30 Morning refreshments

8:10-8:30 Executive Session IV *NSF-555(II)*

8:30-9:00 Plenary Session: Project Team reports on panel questions and concerns *NSF-555(II)*

9:00-9:45 Operations Overview (OOI Project Team) *NSF-555(II)*
- Concept of operations
- Transition to operations
- Operations cost estimates

9:45-10:00 Break

10:00-12:30 Breakout Session II –System Implementation

- o Cyberinfrastructure *NSF-370*
    - o Risk Analysis
    - o Systems Integration (rotating in)
    - o O&M (rotating in)
    - o Education integration (rotating in)
- ▪ Coastal/Global Scale Nodes *NSF-380*
    - o Risk Analysis
    - o Systems Integration (rotating in)
    - o O&M (rotating in)
    - o Education integration (rotating in)
- ▪ Regional Scale Nodes *NSF-365*
    - o Risk Analysis
    - o Systems Integration (rotating in)
    - o O&M (rotating in)
    - o Education integration (rotating in)
- ▪ Project Management/System Engineering (if needed) *NSF-555(II)*

PM

12:30-1:30 Lunch

1:00-1:30 Executive Session V *NSF-555(II)*

1:30-230 Continue Breakout Session II and/or Special Breakout Session to *NSF-370,380,365,555(II)*
address remaining Panel questions/concerns

2:30-330 Executive Session-Subcommittees *NSF-370,380,365,555(II)*

3:30-5:00 Executive Session-Full Panel-report generation planning; identify outstanding issues *NSF-555(II)*

5:00-5:30 Plenary Session: Panel to present questions and concerns to the project team to be addressed at the start of day 3 *NSF-555(II)*

November 14, 2007
AM

8:00-8:30 Morning refreshments

8:10-8:30 Executive Session- report generation planning; identify outstanding issues *NSF-390*

8:30-9:30 Plenary Session: Project Team reports on panel questions and concerns *NSF-110*

9:30-12:00 Continue Breakout Session II and/or Special Breakout Session to *NSF-370, 380, 390, 110*
Address Remaining Panel Questions/Concerns

PM

12:00-1:00 Lunch

1:00-4:00	Executive Session-report writing	*NSF-390*
4:30-5:00	Report-out to NSF and OOI Project Team	*NSF-110*

OOI Project Team Preparation Room — *NSF-110(Wed/Thurs)*
NSF-365(Wed/Fri)

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Appendix C. November 2008 Cost &Schedule Review Report

National Science Foundation Review of the Ocean Observatories Initiative Construction Project

Final Design Review
Report of Subcommittee 4: Cost Estimate, Schedule and Funding
November 6-7, 2008

1. **Introduction.** The National Science Foundation Program Office of the Ocean Observatories Initiative (OOI) requested a review of the final design of the OOI Project; the cost, schedule and funding of the OOI project was reviewed on November 6-7 against the charge and agenda (Appendices I & II) by a committee of independent experts. The committee reviewed the budget estimating and scheduling processes as presented by the project team and a project team self-assessment (Appendix III), sampled some associated processes and cost/schedule data, evaluated the methodology used and looked for possible areas of improvement. The panel also assessed the risk-based contingency and schedule analysis.

2. **Response to Charge.** The committee made the following summary assessment of the OOI project's cost and schedule against the elements of the charge:

   I. **General**

   a. **Does the project cost estimate have a sound basis, supported by documentation, an informed projection of market conditions and consistent with the presented funding profile? YES**
   b. **Does the project have a sound basis for the inflation/escalation factors? YES**
   c. **Is the risk-based contingency adequate to complete the proposed project scope? YES;** the explicit budget contingency is considered adequate but not generous. The project team has additional strategies for value engineering and flexibility in meeting requirements that should be implemented to improve the contingency balance.
   d. **Has the project schedule been sufficiently defined? YES. Does the project have a clear schedule analysis that provides critical/near critical path(s)? YES**
   e. **Is schedule float considered? YES. Are risks and impacts of major schedule delays sufficiently addressed? NO,** additional float is needed on the completion date for such unknowns.
   f. **Is the Project Management Control System an effective tool for cost/schedule status reporting and timely decision-making? YES**

   II. **Cost Estimate and Budget**

   g. **Are the construction cost estimates complete and allocated to WBS levels? YES**
   h. **Are there an adequate number of time-duration based cost estimates? YES**
   i. **Is the distribution of basis-of-estimates (e.g., vendor quotes, engineering estimates, etc.) appropriate for this stage of the project? Is the project cost estimate substantially supported by external or historical data? YES**
   j. **Is there an algorithm for calculating contingency and is this appropriately applied to all relevant WBS elements? YES,** improvements should be undertaken to accommodate management needs during project execution.
   k. **Is there a high expectation that the OOI can be built within the estimated cost and contingency? YES,** additional sources of cost and schedule contingency should be explored now and during the execution phase.
   l. **Are there recommended improvements to the cost estimate, contingency and cost book? YES**

III. Schedule

m. Does the project have a well-developed schedule that is resource loaded? YES

n. **Are the activity durations reasonable? YES. Does the schedule contain appropriate levels and quantity of milestones for tracking purposes? YES. Do the milestones appear achievable? NO, the project completion date is in question;** additional float should be allocated to project completion date when confirmed.

o. Does the schedule include activities for periodic project reviews, production engineering design reviews, safety program reviews? YES

p. Did the schedule development utilize a reasonable schedule analysis that included evaluating activity sequences, durations, resource requirements, constraints? YES

q. Are the critical/near critical path activities identified? YES. Is the total schedule float sufficient considering the risks? NO, additional explicit float on project completion is recommended.

r. Does schedule contingency include the impacts of "marching army" costs in the event of major delays? NO

3. **General assessment.** The OOI project is categorized by NSF as a Major Research Equipment Facility Construction (MREFC) project.

