OOI CYBERINFRASTRUCTURE
NSF OCEAN OBSERVATORIES INITIATIVE

OOI – CyberInfrastructure

Education and Public Engagement Requirements Workshop
Portland, OR
June 16-17, 2008

Workshop Report

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CANDIDATE

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1 Executive Summary

In an effort to further the understanding of community user requirements and constraints for the planned Ocean Observatories Initiative (OOI) CyberInfrastructure (CI), the OOI Cyberinfrastructure Implementing Organization (IO) is holding a series of topic-oriented workshops with scientists and other future users of the CI. These workshops refine and complement the results of prior workshops and requirements efforts that led to the successful completion of PDR in December 2007.

The workshop described in this report was targeted towards Education and Public Engagement (EPE) and was held June 16-16, 2008 in Portland, OR. This workshop was the sixth in the series and succeeded five prior requirements workshops held in July 2007, January 2008 and May 2008 (see [CI-RWS1], [CI-RWS2], [CI-ROOP], [CI-RDPG], and [CI-RIOM]).

Data translators[1] and educators as well as participants from the Regional, Coastal and Global Observatories and the program office of the OOI were invited to this workshop. The workshop goals were cyberinfrastructure user requirements identification, elicitation and documentation, the validation of existing requirements, as well as an outreach measure to future CI user communities. The 1.5 days workshop took place in Portland, OR; it covered introductions to the planned CI and the OOI program, educator background presentations, CI requirements elicitation and validation sessions, domain analysis and use case scenario development sessions as well as feedback opportunities.

The workshop outcome and results include:

- Additional CI user requirements provided by EPE community members;
- Refinement and validation of existing user requirements;
- CI use case scenarios for EPE elaborated during the workshop;
- Collected workshop presentation materials including introductory presentations (OOI, CI, science) on the OOI CI Confluence web site [EPE-WEB];
- Science user questionnaires for requirements elicitation (extended and short versions);
- Completed participant questionnaires.

[1] Data translator = person responsible for analyzing data products and corresponding visualization options with the goal of developing educational applications and/or teaching material

2 Introduction

2.1 Goals and Background

In order to provide the U.S. ocean-sciences research community with access to the basic infrastructure required to make sustained, long-term and adaptive measurements in the oceans, the National Science Foundation (NSF) Ocean Sciences Division has initiated the Ocean Observatories Initiative (OOI). The OOI is the outgrowth of over a decade of national and international scientific planning efforts. As these efforts mature, the research-focused observatories enabled by the OOI will be networked, becoming an integral partner to the proposed Integrated and Sustained Ocean Observing System (IOOS; www.ocean.us). IOOS is an operationally-focused national system, and in turn will be the enabling U.S. contribution to the international Global Ocean Observing System (GOOS; http://www.ioc-goos.org) and the Global Earth Observing System of Systems (GEOSS; www.earthobservations.org). Additionally, the OOI will provide an ocean technology development pathway for other proposed net-centric ocean observing networks such as the Navy's proposed Littoral Battlespace and Fusion Integration program (LBSFI). Additionally, the global community spanning Canada, Asia and Europe is also developing new ocean networks that all contribute to the GEOSS. Developing a robust capability to aggregate these distributed but highly linked efforts is absolutely key for them to achieve success.

The OOI comprises three distributed yet interconnected observatories spanning global, regional and coastal scales that, when their data are combined, will allow scientists to study a range of high priority processes. The OOI CyberInfrastructure (CI) constitutes the integrating element that links and binds the three types of marine observatories and associated sensors into a coherent system-of-systems. The objective of the OOI CI is to provide a comprehensive federated system of observatories, laboratories, classrooms and facilities that realizes the OOI mission. The infrastructure provided to research scientists through the OOI will include everything from seafloor cables to water column fixed and mobile systems. Junction boxes that provide power and two-way data communication to a wide variety of sensors at the sea surface, in the water column and at or beneath the seafloor are central to these observational platforms. The initiative also includes components such as unified project management, data dissemination and archiving as well as education and public engagement activities essential to the long-term success of ocean observatory science. The vision of the OOI CI is to provide the OOI user, beginning with the science community, with a system that enables simple and direct use of OOI resources to accomplish their scientific objectives. This vision includes direct access to instrument data, control and operational activities described above, derived knowledge and the opportunity to seamlessly collaborate with other scientists, institutions, projects and disciplines.

A conceptual architecture for the OOI CyberInfrastructure was developed and published by a committee established by JOI in 2006 (see http://www.orionprogram.org/organization/committees/ciarch) [CI-CARCH]. It describes the core capabilities of such a system. Initial requirements were derived from related cyberinfrastructure projects.

In May 2007, a consortium led by SIO/UCSD, including JPL/NASA, MIT, MBARI, NCSA, NCSU, Rutgers, Univ Chicago, USC/ISI and WHOI, was awarded a contract to be the Implementing Organization (IO) for the development of the OOI CI. The first six months of the design phase have focused on architecture and design refinement and consolidation, and an initial science user requirements analysis and community involvement effort. In December 2007, the preliminary CI design [CI-PAD] was successfully reviewed in a PDR (Preliminary Design Review) by a panel of independent experts appointed by NSF, who provided very positive review comments.

Ongoing and future efforts focus on advancing the CI design and that of its subsystems to the next level to be ready for a Final Design Review (FDR) in November 2008. At the same time, the validation of any previously elicited and documented CI science user and system requirements through the community remains a main concern. Direct involvement of prospective CI user communities is of paramount importance to the success of the program. The requirements elicitation and management process is planned to be an ongoing activity in close collaboration with the user communities involved throughout the design and construction phases.

This report covers the outcome of the sixth requirements workshop with a topic covering Education and Public Engagement (EPE). It took place June 16-17, 2008, at the Embassy Suites in downtown Portland, OR. The focus was on the unique needs of education and outreach professionals who will use the OOI CI for teaching, inspiring the next generation of ocean scientists and fostering a more ocean-literate society.

The EPE workshop continues the series of CI architecture and design team organized workshops to identify and elicit requirements from domain users. Its goals were:

- Elicit requirements from domain education/outreach professionals and science translators who are actively engaged in technology-based observatory-related activities
- Provide an opportunity for exchange between the CI IO and the future EPE IO
- Provide the CI engineering team with further detailed insight into educational programs, and provide insight into current teaching/public outreach projects.
- Identify and elicit new user requirements for the CI from the view of this specific community
- Validate, refine and prioritize existing user requirements
- Refine and consolidate the basis for further requirements elicitation and domain modeling in subsequent instances of this workshop and in ongoing requirements and architecture design work

2.2 Outline

The remaining parts of this report are structured as follows: Section 3 summarizes the presentations given at the workshop and places them into the context of the education and public engagement background. Section 4 documents the direct workshop outcomes, such as discussion summaries, domain models, elaborated scenarios and prioritized requirements. Section 5 lists the science user requirements for the OOI CI originating from this and other workshops. Section 6 documents participant feedback and provides conclusions from the organizers. The appendices contain additional details about the workshop organization and background materials.

2.3 Preparation

The CI ADT has refined and adapted existing questionnaires with relevant questions for user requirements elicitation that was structured into selected categories. A shortened and tailored version of the questionnaire was sent to the workshop participants. The educators were asked to provide answers to the questions prior to the workshop. Appendix C of this report documents the participant questionnaire.

Each EPE invitee was asked to prepare an overview presentation covering projects, research interests and further relevant background information related to the OOI CI. The presentations were supposed to address the main topics covered by the questionnaire. The presentations covered approximately 15-20 minutes each, including questions.

2.4 Acknowledgements

This report was developed by the OOI CI Architecture Design Team; it contains input from many sources, such as the workshop presentations by the organizers and invited science/education and public

engagement users, the completed participant questionnaires, the CI preliminary architecture and design, OOI science background information by the project scientists, and notes taken by Claudiu Farcas and Michael Meisinger. Furthermore, this report contains summarizing and general statements by the organizers.

We thank the participating scientists profoundly for their time and efforts during the workshop and their valuable contributions to the OOI CI requirements elicitation process. We would also like to thank them for their efforts in filling out the participant questionnaire, providing further materials after the workshop, and for reviewing and validating this report.

2.5 Disclaimer

The contents of this report reflect the understanding and analyses of the CI ADT based on written workshop notes and general background. Errors in transforming them into this report are the responsibility of the CI ADT. No statements in this report are verbatim quotations of participants; there were no audio recordings of the discussions taken during the workshop.