   a. **Cost estimate.** [redacted] The estimate was prepared "bottom-up" by experienced technical experts in accordance with a Cost Estimating Plan that prescribes basis of estimate categories, pricing guidelines, and costing, risk management and escalation methodologies. The estimate is well-documented in a flexible, electronic spreadsheet project cost book. OMB-established annual escalation factors for labor and non-labor costs are used to account for inflation effects and appear reasonable based on recent experience. An additional escalating factor of 10% per year has been applied per NSF guidance to account for the inflationary pressure on fuel costs for UNOLS ships. Costs are allocated to level 8 of the project WBS. A tailored ANSI-standard based earned value management system (EVMS) is documented and in place that provides methods and standards for developing and managing the schedule, and reporting status on and updates to the schedule and cost estimate. The project team plans to initiate EV reporting 3-6 months prior to MREFC as a ramp up to MREFC use and compliance in accordance with NSF guidelines. The project reports that there are currently over 700 work packages identified within 240 control accounts, which implies a reasonable ratio for effective management and is in line with project guidelines. The current cost estimate has been developed from 34.8% engineering estimates, 44.4% historical data and experience, 20.7% vendor quotes and 0.04% catalog prices for off-the-shelf items. The project team reports that in most areas the vendor quotes have been provided within the past year and engineering estimates have been similarly updated. Recent receipt of the responses to a large RFP in the RSN IO should significantly increase the fraction of the total estimate that is based on vendor quotes.

b. **Cost contingency.** [redacted] The contingency estimate was developed from a bottom-up risk assessment employing standardized templates that consider risk assessment factors for schedule, cost and technology development; the resultant anticipated contingencies are then applied through the cost book to the associated WBS cost element. The project team has further identified potential cost savings/value engineering opportunities of approximately $ 8-13M and has considered additional scope refinement strategies if needed. The Cost Estimating Plan does not contain an explicit methodology for determining contingency during project execution that would account in a timely way for pending changes to the performance baseline, the effects of residual risk on awarded procurements, or treatment of work-to-go. The electronic cost book, while highly flexible, can be cumbersome in extracting certain useful management information and may tend to "uncouple" the impacts of the current high-medium category risks from the cost estimate as seen by the Control Account Managers or upper management.

c. **Schedule and float.** The OOI project is scheduled for National Science Board approval in May of 2009 with a planned construction start of July 2010 (FY2010). The construction phase (MREFC) is scheduled for 5 years and completes in September 2015 (60 months, Appendix V). The project schedule assessment indicates completion in August 2015, leaving only 1 month (2%) explicit float. The schedule consists of about 1500 tasks, with 42 major milestones (Appendix VI) and approximately 300 other milestones. A schedule analysis performed by the project team, including Monte Carlo analysis, determined 2 critical/near critical paths: (1) weather delays that could impact installation of the Regional Scale Nodes; and (2) potential software development delays in the Cyber-infrastructure, which currently indicates that there could be only 1 month of float remaining on the project completion date. Risk-based schedule contingency is only indirectly determined through the risk management templates. There are some planning assumptions employed by the project and incorporated into the schedule that should be explicitly reflected in the appropriate management plans (Appendix VII). The project risk assessment does not include a specific risk associated with the marching army costs of an unforeseen major schedule delay. The overall schedule float is considered insufficient for the construction period, and efforts should be made to achieve some explicit float of between 5-10% on the project completion date of September 2015.

d. **Funding.** The OOI project has been delayed from an initial planned start in 2008 and is now planned to commence in 2010. The funding profile to be provided through annual Congressional appropriations is proposed in the OOI Acquisition Plan shown in Appendix IV [Appendix IV, Budget and Funding Profile redacted] and is subject to further review and approval by NSF.

4. Cost and schedule findings, comments and recommendations by WBS

4.1 Cyber-infrastructure

4.1.1 Findings. The integration between the cyclical development model and project management is such that the project management system sees the development cycle, and not tasks within the cycles. The project plans to mitigate this mis-match with increased liaison between OOI and the CI IO. The CI milestones need greater visibility at the project level.

4.1.2 Comments. A fully capable CI system is an important part of the overall project. Careful project management will ensure that the overall scope of the CI is preserved and end user needs are met. The software project has a cross cutting, ontological method for identifying risk, and formulating mitigations. This methodology seems appropriate to the software tasks in the CI IO.

4.1.3 Recommendations.

4.1.3.1. Reflect in the project schedule each test case within the generic testing process called for in the OOI system engineering management plan.

4.1.3.2. Risks associated with the aggressive staffing plan that exists at start of the CI project should be quantified and accounted for in contingency planning.

4.1.3.3. Present to the upcoming FDR technical team the underlying CI architecture and maturity of the selected tools that comprise the basis of confidence in the CI schedule/cost estimate.

4.1.3.4. Historical data should be developed during the pilot period to improve the CI BOE which currently reflects considerable engineering judgment.

4.2 Coastal Global Nodes

4.2.1 Findings. Costs and schedule aspects related to existing capabilities and available COTS items in this scope are well-founded. The most significant concerns are related to development and integration of new technologies (high risk subsystems including the Hybrid Profiler (WBS 1.3.3.3.1), Data Concentrator and Logger (WBS 1.3.3.1.1.4), buoy power system (WBS 1.3.3.1.1.1), autonomous underwater vehicle dock (WBS 1.3.3.7.1.2.) White papers and RFIs have made reasonable steps toward assessing cost and availability of these equipments.

4.2.2 Comments. More explicit consideration should be given to the potential impacts of non-readiness of the specified (and any other similar) new technologies on schedule. Given the ‘transformational’ nature of the laboratory, replacement of originally installed equipment when more developed replacements become available should be considered. The many and critical interfaces and dependencies with CI and RSN should be carefully managed throughout project execution. Tracking and managing labor through ratios such as employees/FTEs can improve efficiency and avoid long-term dilution of effort through excessive commitments to other projects. Support is encouraged for continuing vendor workshops, including strong CI participation for standards and continued communication with industry given the delays in project start. It may also be useful to ensure ongoing, explicit QA/QC of systems—including tracking % real time, % total data returns-- during phased development for use as feedback on later phases.

4.2.3 Recommendations.

- Evaluate the impact of non-readiness of new technology items on schedule and define an acceptable level of performance at PRR milestone to trigger mitigation actions.

- o Define and track overlaps of start stop windows, including procurement lead times associated with managing connections and dependencies on CI, RSN
- o Deployment of high latitude Global Mooring arrays should have an explicit non-UNOLS ship time contingency (at relatively low risk, if desired) in the event weather or other factors prevent availability of appropriate UNOLS ship.

4.3 Regional Scale Nodes

4.3.1 Findings. The budget and schedule for RSN have sound bases and are supported by good documentation, experienced personnel, close correlation with market conditions and reflect current technologies. Risk-based contingency has been determined for critical items. Construction cost estimates reviewed by the panel are in line with commercial and industry experience and standards for current projects. The RSN schedule contains an adequate number of time-based estimates and activities; the distribution of the bases of the RSN estimate is in line with other ocean projects of similar concept and scale. The risk assessment for this portion of the project appears reasonable and is supported by commercial experience and historical information.

4.3.2 Comments. The medium voltage converter (MVC) converter remains a critical, high-risk component that can have significant effects on the overall project schedule and budget. The project team has developed a back-up plan for this technology that appears reasonable and adequate to support the current schedule and budget. Further mitigation of risk elements is underway by integrating on-going feedback and lessons-learned on all aspects—but especially equipment and CI-- of the MARS program currently in the water.

4.3.3 Recommendations.

4.3.3.1 Continue interface with MARS program for lessons learned with MVC and other items.

4.4 Education and Public Engagement.

4.4.1 Findings. The EPE aspect of the project has not yet been developed to an equivalent state as the other elements of the OOI. The current budget allocation within the MREFC for these preparatory activities which are largely to be conducted during the post-delivery phase is $5M, of which $3.5M will be allocated to an EPE IO and $1.5M to provide base support at the marine and CI IOs for collaboration and interface work. An IO to develop this infrastructure is expected to be awarded in FY2009 and the OOI program office expects to tailor the EPE scope within this budget'

4.4.2 Comments. The panel noted prior reviews encouragement to development this infrastructure as soon as practicable.

4.4.3 Recommendations. None

4.5 Systems Engineering

4.5.1 Findings. [redacted] The project management tools and plans, including the WBS, SEMP, CMP, Risk Management Plan, EVMP and others are well developed and provide useful frameworks within which to manage the project. The systems engineering effort appears adequate and well-positioned to coordinate integration of the complex interfaces throughout the project.

4.5.2 Comments. OOI requirements definition at all levels appears very rigorous and effective. The cost/schedule impacts associated with specific risks are not explicit to the appropriate manager and require manipulation of the cost book. Some inconsistencies were found in some cost book roll-up data.

4.5.3 Recommendation.

4.5.3.1. Improve the association of impacts within the risk assessment process to enhance management visibility and control, especially as the project proceeds into execution.

4.5.3.2. Scrub/correct inconsistencies in cost book prior to FDR

4.6 Project Management and Operations.

4.6.1 Findings. [redacted] Project management activities are scheduled as level-of-effort and comprise approximately 15% of total scheduled tasks. The Operations and Maintenance (O&M) budget is set per NSF OOI Program Office guidance at $55M per year (in 2015 dollars) beginning in 2015. Some phasing into operations funding is proposed by the OOI Acquisition Plan utilizing other than MREFC funds per NSF policy as various elements of the project complete commissioning. All procurements greater than $250,000 require approval by the NSF OOI Program Office.

4.6.2 Comments. Some reports that would facilitate aggregation of costs by categories and more explicit summation of the impacts of risks would improve useful management assessments at all levels (CAM, intermediate and top-level) but are not yet available from the electronic cost book. While not required by NSF policy, a detailed independent cost review by a panel of technical and management experts could be useful considering the impending transition of some management and the near-term completion of the design and the FDR. It is unclear that major contracts (>$250,000) have sufficient schedule definition or management visibility to ensure timely review and approval.

4.6.3 Recommendations.

4.6.3.1. Ensure appropriate schedule milestones and planning/approval guidelines are incorporated within project plans to avoid delays and provide reasonable management control.

4.6.3.2. Consider the benefits versus the effort associated with an independent cost review upon completion of the FDR.

4.6.3.3. Clarify the project completion milestone date.

Appendix I. Cost and Schedule Review Charge

The National Science Foundation is conducting a Cost and Schedule Review as part of the Final Design Review (FDR) for the Ocean Observatories Initiative (OOI) Project. The purpose of the cost and schedule review is to assess the project budget and schedule to ensure that there is a high degree of confidence that the project can be constructed to this baseline. NSF has implemented a "zero cost overrun" for its MREFC projects, so that the baseline budget defined must be sufficient to cover the needs of the project. Any unanticipated project needs will be dealt with through project scope reductions. The FDR Cost and Schedule Review is scheduled for November 6-7, 2008 at NSF.

On November 12-14, the report from this cost and schedule review panel will be incorporated into an integrated FDR that will assess the final technical design and programmatic elements, including budget and schedule, as defined in the Project Execution Plan (PEP) for the OOI. The cost and schedule panel chair will report out the panel's findings and recommendations to the FDR panel on Day 1 of the review (November 12, 2008). The FDR will take place at NSF.

NSF requests the external review committee advise NSF on the sufficiency of the baseline planning and provide assistive recommendations in the panel review report. The cost and schedule panel will review the budget and schedule estimating processes, drilling down in a few selected areas to evaluate the methodology and identify any areas for improvement. The review panel will also evaluate the OOI project costs at the detailed, WBS level, assess the project risk-based contingency and scrutinize the project schedule and schedule analysis. The panel should answer the following project-level questions:

- Does the project budget have a sound basis of estimate that is supported by documentation substantiated by a firm understanding and informed projection of the market conditions for the construction funding profile presented?
- Does the project have a sound basis for the inflation/escalation factors?
- In your professional opinion, is the risk-based contingency adequate to complete the proposed project scope?
- Has the project schedule been sufficiently defined and presented?
- Will the PMCS be an effective tool for cost/schedule status reporting and timely decision-making by the project?
- Does the project have a clear schedule analysis that provides an optimal critical and near critical path for the project?
- How well does the project address schedule contingency (schedule float)? Are the risks and impacts of major schedule delays sufficiently addressed?