3 Presentations

3.1 OOI CI User Requirements Elicitation Process

Cheryl Peach (Scripps Institution of Oceanography) welcomed the workshop participants, Oscar Schofield provided an overview of the future impact of the OOI on the scientific research process, and Michael Meisinger (University of California, San Diego) described the process for science user requirements elicitation. The OOI project is preparing for final design review in November 2008. A set of important activities covers refining and complementing direct user requirements for the OOI Integrated Obser-

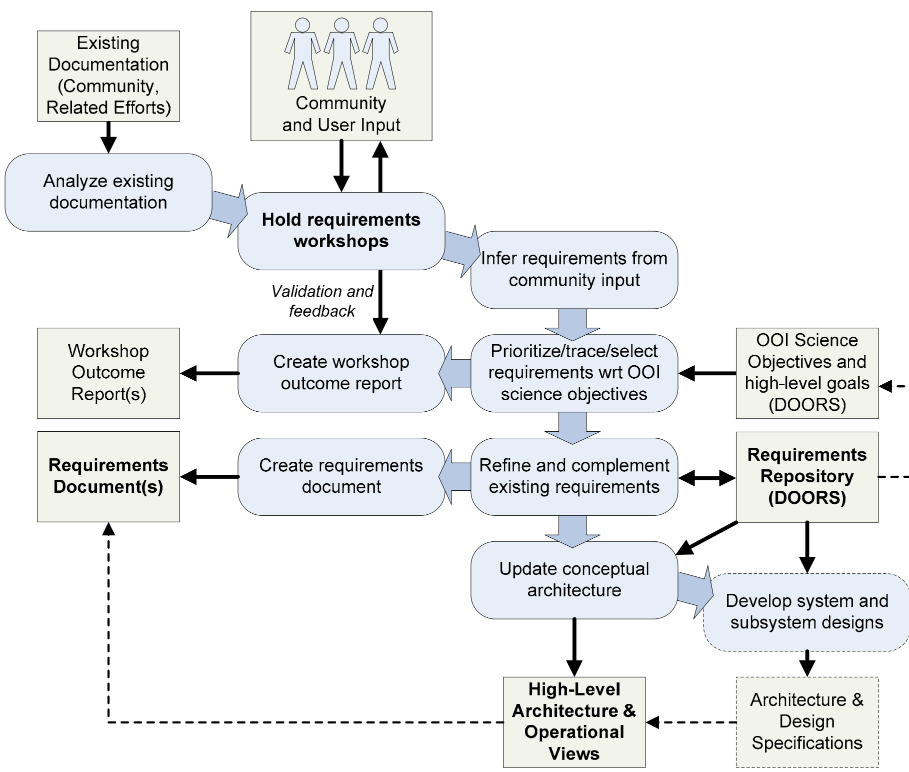


Figure 1: CI user requirements elicitation process until FDR

vatory with the cyberinfrastructure component as its "face". This workshop's goals are the collection of new requirements and validation of existing user requirements directly by workshop participants involved with education and public engagement programs. There have been other requirements workshops focusing on different topics.

3.2 CI Overview, Requirements and Architecture

Matthew Arrott (UCSD/Calit2), OOI CI Project Manager, represented by Michael Meisinger, provided an overview of the OOI CyberInfrastructure project and the CI project organization. The main goal of the CI is to support the three main research activities of observing, modeling and exploiting knowledge through a set of well-rounded resources and services. The CI infrastructure will be distributed across the country and will have points of presence at the sites of the main OOI observatory components on the east and west coasts.

The design process involves several iterations that advance the understanding of requirements and design. Previous design cycles lead to the conceptual architecture, the proposal for the OOI CI and the refinements for Preliminary Design Review (PDR). The current iteration emphasizes refining requirements and design for FDR.

One goal of this workshop is to detail the interfaces with the OOI for (1) the direct access to instruments through commands sent to them, (2) interactions with instrument resource agents through observation plans and (3) interactions between the infrastructure and resources in general. Communities of interest include the OOI marine observatories; each of the observatories and their resources need to be autonomous and all act as capability containers to manage membership, resources, storage, computation etc.

3.3 Project and Research Overview: Cheryl Peach

Cheryl Peach presented the history and context for the Education and Public Engagement (EPE) user requirements workshop. She explained the purpose of the workshop: eliciting requirements to help shape the OOI CI to address the unique needs of the education and outreach professionals, and assist them in their future work. Briefly, from the point of view of the educators, the CI IO provides support for sensor access, instrument data acquisition, processing and distribution, data analysis and visualization, and mission planning and control. The EPE effort is continuing a series of related efforts started in Puerto Rico (early 2005) and continuing through several activities in 2007. The importance of this effort was also reflected in the recommendations of the OOI CI Preliminary Design Review panel: "*A fourth IO for Education and Public Engagement (EPE) will be added … a program structure that will help realize the education goals, and support efforts to engage members of underrepresented groups in ocean science*".

Cheryl presented the role of the Educational Infrastructure (EI) to support "free choice" learning in a variety of physical and virtual environments such as science centers, aquaria, museums, on-line collaboration spaces, internet media, etc. The goal is to raise public awareness about the ocean sciences and related technological capabilities. In support of this goal, the EI will support post-secondary career development, and technical and educator training programs. The selection of an OOI EI facility will be an open competition process to identify a group of partners with the requisite knowledge, skills and experience to create robust, pedagogically sound infrastructure for future educational products and programs. A rigorous requirements, design, and engineering process similar to that of the CI will be applied. The fundamental role of the EPE IO will be the development of systems that bridge the gap between the CI scientific products and needs of the education professionals. For this purpose, a close collaboration with the other IOs and external partners is important.

3.4 Project and Research Overview: Sage Lichtenwalner

Sage Lichtenwalner (Rutgers University) presented the Coastal Ocean Observation Lab (COOL) and its role in promoting the ocean sciences and specific data products through intuitive interfaces to a wide range of users. The COOL Operations Center represents the informational core of this effort. It provides a wide range of services to the scientific community from mission planning and control of glider fleets, to operations and communications, data acquisition/processing/translation, and to specialized web products. The end products are tailored to a broad range of user groups such as faculty, students, educators, the general public, government agencies and coastal managers.

Sage explained that an important part of the COOL effort is data translation that has to take into account the usability, science, storytelling, programming and information aesthetics aspects for each product it delivers. Bridging the gap between the scientist and operator side, and the education and outreach sides, requires a different viewing perspective for science: what story can we tell, how do we represent the science, how do we visualize it? Figure 2 depicts this vision, showing how target audience can be classified based on expected scientific or technical aptitudes and concomitant presentation data complexity. The essence is that the audience is moving through the matrix depending on their current knowledge and usage pattern. For instance, a fisherman may start with tutorials to understand how to use the system, then ask some directed questions to assess his level of understanding; later on he could become very interested in how things work and want to get the raw data.

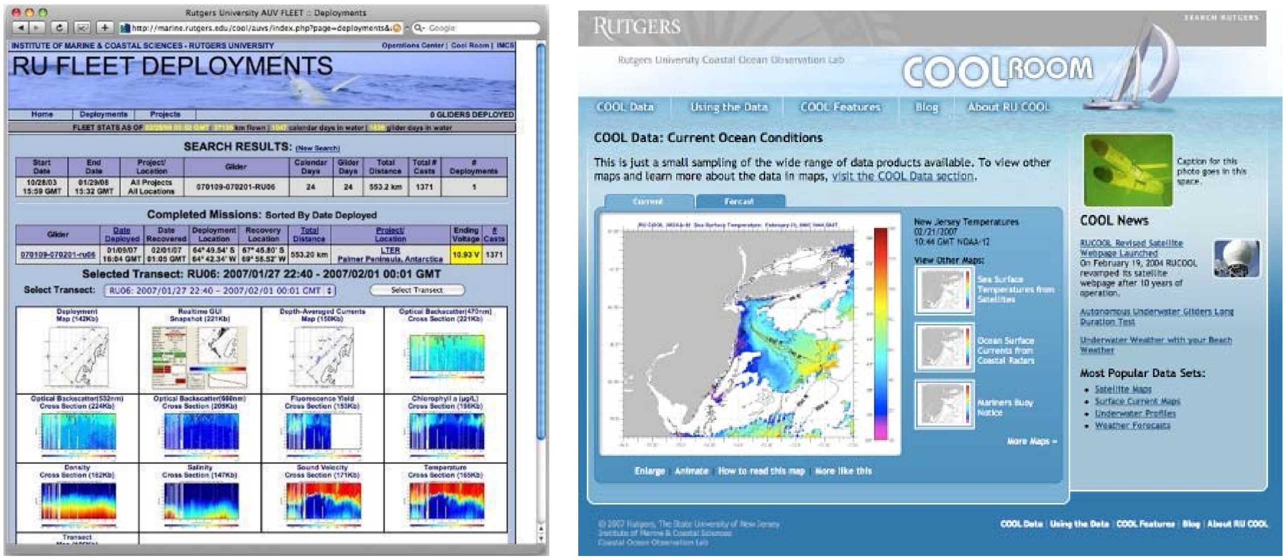
Data Complexity

Raw Data		Graduate Students	Researchers
Visualization Tools	User Tutorials*	Older Students	Typical Users (fishermen, CDM, transportation, etc.)
Canned Images	Younger Students		Curious Adults**
	Directed Inquiry	Guided Inquiry	Full Inquiry

Scientific Aptitude

The end-products, which most often materialize as web portals, have to take into account the data visualization cognitive levels of the target audience. For instance, the researcher-focused webpage from (a) presents data analysis tools and specific instrument information, whereas the recreational/formal education users' webpage from (b) presents intuitive interfaces, ample context, and higher-level data products with clear depiction of data and associated explanations. In this sense, the NEERRS/IOOS effort produced an evaluation for the ways in which K-12 teachers and students can use real-time data and associated education products to understand and appreciate the role of the environment in their lives [RTD].

Sage further presented the COOL classroom project that focuses on real-time data lessons and activities, simpler ways of establishing dialog with the scientific community, access to current research and associated explanation and pervasive teacher support. He also mentioned that there are very limited curricula and textbooks for marine science available. In addition, bringing the scientists, educators, graphic artists, and interface designers together is key in classroom applications. He described other informal learning options, including interactive floor exhibits, the Global Microscope, the Delta Lab at LSC and GAIA. In these cases, the mission is getting people to understand real science processes instead of playing with science experiments.



a) for scientists

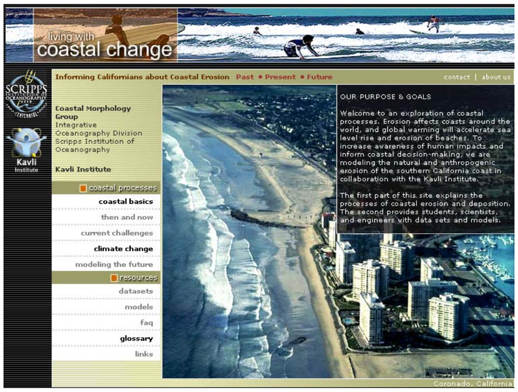
b) for educators and general public

Figure 3. Data Visualization Products

3.5 Project and Research Overview: Memorie Yasuda

Memorie Yasuda (SIO) presented the Earthguide group, a part of the Geosciences Research Division of the Scripps Institution of Oceanography, and its role in educating the public about the environment and in particular, about the oceans. This group works closely with the research community, educational institutions and affiliated educational outreach communities. The main focus is on public science education and literacy, with the main outcome in the form of web-based communication (portals, internet media, etc.). The group develops such information portals targeting non-scientist audiences that usually don't have expert level computer competence. Most of the effort goes into identifying the right content and the means for communicating the intended message to the public so that the resulting interactive experience is in balance with the basic science. As an example, she presented the "Forces of Nature" portal, which uses data from the Western Regional Climate Center and National Data Buoy Center (NDBC) to provide general public relevant information, such as weather forecasts for the Southern California region. Another example is the Earthquake Update Center, which through the ANZA seismic network data provides a simplified view of the earthquakes occurring within various spatiotemporal regions.