Additionally, NSF is requesting that the panel address the following detailed questions:

Cost Estimate and Budget

- Are the construction cost estimates complete and allocated to WBS levels?
- Are there an adequate number of time-duration-based cost estimates?
- What is the distribution of basis of cost estimates (e.g., vendor quote, engineering estimates)? Is the project risk-adjusted cost substantially supported by external or historical data?
- Is there an algorithmically-based procedure for calculating contingency? Is this plan appropriate and is it applied to all relevant WBS elements?
- Has the project sufficiently allowed for changes in the cost of raw materials and labor over the course of project construction? Do the inflation factors reflect current market conditions and future projections?
- Based on the answers above, is there a high expectation that OOI can be built within the estimated cost and contingency?
- Are level-of-effort work packages minimized and only used under appropriate work scopes?

- Are there any recommended improvements to the cost estimate, contingency and cost book?

Schedule

- Does the project have a well developed schedule that is resource loaded
- Are the activity durations reasonable? Does the schedule contain appropriate levels and sufficient quantity of milestones for tracking purposes? Do these milestones appear achievable?
- Does the schedule include activities for periodic project construction reviews, production engineering design reviews, and construction safety program reviews?
- Was the project schedule developed using a reasonable schedule analysis that included evaluating activity sequences, durations, resource requirements and constraints?
- How well are the critical and near critical path activities identified and evaluated? What is the basis for the total float for the project and is it sufficient given the risks of constructing OOI?
- How does the project address schedule contingency? Has the project accommodated for "marching army" costs in the case of major delays?

Panel Report

A draft FDR cost and schedule panel report should respond to each section of the charge and NSF requests that a draft of the report be submitted at the end of the review (November 7th) to the Project Team for fact checking. Any comments on the draft must be submitted to NSF by November 10 through the OOI Program Manager who will distribute them to the Panel. The final report from the cost/schedule panel should be submitted to NSF by November 17, 2008.

Appendix II. Cost and Schedule Review Agenda

November 5, 2008		***Room***
6:00-7:30	Panel meets to discuss FDR Review process and goals	*NSF-120*
November 6, 2008		
8:00–8:30	Morning refreshments	*NSF-120*
8:15-9:00	Executive Session I	*NSF-120*
9:00–9:15	Welcome and Introductions (NSF/Panel Chair) • Meeting agenda; goals of review	*NSF-120*
9:15–9:30	NSF Presentation (NSF) o OOI History o Funding Status and Projection o Project Constraints	*NSF-120*
9:30-10:30	OOI Network Overview (OOI Project Team presentation) o Scope o WBS o PEP Overview (focus on schedule and cost) ▪ Schedule assumptions ▪ Schedule analysis -Critical path and near critical path ▪ Cost estimating plan/assumptions and basis of estimate	*NSF-120*
10:30-10:45	Break	
10:45-12:00	OOI Network Overview (cont.) o Risk analysis-assessment and mitigation o Contingency and contingency management	*NSF-120*
12:00–1:00	Lunch	
12:30-1:00	Executive Session II	
1:00-3:00	Full panel-Cost Estimates and Schedule by WBS element Cyberinfrastructure ▪ Review of schedule and construction costs ▪ Schedule/cost integration with other IOs ▪ Distribution of basis of cost estimates Budget/Contingency ▪ Contingency calculation across WBS ▪ Market drivers and inflation factors	*NSF-120*
3:00-4:30	Breakout sessions 1. Cyberinfrastructure Cost Estimates and Schedule by WBS element ▪ Review of schedule and construction costs ▪ Distribution of basis of cost estimates Budget/Contingency ▪ Contingency calculation across WBS ▪ Market drivers and inflation factors	*NSF-120*
	2. Regional Scale Nodes-Cost Estimates and Schedule by WBS element ▪ Review of schedule and construction costs ▪ Distribution of basis of cost estimates Budget/Contingency ▪ Contingency calculation across WBS ▪ Market drivers and inflation factors	*NSF-755.23*
	3. Coastal-Global Scale Nodes-Cost Estimates and Schedule by WBS element ▪ Review of schedule and construction costs ▪ Distribution of basis of cost estimates	*NSF-425.01*

Budget/Contingency

- Contingency calculation across WBS
- Market drivers and inflation factors

4. System Integrator (PM-SE)-Cost Estimates and Schedule by WBS *NSF-705* element
   - Review of schedule and costs
   - Distribution of basis of cost estimates

   Budget/Contingency
   - Contingency calculation across WBS
   - Market drivers and inflation factors

4:30-5:00 Executive Session III - report generation planning; identify outstanding issues *NSF-120*

5:00-5:30 Plenary Session: Panel to present questions and concerns to the project team to be addressed at the start of day 2 *NSF-120*

November 7, 2008

8:00-8:30 Morning refreshments

8:10-8:30 Executive Session IV-report generation planning; identify outstanding issues *NSF-120*

8:30-9:00 Plenary Session: Project Team reports on panel questions and concerns *NSF-120*

9:00-12:00 Breakout sessions (cont.) (break as needed)

	1. Cyberinfrastructure Cost Estimates and Schedule by WBS element Budget/Contingency	*NSF-120*
	2. Regional Scale Nodes Cost Estimates and Schedule by WBS element Budget/Contingency	*NSF-515(II)*
	3. Coastal-Global Scale Nodes Cost Estimates and Schedule by WBS element Budget/Contingency	*NSF-791*
	4. System Integrator (PM-SE) Cost Estimates and Schedule by WBS element Budget/Contingency	*NSF-705*
12:00-1:00	Lunch	
12:30-1:00	Executive Session V	*NSF-120*
1:00-2:00	Continued Cost and Schedule Assessment (as needed)	*NSF-120*
2:00-4:30	Executive Session VI-report generation	*NSF-120*
4:30-5:00	Report-out to NSF and OOI Project Team	*NSF-120*
OOI Project Team preparation room		*NSF-130* *NSF-330 (8-2, 4-5 Thurs, all day Fri)*

Appendix III. OOI Project Self-Assessment to the Committee Charge

High Level questions:

o Does the project budget have a sound basis of estimate that is supported by documentation substantiated by a firm understanding and informed projection of the market conditions for the construction funding profile presented?

Yes, the basis of estimate is sound and supported by documentation. The budget has been developed based upon a product-oriented Work Breakdown Structure (WBS) (See Table 1) created from the science requirements that defined the scope of the program. This provides the framework for an effective project management control system based on earned Value Management principles. The details of the estimate were developed by the product managers, captured in the Cost Book, and integrated with MS Project to generate the resource loaded schedule. Projected market factors are reflected in the cost book escalation and contingency assignments.

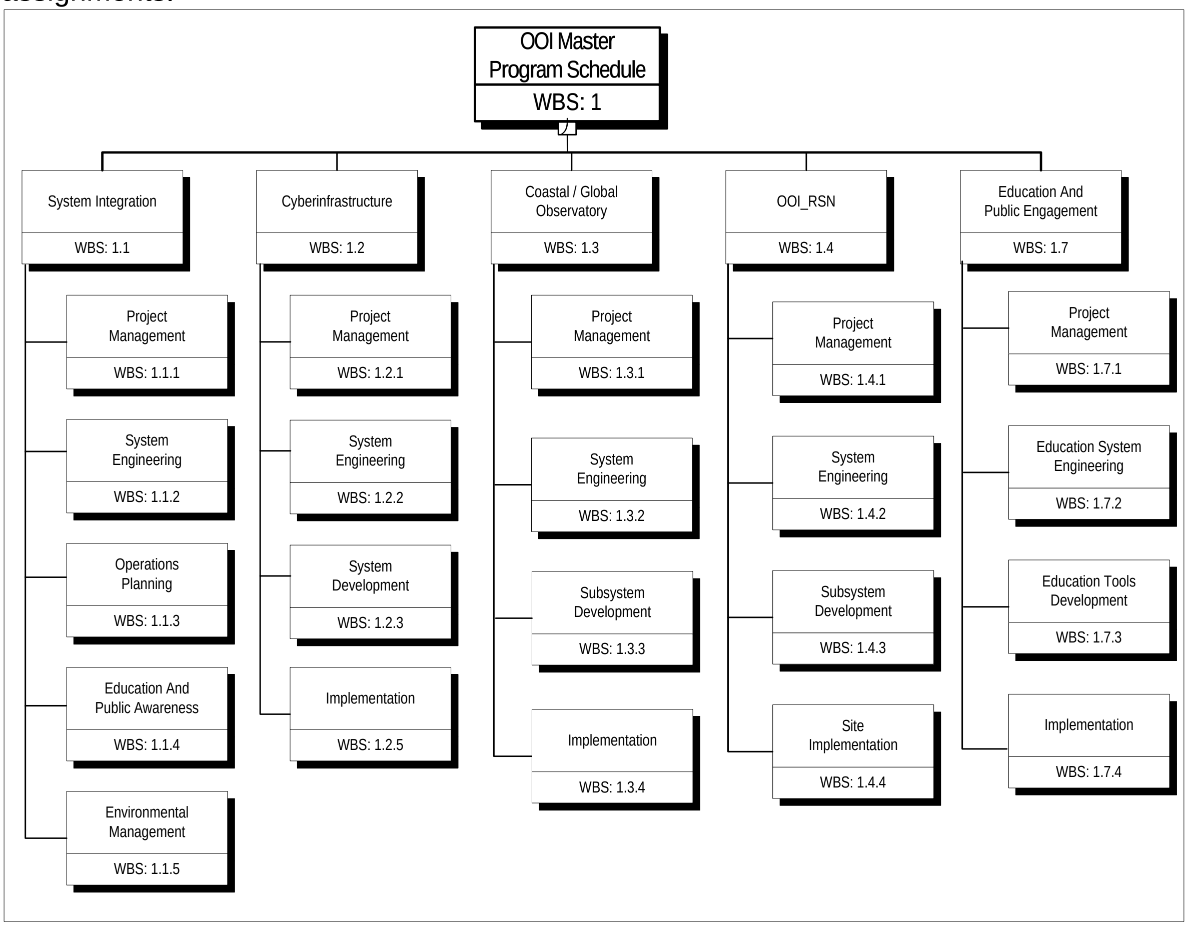


Table 1 OOI WBS

o Does the project have a sound basis for the inflation/escalation factors?

Yes, the Program Office has used the most recent OMB inflation guidance (July 2008) as the primary data to inflate and escalate both the MREFC and Operations and Maintenance (O&M) estimates. The approach for incorporating the impact of inflation and escalation is documented in the Cost Estimating Plan (CEP).

- In your professional opinion, is the risk-based contingency adequate to complete the proposed project scope?

The OOI risk-based contingency is adequate to complete the proposed project scope. Overall contingency currently stands at 24.9% of the projected Total Project Cost. This is approximately 4% higher than presented at PDR. Additionally, 6 months of budgeted schedule reserve has been added to the end of the schedule. The project has taken steps to improve the quality of the bottoms up estimate and has begun mitigation of major risks. The Technical Specifications for major sub awards are mature. [redacted]…the Project's estimate for the Wet Plant is reasonable and achievable given current market conditions. Estimates for other significant marine components of both the Regional and Coastal/Global systems have been verified by Requests for Information (RFI) directly to the manufactures. The BOEs reflect the latest pricing information for the various subsystems.

- Has the project schedule been sufficiently defined and presented?