Memorie explained that in most cases educators have to deal with non-expert computer users; hence, intuitive tools and visual interfaces are needed. In addition, with increasing processing power and related computing capabilities for most consumer devices, the educators have to adapt and evolve visualization options to keep them modern and attractive. Security concerns due to executable content or end-user platforms are highly relevant for developing the tools and associated electronic material.
Prototyping (with the help of graphic artists) is also very important to aid a select group of end-users in formulating the requirements/wishes more clearly. Most visualizations are produced from multiple data sets that are often difficult to locate and integrate. The retrieved data are processed and stored locally, as the state of the data sources is uncertain.



Living Off the Land
Public website

For teachers
SDUSD

For students
SDUSD

For parents
SDUSD

Figure 4 - Quick tour of the Earthguide products

3.6 Project and Research Overview: Liesl Hotaling

Liesl Hotaling (Beacon Institute for Rivers and Estuaries) started by explaining the mission of her workplace toward building and sharing understanding and expert knowledge about the interaction of communities and ecosystems. The current project, River and Estuary Observatory Network (REON), is a collaboration with IBM and Clarkson University to monitor New York's Hudson River via a distributed system of sensor networks and robotics. The goal is to provide knowledge accessibility at all levels, starting with understanding on first glance for teachers and going toward easier usage of real-time data by end-users. This effort aims to provide innovative, standards-based curricula in multiple scientific fields for K-16 classrooms to help with experiment and sampling equipment design. Various means will be used to promote these outreach efforts: professional development workshops, public and school programming in Building One at Denning's Point State Park on the Beacon waterfront and elsewhere, postdoctoral fellowships in collaboration with WHOI, etc.

Liesl explained that the first step in establishing a knowledge path for students is addressing the accessibility problem for non-expert audiences. The data should be accessible by the public, easy to communicate, use, and understand. The accessibility aspect is tightly correlated with the reliability aspect for data distribution. A frequently "down" data source has limited appeal to end-users; hence, many educators currently mirror the data they need for teaching. Another limitation derives from the available bandwidth in many teaching environments. Displaying the data is problematic from both the technology (tools and platforms required) and semantic (how do we understand the data without being experts) points of view. To address the latter, the key is good organization of the data and maintaining some conventions on the way they are presented to the end-users.

Liesl suggested the following steps for improving the usability and understanding of data of interest. The learning experience should prepare and also empower students to address real-world complex problems. These kinds of problems and hands-on experience in solving them are generally more engaging that over-used textbook examples. The target outcome is to stimulate the students' ability to use scientific methods, teach them how to critically evaluate the integrity, reliability and robustness of data, and provide them with critical communication and technical skills. To achieve this goal, the next step is helping the educator understand the data, lessons and classroom implementation, and integrating them into current teaching practices. As a result, educators effectively prepared in how to use real time data in the classroom achieve better results in disseminating the knowledge and keeping the audience interested. The final step is the preparation of the general public, K-12 students, teachers and other educators for understanding and applying observatory data to real-life situations.

3.7 Project and Research Overview: Bob Collier

Robert (Bob) Collier (Oregon State University) started with a depiction of the OSU plans for education and public outreach: using the OOI as an opportunity for engineering education and providing support for marine/environmental policy decisions. One of the greatest challenges currently faced by the EPE effort is bridging the gap between science, engineering, educators and the public.

Bob then presented the goals of the adult education program: assisting adults in obtaining the knowledge and skills necessary for employment and self sufficiency; assisting parents in obtaining educational skills necessary to become full partners in their children's education; assisting adults in completing high school or the equivalent, and becoming effective citizens and community members. The program takes into account the different needs of each learner and is supported by both part-time and full-time paid teachers, non-paid volunteer tutors and paid instructional assistants. The learning process is conducted in various ways, including direct instruction classroom, one-on-one tutoring, self-paced lab training and self-directed learning via technology (e.g., web-based material).

Afterwards, he presented the Ocean Sciences and Math Collaborative Project that engages adult learners by linking ocean sciences with employment, environmental and economic concerns. This project is supported by the Oregon Department of Community Colleges and Workforce Development, the College of Oceanic and Atmospheric Sciences of Oregon State University, the Oregon Sea Grant and Hatfield Marine Science Center and the National Institute for Literacy. The adult learners benefit from content-based education in reading, writing, mathematical problem solving and using modern technology that helps expand their global perspective and environmental/ocean literacy. Students gain further motivation in studying ocean sciences, as they no longer feel like they are in remedial programs. This boosts the respect for the educational process and nurtures stewardship. In addition, teachers benefit from intensive three-day instruction and interesting opportunities to learn about the ocean sciences by participating in traditional oceanographic expeditions. The process is enhanced by conversations and communications between individual oceanographers and instructors, including visits of oceanographers to communities.

These EPE efforts target a broad audience ranging from community colleges, K-12, to correctional institutions, libraries, literacy councils, etc. The web is an integral part of the education process, as it promotes on-going communication and discussion among participants, media-rich content, and abstraction of the physical location of the teaching material. For instance, the IRIS Active Earth Display plots on a real-time map the earthquakes from the past 30 days in a simple, intuitive way adequate for the general public. Such educational material is easily adapted to other presentation mechanisms such as kiosks, large displays/billboards, etc.

3.8 Project and Research Overview: Deborah Kelley

Deborah Kelley's (University of Washington) presentation focused on the UW vision for the educational process enriched by the OOI. She pointed out the relationship between the oceanic crust and life as extremely complex and mostly unexplored: the ocean makes the Earth habitable. The ocean is though to be the birthplace of initial life-forms on our planet, and millions of years later it supports a great diversity of life and ecosystems. From her perspective, there are at least two science themes for OOI: plate-scale geodynamics (crustal movements and interactions at plate boundaries), and fluid-rock interactions and the subseafloor biosphere.

To explore the vast unknown that the ocean provides us, a series of sensor arrays will be deployed. The sensor arrays will provide measurements regarding earthquakes, volcanic eruptions, etc and will enable interactive experiments and study/surveillance of marine mammals in real-time. A strong collaboration with the EarthScope project will ensure better understanding of the ocean-crust movement processes. A particular area of interest is the Juan de Fuca Plate, where additional collaboration with the PNW seismic network and the Neptune Canada project will enable better earthquake and tsunami simulations and predictions (in a later phase).

Other exciting areas of interest for oceanographic studies are the blanco fracture zone and the axial seamount. The relationships between seismicity, deformation and fluid flow will be analyzed, along with their impact on topography. At the mid-ocean ridges more than 60% of our planet's volcanism occurs, yet there is a vast subseafloor biosphere with most ancient organisms waiting to be discovered. A wide range of instruments will be deployed to study these phenomena, from seismometers, thermistor arrays, cam-

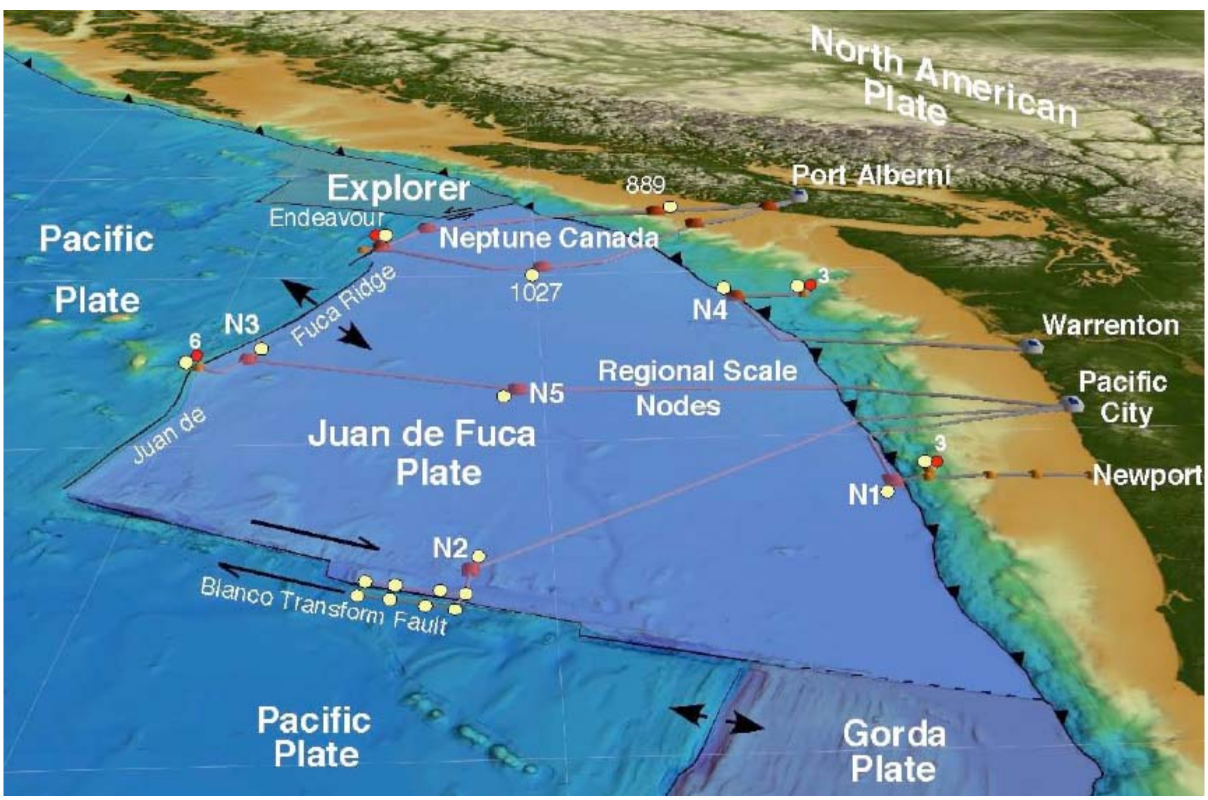


Figure 5 - Sensor arrays

eras, microbial and fluid samplers, mass spectrometers, pressure recorders. With such huge amounts of data coming to shore for analysis, there are many opportunities for bridging the science and education.

Of particular interest for a wider audience would be high-definition video streams from the seafloor to research institutions around the world. This would present some challenges in distribution of such multimedia content to institutions connected via low bandwidth links (a solution would be to provide still images and links for downloading large materials).

3.9 Project and Research Overview: Andrea Thorrold

Andrea Thorrold (WHOI/COSEE) presented the EPE efforts at WHOI and focused on the COSEE Networked Ocean World project. This project plans to use the observatories to educate the general public about the ocean. It aims to bridge the OOI and IOOS educational efforts and create a collaborative community by creating the right mix between the science and educational pedagogies. The reason is that for educating future generations, the sharing of information between scientists, teachers, tool developers, etc is essential. Particularly interesting challenges that could be addressed by efforts such as the OOI are the lack of online collaborative tools specific to the educational process and the research/discovery mechanisms for the collaboration opportunities in this field. Her work seeks to tap into existing infrastructure and projects to optimize availability and close the identified gaps.

She also presented Whyville, a science collaborative space for K-12 that educates kids in modeling and simulations and provides conceptual understanding through simplified models of oceanographic processes. Whyville provides services to approximately 3.5 million registered users spending an average of 3.5 hours per month each, generating around 1.2 million visits per month. Engaging the youngsters is important, as they have time to dig into details and develop new perspectives associated with oceanographic processes. For educators, there are tools to analyze the usage patterns of the end-users in detail that help in enriching the end-user experience and identifying new usage patterns. This project highlights the general idea that the content and visualization needs have to be carefully analyzed to gain the end-users' acceptance of any educational tool/website.

Figure 6 - Various EPE opportunities

4 Workshop Outcome

4.1 Questionnaire Response Analysis

The CI ADT received substantial input from the participating educators through the questionnaires that were handed to them prior to the workshop. The input from the questionnaires was analyzed and led to refinement and validation of the science user requirements. Selected statements are listed in the individual scientist background sections.

Questionnaires were received from:

- Sage Lichtenwalner
- Memorie Yasuda
- Liesl Hotaling

Major Challenges:

- The education and public outreach applications will use OOI data in science centers, zoos, aquaria, parks/river walks/fishing piers and weather reports/shore forecasts. For this purpose, a significant challenge arises in making the data accessible to various audiences (e.g., translation of data/information for a wide spectrum of learners, developing intuitive displays and interfaces for users to access datasets in ways appropriate for their needs and expertise).
- Developing the contextual support (tutorials and background information) that explain the data. For example, what instrument was used, why was that instrument used, what will it collect, what significance does the measured variable have in the region being studied/monitored and why is that important?
- In the education community, proper context also includes developing lessons with well-posed "problems" that have meaning to students (motivation) and address relevant standards (both content and skills).
- Showing data within its proper scientific context (e.g. within climate averages, compared to notable extreme values or events)
- Developing new pseudo-datasets and/or visualizations that have more meaning for the audience being served (e.g., an anomaly map instead of a real-value map or having students analyze ocean/land temperature differences to study the concept of heat capacity instead of just looking at one variable for the sake of "playing with data")

From the point of view of educators, the ideal CI would allow for multiple Levels of Scaled Interactions:

- Entry Level – Packaged (archived) and pushed data that tells a concise "story"
- Adoption Level – Lessons and activities that utilize packaged data
- Adaptation Level – Lessons and activities that utilize real-time data and push for analysis/interpretation/prediction
- Interactivity Level – Lessons and activities that manipulate data using models
- Invention Level – User-designed investigations

CI short-term support:

- Data available in standardized forms
- Simplified navigation through metadata
- Ability to subset data based on lat/long (GUI preferred) and other parameters
- Real-time data transfers
- Reliable data set access

CI mid-term support:

- better data visualization,
- repository of tools to browse, transform and visualize data
- improved data accessibility and organization
- real-time data transfer
- intuitive interactivity with the integrated observatory

CI long-term support

- flexible data use through web 2.0 and succeeding tools for
  - browsing through datasets using several visualization styles
  - producing ready-to-use material for websites (e.g., plots)
  - processing data in various formats (GMT, GIS, ASCII for Flash, XML)
  - geospatial transformations
- interoperability with other observatories across disciplines/directorates.

Data sources that are currently used:

- Rutgers Sea Surface Temperature (SST) satellite maps: http://marine.rutgers.edu/mrs/sat_data/
- Satellite chlorophyll, HF radar surface current maps and glider transect data
- Time-series data from NDBC buoys or USGS stream gauges
- Hourly land-based data from historical weather station data archived at the Western Regional Climate Center
- Ocean-based data from the National Data Buoy Center, including data from NOAA and Scripps' CDIP buoys
- Bathymetry and elevation
  - NGDC - ETOPO5 and GLOBE composite.
  - GEBCO
- High-resolution bathymetry from selected regions – La Jolla Canyon, Hawaii, etc.
- Seismic forecast visualizations – TeraShake earthquake simulations
- Hydrographic conditions and seawater chemistry – WOCE, CalCOFI
- Satellite imagery – GOES, SSEC U. of Wisconsin
- ENSO – various
- Tide prediction and simulation – NOAA, OSU
- Global wave height – FNOC (Navy)
- Various data types accessible on NASA Visible Earth
- Weather – National Weather Service (NWS)

Currently used applications:

- Matlab scripts
- Flash for web-based interactive content (regular HTML for websites)
- Experimental stage: Mapserver, Google Earth and other tools for interactive data display

4.2 Domain Analysis and Modeling Sessions

The effort of the educators target the following user groups:

- teachers
- students
- community college institution
- data translators (developers of educational applications/teaching materials)
- application developers
- non-academic (general public)

High-level CI capabilities expected by educators:

- Repository for tools, transformations
  - E.g., WHOI Matlab toolbox
- Search for information & data sources
- Track data provenance
- Collect content materials (e.g., Wikipedia)
- Provide collaborative workspace
  - E.g., similar to Confluence, equivalent of "Google Docs for data"
  - document, file, content sharing capabilities
  - chat, feedback, and comment capabilities
- Standard way of accessing data
- Support for various application technologies
- Establish loose coupling between data producers and data consumers
  - use well-defined standards
  - maintain compatibility
- Provide non-disruptive operational environment
- Support debugging and troubleshooting
- Provide user-access statistics
- Enable controlled, moderated social networking
- Provide multimedia content in various output formats (e.g., Flash, Quicktime)
- Support versioning and configuration control of tools, code, content and designs
- Extensible by end users

Low level details of CI capabilities, as seen by educators (wish list):

- environment evaluation
- dashboard-like environment
  - how tos – to help educators get started with new lessons, experiments, etc.
  - projects – space for grouping together all of the information regarding specific projects
    - collaboration with other schools or institutions
    - data capabilities
      - aggregation
      - filtering
      - qa/qc
    - transformation capabilities
      - provide processing tools
        - get standardized input
        - produce standardized output
        - extension can be uploaded
        - version information is attached
      - enable map projection
      - sketch and test applets
    - visualization capabilities
      - active user interfaces (interactivity is very important)
        - customizable tool boxes with multiple choices (e.g, maps)
        - analysis and visualization feedback
        - interactive annotation for available material
        - highlight key findings
        - two-way interactions between user and data
        - commenting on resources is valuable to select best data sources
        - provide simple widgets
          - display / plot / aggregate

          - publishable
          - in repository
          - history
          - wizard to confirm options
          - preset options (templates)
        - data details revealed incrementally (click to get more)
          - display of sensor locations (3d)
          - history
      - templates for interface builders
      - pre-packaged material
        - images
        - videos
    - teaching tools repository
    - experiment organization capabilities
      - characterize platform, experiment, rationale
    - virtual labs for students
  - shareable with community
  - personalized aka iGoogle
  - group-relevant information
- social networking
  - "Amazon recommends" capability
  - share knowledge
  - share tools
  - share models
  - share templates
  - swivel
  - IBM Many Eyes (http://services.alphaworks.ibm.com/manyeyes/app)
  - blogs for resources, visualizations
  - publish science
  - make easy for other people to contribute
  - what are the benefits of sharing?
    - incentives
- general public
  - can feed data
  - can interact
  - gets real-time coverage
- store
  - data
  - tools of various kinds
  - history

4.2.1 Scenario 1

Question: What is the role of the ocean in the CO_2 problem?
Display: Digital display at a science center such as Global microscope/Science of a sphere (a big globe using projection to show images)
Audience: Free choice
Content: prepackaged or "real-time"
Output: generally web, images, sometimes pre-rendered videos, nothing 3d real-time.