The project schedule is sufficiently defined and has been resource loaded. The OOI Integrated Master Schedule (IMS) is a hierarchical decomposition of the WBS using ANSI/EIA-748A approved process and commercially available Microsoft Office Project 2003 software. This process formed a network of tasks that are loaded with the budgeted resources, and dynamically linked using identified predecessor and successor tasks. The IMS baseline will be the basis for analysis and reporting.
OOI follows a "rolling wave" process for detailed planning of current year activities associated with each annual funding increment. Out-year resources are loaded at the Work package level to allow for future detail planning. This enables the program to adjust to actual funding levels, prior year accomplishments/ lessons learned, and the availability of more mature/definitized pricing.

- Will the PMCS be an effective tool for cost/schedule status reporting and timely decision-making by the project?

The Program Management Control System (PMCS) process is in place and will provide timely and useful information for effective decision making. The PMCS combines industry standard tools and a robust infrastructure to track progress on the construction program. OOI uses the forProject Technology Inc. tool suite integrated with MS Project as the schedule engine for earned value management. The system has been installed at each IO and tested to demonstrate connectivity of the system with OL. The final piece of the PMCS generates PM information products to support internal decision making and cost/schedule status reporting.

- Does the project have a clear schedule analysis that provides an optimal critical and near critical path for the project?

The OOI has completed a clear schedule analysis that indicates the critical path is dominated by the Vertical Mooring development, followed closely by Cyberinfrastructure software development.

The Critical Path Methodology (CPM) used by OOI included the traditional analysis of tasks and scope that are fixed and certain. It also recognized that some items within the IMS contain risk elements where durations are uncertain and beyond program control. For these items the duration boundaries were quantified with the best information available, and then analyzed using a Monte Carlo simulation to determine possible effects to the OOI Program. These schedule analyses were further augmented by objective risk analyses performed by technical leaders at the work package level. Considering all of these factors, OOI identified work packages and schedule tasks on or near the critical path. These analyses will be updated monthly through out the life of the program and will be an integral component of recurring status reviews.

- o How well does the project address schedule contingency (schedule float)? Are the risks and impacts of major schedule delays sufficiently addressed?

The project has adequately addressed schedule contingency. Software development and weather impacts on deployment have been identified as the two highest schedule risks. Six months of schedule contingency (10%) have been planned and budgeted at the end of the project to mitigate these risks. This is a change from the schedule contingency strategy presented at PDR where OOI planned to use contingency budget to “buy additional schedule” as required.

Schedule float is the ability to accelerate or delay an activity or series of activities without affecting a delivery milestone or extending the program period of performance. Schedule float for activities on the critical and near-critical paths is managed by the OOI Program Office. Schedule float for non-critical activities (float greater than 5 days) is managed by IO and subsystem managers.

Cost Estimate and Budget

- o Are the construction cost estimates complete and allocated to WBS levels?

The construction estimates are complete and allocated to the work package level of the WBS. The WBS is product-oriented and costs are estimated by technical experts at the work package or activity level. BOEs for each work package are documented in the Cost Book and reflect the full range of approaches being used to acquire the various OOI subsystems. Some major components, like the Regional Scale backbone cable, are contracted for as part of a contract with industry. Other parts of the system, like the Global buoys, are being constructed by the Implementing Organizations.

- o Are there an adequate number of time-duration-based cost estimates?

One of the key requirements of EVMS is creating a product-oriented WBS with short duration activities directly linked to completion of the product. Most OOI WBS elements reflect this convention and the supporting work packages are planned to be accomplished in less than a year. An exception exists for functionally based WBS elements that provide for cross-cutting support/effort in many areas of construction. These include, for example, project management and systems engineering efforts. Work packages within these elements are aligned with funding increments, and are generally one-year long. Additionally, the Cyberinfrastructure spiral development process is 16 months long. Each corresponding work package is 16 months long and includes development, test, integration and deployment. The functional content of each release is further detailed as part of the OOI “rolling wave” of detailed planning.

- o What is the distribution of basis of cost estimates (e.g., vendor quote, engineering estimates)? Is the project risk-adjusted cost substantially supported by external or historical data?

The following information is generated from the Cost Book. It shows that 44% of the estimate is based on Vendor Quotes,35% from engineering estimates,<1% from Catalog Pricing and 20% from Historical Data. Appropriate BOEs were checked for consistency with information from external sources like the Neptune Canada project and the NSF’s MARS test bed.

- o Is there an algorithmically-based procedure for calculating contingency? Is this plan appropriate and is it applied to all relevant WBS elements?

There is an appropriate algorithmic-based procedure for calculating contingency built into the Cost Book. Each element of the Cost Book includes a risk-based contingency component. Contingency ranges from 5% to 74%, with the overall level at 22% for the whole OOI. In addition NSF is holding $10 million as a program reserve, which equates to approximately 3%.

- o Has the project sufficiently allowed for changes in the cost of raw materials and labor over the course of project construction? Do the inflation factors reflect current market conditions and future projections?

At the work package level the impact of raw materials has been incorporated into the estimates. The reality is that there have been unprecedented swings in commodity prices while this estimate was under development. Certain elements, like the pressure housings for the deepwater electrical and electronic components that use titanium, have increased inflation factors. The same is true for higher inflation for ship days at sea. For the remainder of the estimate OMB inflators have been used. They provide a 10 year projection for both labor and construction.

- o Based on the answers above, is there a high expectation that OOI can be built within the estimated cost and contingency?

Yes. A majority of the system is based upon current technology that is either commercial off the shelf or is currently under construction by other programs. The project has used technical experts to assign appropriate risk-based contingency at the lowest level of work. Appropriate OMB escalation factors have been used to adjust project cost to then-year dollars in most cases. Where market volatility justifies more severe escalation assumptions, OMB rates have been adjusted upward. Potential weather impacts and software development uncertainties have been mitigated by funded schedule reserve, and the NSF will hold a $10M (3%) management reserve.

- o Are level-of-effort work packages minimized and only used under appropriate work scopes?

One of the key requirements of EVMS is creating a product-oriented WBS with short duration activities directly linked to completion of the product. Most OOI WBS elements reflect this convention and the supporting work packages are planned to be accomplished in less than a year. An exception exists for functionally based WBS elements that provide for cross-cutting support/effort in many areas of construction. These include, for example, project management and systems engineering efforts. Work packages within these elements are aligned with funding increments, and are generally one-year long. Approximately 20% of the projected OOI total project cost is allocated to LOE work packages.