Process:

1. Develop a vision of the teaching process with main concepts in place (e.g., what do you want to teach, at which level, etc.)
2. Collect contextual information: e.g., Google search, listserv postings, conferences, social networking with peers/contacts
3. Develop proposal by laying out the ocean concepts and science, describe data sources and resources to be used, detail the teaching plan and outreach goals.
4. Define/decide on which interactive platform to use for the application, views to present. Identify future extensibility and adaptability aspects of the selected visualization option.
   Perform the following iterative process (with quality control from peers/collaborators):
   - Select data sources to be used (OOI vs non-OOI) and check their capabilities (data quality, reliability, real-time availability, etc).
   - Identify the means for data transfers: streams, http/ftp download.
   - Establish the data transformations and format conversions needed by the target application with respect to available data sources.
   - Begin to shape the educational stories and sketch data flow and target data products
   - Add content materials while taking into account their source and cost.
   - Address the issues of intellectual property and establish agreements/contracts with clearly defined permissions.
   - Add language translations for products targeting non-English speaking audiences.
5. Design the solution based on the needs of the target audience
6. Start the integration process:
   - interact with the data providers;
   - request adaptations where needed/possible of data formats;
   - establish partnerships with PIs of various projects of interest (e.g., for visualizations);
   - contact agencies such as NOAA, ONR and data centers for access to data repositories;
   - look for/at existing toolboxes and identify how can they be adapted to the target product.
7. Develop storyline - convey the main messages and brainstorm for ideas on follow-ups. Modify visualization options, add components such as flash animations, videos, etc. Iterate this development process for weeks to months and produce several prototypes.
8. Get end-user involvement: create focus groups, solicit feedback on prototypes, incorporate feedback into subsequent releases.
9. Define quality control methods: evaluation plan, formal evaluation if required, different levels of assessment based on target audiences, formal reviews with specialized panels.
10. Roll out the official releases to public (generally after one year of development).
11. Establish operation and maintenance plans (generally out of budget): no change plans, defer to IT support, in-house support for major projects.

4.2.2 Scenario 2

Question: how do methane hydrates develop at 10,000 years scale?
Display: interactive visual observation display
Audience: general public
Content: Use gas hydrate observatories for initial material
Output: From education story back to virtual ocean environment up to the climate process. Tools and visualization capabilities should be provided to enable simple navigation across various data abstraction levels.

Current challenges:

- No way to keep track of developments made over time for specific purposes
  - Corporate memory
  - Rationale

- Changes to data formats
- Co-registration of data in space
- Disruptions in data flow
- Get teachers to understand and use applications
- Video playing in classrooms
- Not much demand for design documentation
- Not enough data translators
    - not enough trained individuals
    - requires specific qualifications
        - science writing
        - science background
        - visualization
    - very specific subset of already specialized data handling
- Tagging of data, being able to find data when needed
    - scientific meta-data are not always descriptive enough (explanations are needed for complex processes)
- Ocean science needs further grounding in other sciences
    - translation/mapping needs to be present for teachers
- Difficulty of multiple contributions
- Extensibility

4.3 Most important features for educators

The participants were asked to vote on the two most wanted features from the initial release of the OOI CI from their individual points of view. The results are summarized below:

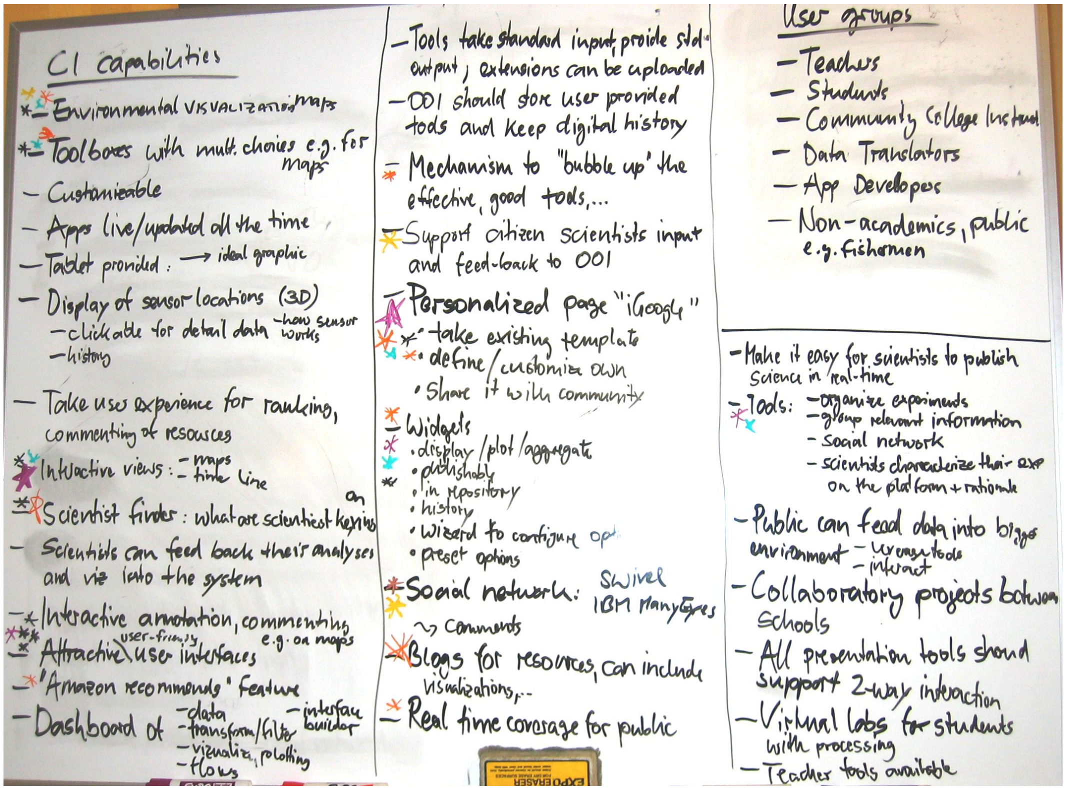


Figure 7 - Voting for the top CI features needed by educators

4x environmental visualizations
3x toolboxes w/ multiple choices (e.g, for maps)5x interactive views
5x “attractive” user interfaces
1x “amazon recommends”
1x mechanisms to bubble up the effectiveness of applications by targeting larger audiences
1x support citizen scientist input and feedback into OOI
5x personalized iGoogle-like page

- 2x take existing templates
- 2x define/customize own page

4x widgets

- 1x display/ plot /aggregate
- 1x publishable
- 1x in repository

2x social networking
1x blogs for resources
1x real-time coverage for public
2x tools for organizing experiments, group related info, etc
2x make it easier for more people to contribute
3x contribute applets, processing tools, etc

5 Science User Requirements

5.1 Requirements Elicitation Process

The requirements listed in the next section represent the current collection of science user requirements for the OOI CI. Some of the requirements were identified in prior requirements workshops and partially validated by the participants. Further requirements originate from the analysis of related cyber-infrastructure efforts. The remaining requirements were identified through a thorough post-workshop analysis process. Requirements were either directly stated by the participants during the workshop discussions, called out in the participant questionnaires or inferred through a requirements analysis process by the CI architecture and design team. Requirements are grouped into categories and formatted according to a template as described below.

In order to uniquely identify the elicited requirements, each requirement in this report follows a standard template. Each requirement contains a unique identifier issued by the DOORS requirements management system. Furthermore, each requirement contains a label and an explanation. Requirement labels are constructed in a schematic way.

The listed requirements strive to be atomic (i.e., they express one idea only and do not contain sub-requirements). However, requirements might be related and one requirement might be influenced by another requirement. Further, the explanation might contain additional details about the requirement.

5.2 OOI Cyber User Requirements

This section contains a list of science user requirements as exported from the OOI cyber user requirements DOORS module on 7/31/08. It shows the identifiers and requirements labels and omits explanations and further attributes, such as priority. Please refer to [OOI-CU-REQ] for a full generated view containing all attributes. Requirements are grouped into categories, as indicated by the bold labels in the table. The numbering reflects the structure of the DOORS module. The requirements list contains all CI user requirements to date. Requirements that are traceable to the Education and Public Engagement (EPE) requirements workshop are marked in italics.

ID	Requirement / Category Heading
	4.1 Resource Management
L2-CU-RQ-50	The CI shall support distributed resources, applications and actors
L2-CU-RQ-51	The CI shall provide the capability for a given resource to initiate change in another resource
L2-CU-RQ-52	All resources under CI governance shall be identifiable
L2-CU-RQ-53	All resources under CI governance shall be authenticatable
L2-CU-RQ-54	All resources under CI governance shall be authorizable
L2-CU-RQ-55	All resources under CI governance shall be auditable
L2-CU-RQ-56	The CI shall incorporate a policy-based decision system for the management of CI-governed resources
L2-CU-RQ-57	The CI shall ensure that resource utilization is governed by the rights and allocations of the initiating actor
L2-CU-RQ-58	The CI shall enable non-persistent connection of resources, users and applications
L2-CU-RQ-59	The CI shall act as the facilitator and broker for resource usage
L2-CU-RQ-60	The CI shall schedule resource usage based on capacity, capability and availability
L2-CU-RQ-61	The CI shall support the evolution of resources under CI governance
L2-CU-RQ-62	The CI shall support the resource life cycle, providing notification to resource providers and consumers when manual intervention is required

ID	Requirement / Category Heading
L2-CU-RQ-63	The CI shall provide a catalog listing all resources under CI governance
L2-CU-RQ-64	The CI catalog shall provide status information for all resources under CI governance
L2-CU-RQ-65	All resources under CI governance shall be discoverable, either directly, by content or through their associated metadata
L2-CU-RQ-66	Multiple actors shall be able to simultaneously discover the same resource
L2-CU-RQ-67	The CI shall integrate resource discovery with resource access subject to policy
L2-CU-RQ-68	The resource catalog shall link entries to the associated metadata
L2-CU-RQ-69	The resource catalog shall incorporate information about physical samples
L2-CU-RQ-70	The CI shall cross-reference CI-governed resource catalogs and external resource catalogs
L2-CU-RQ-71	The CI shall enable discovery of all information resources that are derived from a given original information resource
L2-CU-RQ-72	The CI shall provide resource subscribers automatic and manual fallback options with similar characteristics in case the original resource becomes unavailable
L2-CU-RQ-73	The CI shall provide services to group resources
L2-CU-RQ-74	The CI shall provide registration services for resource notification
L2-CU-RQ-75	The CI shall automatically register resources for notification to the observatory operator
L2-CU-RQ-76	The CI shall provide notification of resource state change to all resource subscribers
L2-CU-RQ-77	The CI shall bind metadata to all resources under CI governance throughout the resource life cycle
L2-CU-RQ-78	The CI shall support standard OOI-standard metadata content that includes, but is not limited to, a complete description of resource behavior, content, syntax, semantics, provenance, quality, context, citation, correspondence and lineage
L2-CU-RQ-79	The CI shall specify and utilize a standard vocabulary
L2-CU-RQ-80	The CI shall maintain the relationship between OOI standard metadata and the vocabulary
L2-CU-RQ-81	The CI shall allow resource discovery utilizing the standard vocabulary
L2-CU-RQ-82	The standard vocabulary shall accommodate information on physical samples
L2-CU-RQ-83	The CI shall provide data generating resources using proprietary metadata formats with a means to transform them to OOI standard metadata
L2-CU-RQ-84	The CI shall support the provisioning of OOI standard metadata
L2-CU-RQ-85	The CI shall verify compliance of metadata with the OOI standard
L2-CU-RQ-86	The CI shall update resource metadata within 5 seconds of resource reconfiguration
L2-CU-RQ-87	The CI shall provide services for control and monitoring of observatory infrastructure resources
L2-CU-RQ-88	The CI shall provide services for pervasive resource monitoring and control
	4.2 Data Management
L2-CU-RQ-90	The CI shall be capable of archiving all data and data products associated with an OOI observatory
L2-CU-RQ-91	The CI shall act as a broker for CI-managed data products
L2-CU-RQ-92	The CI shall ingest data with variable delivery order
L2-CU-RQ-93	The CI shall support the delayed distribution of temporarily sequestered data
L2-CU-RQ-94	The CI shall ensure the integrity and completeness of all archived data products throughout the OOI life cycle
L2-CU-RQ-95	The CI shall ensure that all archived data products can be restored to their most recent state
L2-CU-RQ-96	The CI shall provide a topic-based (publish/subscribe) data distribution infrastructure
L2-CU-RQ-97	The CI shall provide registration services for data subscriptions
L2-CU-RQ-98	The CI shall publish unprocessed raw sensor data

ID	Requirement / Category Heading
L2-CU-RQ-99	The CI shall archive unprocessed raw sensor data
L2-CU-RQ-100	The CI shall support the publication, distribution and archiving of different versions of the same data product or stream
L2-CU-RQ-101	The CI shall support real-time data delivery
L2-CU-RQ-102	The CI shall support guaranteed data delivery
L2-CU-RQ-103	The CI shall support store until requested (pull mode) data delivery
L2-CU-RQ-104	The CI shall support streaming data delivery
L2-CU-RQ-105	The CI shall integrate multiple data streams or data sets into a single stream or set, eliminating redundant entries
L2-CU-RQ-106	The CI shall support peer-to-peer communication between discoverable resources
L2-CU-RQ-107	The CI shall support secure data delivery
L2-CU-RQ-108	The CI shall adapt data delivery in the presence of limited available bandwidth according to policy
L2-CU-RQ-109	The CI shall notify registered resource users when data delivery cannot be achieved due to low available bandwidth
L2-CU-RQ-110	The CI shall adapt data delivery in the presence of high channel latency according to policy
L2-CU-RQ-111	The CI shall notify registered resource users when data delivery cannot be achieved due to high channel latency
L2-CU-RQ-112	The CI shall publish data from external data sources, data bases, and data distribution networks from related scientific domains.
L2-CU-RQ-113	The CI shall provide support for large volumes of data
L2-CU-RQ-114	The CI shall archive and catalog text, images, pdf, .doc files and spreadsheets
L2-CU-RQ-115	The CI shall flag and notify data stream and data set state change
L2-CU-RQ-116	The CI shall flag and notify redundant data and metadata
L2-CU-RQ-117	The CI shall acknowledge requests for data with an estimate of delivery latency
L2-CU-RQ-118	The CI shall credit data publishers when data products are accessed
L2-CU-RQ-119	The CI shall provide services and interfaces for the acquisition of bulk data
L2-CU-RQ-120	The CI shall associate bulk data with their metadata and related data products
	4.2.1 Data Transformation
L2-CU-RQ-122	The CI shall support the moderation and auditing of published data
L2-CU-RQ-123	The CI shall provide services for interactive and automated data quality control (QC)
L2-CU-RQ-124	The CI shall perform automated quality control of observational data products in near real-time
L2-CU-RQ-125	The CI shall provide standard and user-defined methods to assess the quality of data
L2-CU-RQ-126	The CI shall specify data models for resources based on characterization of structure (syntax)
L2-CU-RQ-127	The CI shall translate between standard syntactic data models without loss of information
L2-CU-RQ-128	The CI shall support translation between user-specified syntactic data models
L2-CU-RQ-129	The CI shall specify data models for resources based on characterization of meaning (semantics)
L2-CU-RQ-130	The CI shall support mapping between senders and receivers using the standard vocabulary without loss of information
L2-CU-RQ-131	The CI shall provide capabilities to define event detectors
L2-CU-RQ-132	The CI shall provide event detection services
L2-CU-RQ-133	The CI shall provide registration services for event notification
L2-CU-RQ-134	The CI shall provide notification of detected events

ID	Requirement / Category Heading
L2-CU-RQ-135	The CI shall provide versioning for detected events
L2-CU-RQ-136	The CI shall update data sets as sensor calibrations become available
L2-CU-RQ-137	The CI shall be able to accumulate knowledge about the scientific interpretation of observational data from manual mapping and linking of variables between different data sets
L2-CU-RQ-138	The CI shall be capable of co-registering data from different instruments in space and time
	4.3 Research and Analysis
L2-CU-RQ-140	The CI shall suggest suitable data products, observation resources, analysis tools, visualization tools and other OOI resources based on user-specified research questions using the standard vocabulary
L2-CU-RQ-141	The CI shall support interactive data analysis and visualization through tools and user interfaces
L2-CU-RQ-142	The CI shall provide a standard, extensible set of data processing elements that provide data assimilation, alignment, consolidation, aggregation, transformation, filtering, subsetting, averaging and scaling
L2-CU-RQ-143	The CI shall provide capabilities for analysis and presentation of environmental data at specified sites
L2-CU-RQ-144	The CI shall support the integration of external analysis tools
L2-CU-RQ-145	The CI shall provide capabilities to transform between coordinate systems
L2-CU-RQ-146	The CI shall provide capabilities to transform between map projections
	4.4 Ocean Modeling
L2-CU-RQ-148	The CI shall enable the efficient configuration, execution, and debugging of numerical ocean models
L2-CU-RQ-149	The CI shall support the interaction of model developers and non-expert model users
L2-CU-RQ-150	The CI shall provide capabilities to tune numerical models
L2-CU-RQ-151	The CI shall provide a virtual model environment and simulator to determine optimal model inputs, parameterizations and outcome qualities
L2-CU-RQ-152	The CI shall enable the sharing of ocean modeling, data assimilation and visualization components, including the extension of models with new model components
L2-CU-RQ-153	The CI shall provide a repository and sharing capabilities for numerical model algorithms, model configurations, data processing tools and documentation
L2-CU-RQ-154	The CI shall archive numerical model workflows under configuration control
L2-CU-RQ-155	The CI shall recompute model data products using archived workflows
L2-CU-RQ-156	The CI shall enable the modification of archived workflows
L2-CU-RQ-157	The CI shall provide an environment for the development of community numerical models under community process support
L2-CU-RQ-158	The CI shall provide a non-restricted environment for the development of independent numerical models
L2-CU-RQ-159	The CI shall support the nesting of ocean models at different geographical scales
L2-CU-RQ-160	The CI shall provide a framework for the adaptation of model resolution to the available resources
L2-CU-RQ-161	The CI shall support model ensemble definition, execution and analysis
L2-CU-RQ-162	The CI shall publish both elements of and aggregated ensemble data products from ocean models
L2-CU-RQ-163	The CI shall support flexible high performance model execution
	4.5 Visualization
L2-CU-RQ-165	The CI shall provide interactive 2D, 3D and 4D visualization tools
L2-CU-RQ-166	The CI shall provide 3D visualization of sensor locations and their environment