- o Are there any recommended improvements to the cost estimate, contingency and cost book?

The value of the funded schedule contingency at the end of construction should be included as a component of the contingency budget, and excluded from the estimated cost to complete. The NSF management reserve should be a component of the planned contingency budget, not an additional budget requirement.

- o Post FDR the project team will continue to refine the cost estimate as work in the Pilot Period continues.

Schedule

- o Does the project have a well developed schedule that is resource loaded

Yes. The OOI used the WBS to form a top-down product oriented structure from which each IO schedule was developed. Inter-task dependencies are evaluated and resources are loaded at the lowest possible level.

- o Are the activity durations reasonable? Does the schedule contain appropriate levels and sufficient quantity of milestones for tracking purposes? Do these milestones appear achievable?

Yes. OOI plans to follow an annual rolling wave detailed planning process. Each year, near term work packages will be further defined to tasks and activities, logical dependencies identified, and necessary resources assigned at the lowest level. This will result in a fully integrated master schedule for the execution year. In every case milestones are the juncture of technical touch-points, and major review preparation and culmination points. The PMO in conjunction with the IOs have identified and properly placed OOI program milestones, IO intermediary milestone and detail-activity completion milestones. As all milestones are derived from the activity/task schedule network relationships they are correspondingly achievable vis-à-vis the schedule.

- o Does the schedule include activities for periodic project construction reviews, production engineering design reviews, and construction safety program reviews?

Yes. Each test completion milestone, release milestone, major assembly and-or subsystem completion milestone is preceded by a review period at the Ocean Leadership level, or at the Implementing Organization level.

- o Was the project schedule developed using a reasonable schedule analysis that included evaluating activity sequences, durations, resource requirements and constraints?

Yes. Each Implementing Organization schedule was developed using industry standard best practices, and guidance from the OOI Schedule Management Plan. These guidelines require consistency in relationships, consideration of resource requirements, minimal scheduling constraints, and assessment of task durations. By OL directive and with OL Master Scheduler hands-on guidance, schedule constraints are limited, and where found, judiciously applied.

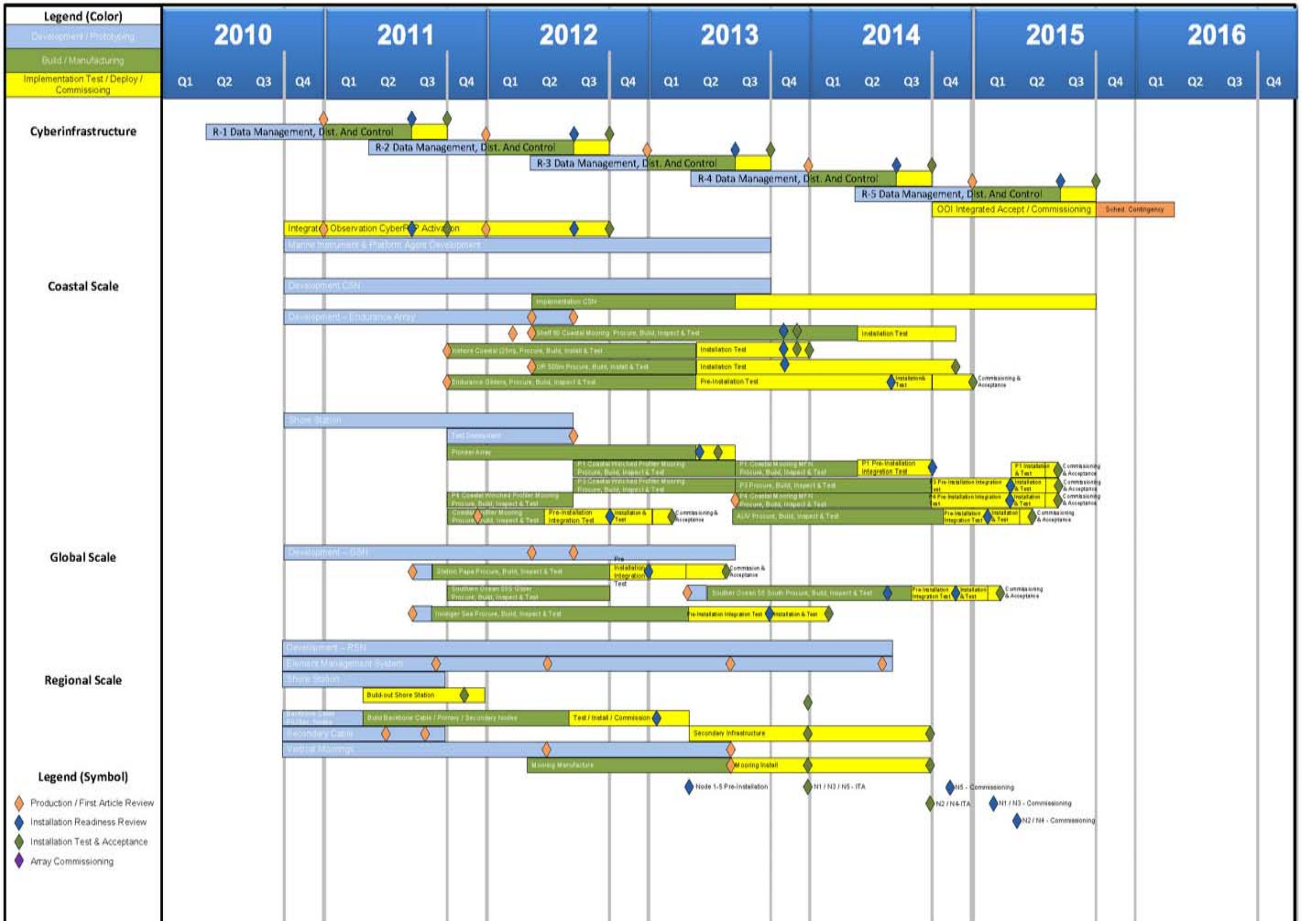
- o How well are the critical and near critical path activities identified and evaluated? What is the basis for the total float for the project and is it sufficient given the risks of constructing OOI?