ID	Requirement / Category Heading
L2-CU-RQ-167	The CI shall support the integration of external visualization tools
L2-CU-RQ-168	The CI shall provide extensible, configurable visualization capabilities for data streams
L2-CU-RQ-169	The CI shall provide a zooming interface for all visualizations with at least three levels of detail
L2-CU-RQ-170	The CI shall provide a user interface system that includes at least two different views of the data
	4.6 Computation and Process Execution
L2-CU-RQ-172	The CI shall support the execution of large scale numerical ocean models across different locations on the network
L2-CU-RQ-173	The CI shall support workflows for automated numerical model execution, including just-in-time input data preparation, model computation, output post-processing, and publication of results
L2-CU-RQ-174	The CI shall enable the one-time and recurring execution of numerical models on any net-worked computational resource with quality-of-service guarantees based on contracts and policy.
L2-CU-RQ-175	The CI shall provide interfaces to compose workflows
L2-CU-RQ-176	The CI shall provide services to execute workflows on computational resources with varying characteristics
L2-CU-RQ-177	The CI shall provide services to chain a plurality of workflows
L2-CU-RQ-178	The CI shall provide services to monitor and control instantiated processes
L2-CU-RQ-179	The CI shall provide actors with estimated performance/turnaround for instantiated proc-esses
L2-CU-RQ-180	The CI shall provide event-triggered workflow execution services
L2-CU-RQ-181	The CI shall provide real-time access to high performance computation resources
L2-CU-RQ-182	The CI shall provide process support for the planning and operation of observational pro-grams
L2-CU-RQ-183	The CI shall provide process support for the coordination of instrument recovery, mainte-nance and replacement
L2-CU-RQ-184	The CI shall support, automate and combine workflows of shipboard observers
	4.7 Sensors and Instrument Interfaces
L2-CU-RQ-186	The CI shall provide a real-time communication interface for remote resources
L2-CU-RQ-187	The CI shall support robust instrument development, operation and maintenance processes
L2-CU-RQ-188	The CI shall support discovery of the characteristics of sensors deployed on an instrument platform
L2-CU-RQ-189	The CI shall support adaptive observation resource control
L2-CU-RQ-190	The CI time standard shall be NIST traceable
L2-CU-RQ-191	The CI shall provide a synoptic time service with an accuracy of 1 microsecond to all re-sources connected to the OOI observatories
L2-CU-RQ-192	The CI shall serve synoptic time throughout the observatory using Network Time Protocol
L2-CU-RQ-193	The CI shall provide services to correct remote clocks to a synoptic standard
L2-CU-RQ-194	The CI shall provide services to synchronize remote clocks relative to each other with an accuracy of 1 microsecond
L2-CU-RQ-195	Upon receipt, the CI shall synoptically timestamp message headers with an accuracy of 1 millisecond
L2-CU-RQ-196	The CI shall provide robust instrument access protocols
L2-CU-RQ-197	The CI shall provide direct bidirectional communications to resources that preserves their native functionality

ID	Requirement / Category Heading
L2-CU-RQ-198	The CI shall provide remote desktop access to resources that preserves their native functionality
L2-CU-RQ-199	The CI shall automatically close down inactive direct access sessions
L2-CU-RQ-200	The CI shall provide interactive web-based configuration of instrument platforms, instruments and sensors
L2-CU-RQ-201	The CI shall provide capabilities and interfaces for monitoring of resource-specific operational and environmental parameters
L2-CU-RQ-202	The CI shall provide services for positioning of mobile assets with a precision commensurate with the location technology
L2-CU-RQ-203	The CI shall support automated docking of mobile resources, including power management and high speed data down and up load
L2-CU-RQ-204	The CI shall be capable of triggering instrument measurements
	4.8 Mission Planning and Control
L2-CU-RQ-206	The CI shall support swarm-based deployment patterns for mobile instruments
L2-CU-RQ-207	The CI shall provide a repository for instrument behaviors
L2-CU-RQ-208	The CI shall provide a repository for observation plans
L2-CU-RQ-209	The CI shall provide shore-side and on-vehicle control capabilities for autonomous observational resources
L2-CU-RQ-210	The CI shall support observational resource control at different user-selected levels
L2-CU-RQ-211	The CI shall integrate environment and vehicle behavior models for event detection, coordinated control and adaptive sampling
L2-CU-RQ-212	The CI shall provide capabilities and interfaces for planning longitudinal observations
L2-CU-RQ-213	The CI shall provide capabilities and interfaces for planning objective-driven observations
L2-CU-RQ-214	The CI shall provide capabilities and interfaces for ad-hoc interactive and automated modification of ongoing observations
L2-CU-RQ-215	The CI shall provide capabilities and interfaces for simulating and verifying observation plans
L2-CU-RQ-216	The CI shall provide resource provisioning calculations from observation plans
L2-CU-RQ-217	The CI shall support observation planning and scheduling decisions based on the opportunity cost of observations and resource provisioning
L2-CU-RQ-218	The CI shall provide graphical user interfaces for planning observations and missions with spatial and temporal visualization of observation parameters
L2-CU-RQ-219	The CI shall provide spatial visualization of observation data overlaid with observation plans
L2-CU-RQ-220	The CI shall support tasking, deployment, mission control and retrieval of mobile and fixed instruments
L2-CU-RQ-221	The CI shall provide capabilities and interfaces for the simulation of observational infrastructure
	4.9 Application Integration and External Interfaces
L2-CU-RQ-223	The CI shall provide documented resource-data connectors for all services
L2-CU-RQ-224	Conditional on OOI policy, the CI shall not impose specific processes, tools and formats on resource providers for the operation and control of their OOI-connected resources
L2-CU-RQ-225	The CI shall interface with external resource monitoring, operation and control systems
L2-CU-RQ-226	The CI shall provide a Web 2.0 environment
L2-CU-RQ-227	The CI shall support interfacing with web service-accessible resources
L2-CU-RQ-228	The CI shall interface to live video feeds during instrument operation and maintenance
L2-CU-RQ-229	The CI shall provide interface support for Java-based tools and scripting languages
L2-CU-RQ-230	The CI shall provide standalone installations that may have no or intermittent connection to

ID	Requirement / Category Heading
	the OOI network
	4.10 Presentation and User Interfaces
L2-CU-RQ-232	The CI shall provide annotation, commenting, ranking and rating services for CI-managed resources
L2-CU-RQ-233	*The CI shall provide user and group workspace capabilities*
L2-CU-RQ-234	*The CI shall provide capabilities to personalize user and group workspaces*
L2-CU-RQ-235	The CI shall provide social networking capabilities
L2-CU-RQ-236	The CI shall provide an intuitive interface to access the functionality of all CI services and resources
L2-CU-RQ-237	*The CI shall present the full CI functionality at a single access point with a single dashboard*
L2-CU-RQ-238	The CI shall provide services to make OOI-standard metadata human readable
L2-CU-RQ-239	The CI shall provide a resource monitoring and control interface
L2-CU-RQ-240	The CI shall provide an adaptive, simple-to-use interface for data access
L2-CU-RQ-241	The CI shall provide transparent access to heterogeneous, large-scale computational resources
L2-CU-RQ-242	The CI shall provide transparent access to heterogeneous, large-scale storage resources
L2-CU-RQ-243	The CI shall provide a single user interface that supports observatory operators, science and engineering users, the education community and the general public
L2-CU-RQ-244	The CI shall provide dialog box interaction for operations requiring the input of more than two parameters
L2-CU-RQ-245	The CI shall provide input screens that include tabs for any process that requires users to input more than five parameters
L2-CU-RQ-246	The CI shall provide a common font set for all screens
L2-CU-RQ-247	The CI shall employ a common look and feel based on a standard screen design
L2-CU-RQ-248	The CI shall employ a standard set of colors for use in all user interface presentation screens
L2-CU-RQ-249	The CI shall employ a standard workflow for all user interface screens
L2-CU-RQ-250	The CI shall employ a common navigation scheme that is consistent from application to application
L2-CU-RQ-251	The CI shall provide visualization and metadata browsing of the processing pipeline
L2-CU-RQ-252	The CI shall provide checklists for standard instrument operations
L2-CU-RQ-253	The CI shall provide capabilities and interfaces to capture structured input, feedback and results from analysis processes on data
	4.11 Security, Safety and Privacy Properties
L2-CU-RQ-255	The CI shall authenticate and authorize all resources connected to an OOI observatory
L2-CU-RQ-256	The CI shall authenticate all observatory actors
L2-CU-RQ-257	The CI shall provide different levels of access to actors with different levels of authorization
L2-CU-RQ-258	The CI shall enforce user privacy policies
L2-CU-RQ-259	The CI shall be capable of auditing all services and resources under CI governance
L2-CU-RQ-260	The CI shall trace resource utilization to the initiating actor
L2-CU-RQ-261	The CI shall support different levels of access for resources and their metadata
L2-CU-RQ-262	The CI shall protect physical resources from damage and misuse by enforcing resource use policies
L2-CU-RQ-263	The CI shall provide interfaces to define security and policy for information managers at participating institutions
L2-CU-RQ-264	The CI shall support the diversion, filtering and sequestering of raw data streams at the acquisition point