Critical path and near critical paths have been identified and characterized in the OOI Critical Path and IMS Analysis. Each Implementing Organization's technical touch-points have been identified. Those touch points are managed as priority activities throughout the lifecycle of the project. Each technical touch-point or cross project dependency (CPD) is flagged in the IMS and acts as a schedule status checkpoint whether it falls on the critical path or not.
Total float for OOI is a measure of the calculated early starts/early finishes against late starts/late finishes of activities in the schedule. Changes in Total float have the potential to impact program milestones and/or critical path. Management of total float is an OL responsibility and schedule delays impacting total float are immediately reportable to Ocean Leadership.

- o How does the project address schedule contingency? Has the project accommodated for "marching army" costs in the case of major delays?

The Project has budgeted six months of schedule contingency (10%) at the end of the project to mitigate weather delays to deployment and prolonged software development. The associated marching army costs are limited to management and direct personnel required to address these tasks.

Appendix V. Schedule



Appendix VI. Table of Major Milestones (from OOI PEP)

Item	Task Name	Completion
1	OOI Construction Project Baseline and U.S. National Science Board Construction Funding Approval	July 2010
2	RSN Authorization to Proceed	July 2010
3	RSN Requirements Readiness Review	July 2010
4	RSN Cable Plant Award	July 2010
5	Release RFP for Education and Public Engagement IO	Dec 2009
6	CI System Software “Release-1” Complete	June 2011
7	Contract Award – Education Infrastructure Facility	July 2010
8	RSN Shore Stations Build Out Complete	Feb 2012
9	Pioneer Coastal Profiler Critical Design Review (ifdr)	Aug 2011
10	Station Papa ifdr	Nov 2011
11	Irminger Sea ifdr	Nov 2011
12	PNW Uncabled Array ifdr	Nov 2011
13	Coastal Gliders ifdr	Nov 2011
14	RSN Backbone / Cable Construction Complete	Mar 2012
15	CI System Software “Release-2” Complete	June 2012
16	PNW Cabled Endurance Array ifdr	May 2012
17	RSN Low Voltage Node Design complete	Feb 2012
18	RSN Junction Box Design complete	Feb 2012
19	Shore Station Design Complete	July 2010
20	Pioneer Coastal Profiler Installation Readiness Review / Physical Configuration Audit (PCA)	July 2012
21	RSN Secondary Cable Design Complete	Nov 2010
22	RSN Mooring Design Complete	Mar 2011
23	RSN Secondary Cable First Article Review	June 2011
24	RSN Junction Box First Article Review	Feb 2012
25	PNW Endurance Array Installation Readiness Review / PCA – Gliders	Apr 2013
26	Pioneer Coastal Gliders Installation Readiness Review / PCA	Apr 2013
27	Southern Ocean ifdr	Apr 2013
28	Pioneer P1 - P4 ifdr	Apr 2013
29	AUV and AUV Dock ifdr	Apr 2013
30	CI System Software “Release-3” Complete	June 2013
31	Station Papa Installation Readiness Review/ PCA	May 2013
32	PNW Endurance Array Installation Readiness Review/ PCA – Uncabled	July 2013
33	PNW Endurance Array Installation Readiness Review/ PCA – Cabled	Aug 2014
34	Irminger Sea Installation Readiness Review/ PCA	Nov 2013
35	CI System Software “Release-4” Complete	June 2014
36	Pioneer P1 - P4 Installation Readiness Review / PCA	Aug 2014
37	Southern Ocean Installation Readiness Review / PCA	Dec 2014
38	AUV Installation Readiness Review / PCA	Nov 2014
39	CI System Software “Release-5” Complete	June 2015
40	Education Infrastructure Operational	June 2015
41	RSN Start Commissioning Node 1	Apr 2015
42	OOI Complete	July 2015

Appendix VII. Schedule Assumptions
OOI Schedule Assumptions/Constraints

OOI / OL

WBS Developed from the top-down, product oriented, ANSI compliant.

Production limited schedule; ability to produce and assemble are the primary limiting factors.

CI:

The CI schedule is dominated by 5 major releases.

Each release duration is 16 months and is divided into four phases, subsequent releases overlap by 4 months.

Releases 1-3 are linearly dependent, a slip in one results in a linear slip to the subsequent release.

Release 4 and 5 are independent of other releases.

The functionality is phased to provide base functionality first with higher order needs met by later builds. This is reflected in both the name of the releases and the release numbers applicable to each subsystem.

Release 1: Data Distribution Network

Release 2: Managed Instrument Network

Release 3: On-Demand Measurement Process

Release 4: Integrated Modeling Network

Release 5: Interactive Ocean Observatory

Each release provides increasing levels of functionality for 6 major subsystems.

- Common operating infrastructure (Releases 1-2)
- Common execution infrastructure (Releases 1-2)
- Sensing and Acquisition (Releases 1-3)
- Data management (Releases 1-3)
- Analysis and Synthesis (Releases 2-4)
- Planning and prosecution (Releases 3-5)

RSN:

The RSN schedule is driven by production and deployment windows.

- Weather impacts the number of productive days spent at sea
- Generic weather contingency for the budgeted at 2 days per 30 day cruise
- Primary Infrastructure total weather days are 4
- Secondary Infrastructure total weather days equal 10.

CGSN:

The CGSN schedule is production driven.

Installations are being planned incrementally, largely to reduce production pressures.

Production efforts have been leveled to sustain a constant level work force.

The schedule has been developed to move production out ahead of deployment needs.

Long lead planning and economies of scale have placed many procurement activities early in the MREFC.

Development activities have been scheduled to minimize potential schedule impacts using a "Production Readiness" gate to distinguish between development and implementation.

Incremental installations provide schedule slack for development dependent instrumentation.

High latitude deployments are feasible for about 3 months out of the year