ID	Requirement / Category Heading
	4.12 Quality Properties
L2-CU-RQ-266	The CI infrastructure shall deliver messages with reliability that is comparable to that of the Internet
L2-CU-RQ-267	The CI shall provide robust, reliable remotely deployed components
L2-CU-RQ-268	The CI shall provide services with reliability and accuracy that is comparable to those of distributed Internet applications
	4.13 Education and Outreach
L2-CU-RQ-270	The CI shall provide numerical ocean models with a limited set of modifiable parameters for educational purposes
L2-CU-RQ-271	*The CI access point shall provide educators with instructions about data usage*
L2-CU-RQ-272	*The CI access point shall provide the educator with a list of projects and their attributes*
L2-CU-RQ-273	*The CI access point shall provide the educator with a means for social networking.*
L2-CU-RQ-274	*The CI shall provide a discoverable repository for educator-provided tools*
L2-CU-RQ-275	*The CI shall provide versioning and citation for educator assets*
	4.14 Documentation
L2-CU-RQ-277	The CI IO shall make all source code for the OOI Cyberinfrastructure implementation and drivers publicly available, subject to applicable licenses
L2-CU-RQ-278	The CI IO shall document all external interfaces
L2-CU-RQ-279	The CI IO shall document all device drivers
L2-CU-RQ-280	The CI shall provide discoverable web-based documentation for all services
L2-CU-RQ-281	The CI shall utilize a naming scheme that is compliant with OOI naming conventions
L2-CU-RQ-282	**4.15 Development Process**
L2-CU-RQ-283	The CI IO shall seek to influence the direction of CI standards to effectively meet the needs of OOI users
L2-CU-RQ-284	The CI shall utilize open standards and open source software to the maximum possible extent
L2-CU-RQ-285	The CI IO shall accommodate local innovation that can be scaled to the community level
L2-CU-RQ-286	The CI IO shall support the verification of hardware and software components that will be deployed on OOI infrastructure
L2-CU-RQ-287	The CI shall support modular components
L2-CU-RQ-288	The CI implementation shall be platform-independent
L2-CU-RQ-289	CI service interfaces and capabilities shall maintain backward compatibility as the services evolve
L2-CU-RQ-290	The CI architecture shall be scalable to accommodate an increasing range of actors, resources, and services
L2-CU-RQ-291	The CI shall be extensible to allow the addition of new resources, services and applications to the OOI infrastructure
	4.15.1 Other
L2-CU-RQ-293	The CI shall provide process support for "dry" observational infrastructure development, verification and simulation
L2-CU-RQ-294	The CI IO shall provide technically-qualified user care support and assistance through a human actor
L2-CU-RQ-295	The CI shall provide capabilities to maintain contact between users and user care
L2-CU-RQ-296	The CI shall provide capabilities to initiate and track trouble tickets
L2-CU-RQ-297	The CI shall provide tools for observatory operators to communicate with users

6 Workshop Conclusions

6.1 Feedback from the Participants

The following list contains feedback statements from the workshop participants that were provided during and at the end of the workshop in specific feedback sessions. The statements are listed anonymously and in no given order. Statements from different persons are grouped together in order to ease understandability. Statements might be redundant, overlapping and contradictory due to the fact that they originate from different individuals.

- There is a lot of overlap between the EPE efforts of various communities. Currently, the challenge is leveraging such efforts to avoid the overlap, enhance everybody's productivity and feed the collective knowledge into better products.
- There is a global effort to share data and knowledge, and OOI is probably the furthest ahead. The closest seems to be NEON.
- We wanted and got a nice group conversation addressing the new technologies coming up.
- Data are getting more and more important and also getting hugely complex.
- It is important to enable more and more people to get the knowledge and awareness associated with the environment and oceans in particular.
- It seems that the education aspect is a shoestring last minute low budget effort, but it is exciting to be proactive through this workshop.
- We appreciate the professional process of conducting these workshops and the UCSD contributions.
- We were struck through discussions by how important the advancements in computing have made data more accessible and complex at the same time. In a way this also drives the tools that educators want.
- There is a big overlap between the educator's needs and the science user expectations.
- It was a very effective use of time with smaller-sized groups of participants.
- There is a big marine education community out there that needs to stay invested/included/engaged in our efforts.
- Hearing about different ways of approaching outreach was very interesting.
- This workshop was an important step in the overall process of defining the EPE plan and the next steps.
- We set a benchmark for further steps.

6.2 Next Steps and Action Items

Next steps include:

- Consolidate requirements from all user requirements workshops into a consistent list of CI user requirements.
- Prioritize and rank all user requirements, leading to a selection of baseline requirements for the construction of the OOI, to be reviewed during FDR.
- The user community will be asked to validate the requirements as well as their prioritization and selection during various phases before and after FDR.
- The requirements validation and community involvement process will continue past FDR throughout the entire OOI design and construction program.

6.3 Conclusions from the Organizers

The OOI Education and Public Engagement Requirements Workshop, hosted in Portland, OR, provided numerous and valuable insights into current educational efforts for ocean literacy and scientific data transformation for the general public, as well as mid-term and long-term requirements for an OOI cyberinfrastructure that should provide transformative support for the entire ocean observing community and beyond. During this workshop, invited educators and system architects from the CI architecture and design team, project scientists and other members of the OOI program office discussed and collaborated on creating this outcome and a vision for the future of the overall OOI integrated observatory and its impact on education.

This workshop was very successful in advancing the CI requirements definition and validation efforts, for refining and complementing the CI architecture and design and in further fostering the mutual understanding of prospective CI user communities and the CI design team. Direct outcomes include a list of identified and validated requirements, jointly developed domain analyses and several extensive current day and future use scenarios. Each will contribute to complementing and refining the OOI requirements and design efforts in preparation of the upcoming Final Design Review in November and the ensuing pilot period.

All presentation materials can be found on the workshop website [CI-EPE-WEB]. The CI workshop overview page [CI-WS-WEB] provides a more general context for all of the CI requirements and design workshops scheduled and completed before FDR, with detailed background and accompanying materials.

Appendices

A Additional Material

A.1 Tools and collaboration spaces

Social data networking sites:

- http://services.alphaworks.ibm.com/manyeyes/home
- http://www.swivel.com/

Visualization Tools

- http://www.richchartlive.com/RichChartLive/
- http://code.google.com/apis/visualization/

A.2 Curriculum-related material

Oceans Connecting A Nation - Development of an Internet based curriculum focused on excess nitrogen loading and its effects on coastal ocean waters. http://www.ciese.org/curriculum/oceansproj_new/

Air Pollution: What's the Solution? – Development of curricula focused on real time air quality data in partnership with the US Department of Environmental Protection (USEPA) and the Northeast States for Coordinated Air Use Management (NESCAUM). http://www.k12science.org/curriculum/airproj/

Downwind – Development of curricula focused on the IGEMS/ISC model used by the USEPA in partnership with the USEPA. http://www.k12science.org/curriculum/downwind/

Is Your School Bus Exhausting? – Development of middle school curricula, grades 6, 7, 8 and 9 focused on the impact of diesel school bus engines and cleaner fuel technologies in partnership with the Connecticut Department of Environmental Protection (CTDEP). http://www.ciese.org/curriculum/bus/

Gulf Stream Voyage (renovation) - Students use real time data in various scientific applications in order to discover the mysteries of the Gulf Stream. Individual lessons may be easily adapted to traditional biology, chemistry and physics classes. http://www.k12science.org/curriculum/gulfstream/index.shtml

Global Water Sampling Project (renovation) – High school students will team up around the globe to test the water quality of their local river, stream, lake or pond with other fresh water sources around the world. http://www.k12science.org/curriculum/waterproj/index.shtml

Take A Dip (Middle school students) http://www.k12science.org/curriculum/dipproj2/en/
Bucket Buddies (Elementary school students) http://www.ciese.org/curriculum/bucketproj/

Tsunami Surge - Tsunami Surge is a project for students in grades 6-12 that uses real-time data sources from the internet to help students answer these questions. They will be challenged to think critically and creatively in their efforts to understand, predict, and guard against this powerful force of nature. http://www.ciese.org/curriculum/tsunami/

Catch A Wave - An educational project for students, grades 6 - 12, that uses online real time data to guide student discovery of the causes and effects of ocean waves and tides. http://www.ciese.org/curriculum/tideproj/index.shtml

Build IT - Build IT! is an innovative student design challenge that fosters an active, inquiry-based and challenging learning environment that integrates the application of many IT, scientific, and engineering principles. The goal of the Build IT! project is to challenge students to design, build and program an underwater remotely and autonomously operated vehicle from LEGO and other parts.
http://www.k12science.org/buildit/

A.3 Related educational projects

Science & Numeracy Special Collection: http://literacynet.org/sciencelincs

Polar Science Station: http://literacynet.org/polar

Real-time data K-12 needs assessment http://marine.rutgers.edu/outreach/rtd/

The new COOL Classroom (formal education) http://new.coolclassroom.org/

The COOLroom (public data interface) http://thecoolroom.org/

Striped Bass tracking project http://stripertracker.org/

Prototype narrative displays for LSC http://marine.rutgers.edu/~sage/lsc/

Annotated list of OOS Data Sites http://marine.rutgers.edu/outreach/rtd/resources.htm

Rapid Earthquake Viewer http://rev.seis.sc.edu/

Ozone Watch http://ozonewatch.gsfc.nasa.gov/

B Workshop Participant Questionnaire

The CI ADT refined the OOI CI requirements questionnaire from the previous workshops (see [CI-RWS2]) with specific adaptations for the education and public engagement topics. The invitees were asked to provide answers to these questions prior to the workshop.

Intent of this template

- This slide set is a template for participants at the OOI CI requirements workshop
  - For presentations during the workshop
  - To capture relevant information in a structured way for later analysis
  - To complement knowledge transfer during the workshop
- Goals of this exercise are
  - To capture CI-relevant information precisely and extensively
  - To capture structured, relevant information for use during and after the workshop
  - To provide you some ideas about the expected outcome and materials covered during the workshop from the perspective of the CI design team
- We ask you to please fill it out to the degree possible/applicable. Please try to provide answers to as many (relevant) questions as you can
- You can use this template as you like. You can modify it, take only parts of it, add your own slides, copy/paste from it, use it to structure your own text/spreadsheed/slideset documents …

General Goals for the Requirements Analysis

- Capture the current situation
  - Your institutional environment and basic goals
  - Tools, technologies, processes, data used and/or available
  - Organizational details (e.g. responsibilities, roles in team, workflows, policies)
  - What works well?
  - What are your biggest challenges?
- Determine short-term improvements
  - What would make every-day education and public engagement tasks easier and more effective?
  - What problems are causing delays or other issues and need to be addressed ASAP?
- Identify CI transformative vision and requirements
  - Assuming there is a transformative community CyberInfrastructure in place, what are the expectations for an "ideal CI" to support your work?
  - Capabilities, interfaces, necessary guarantees, resources provided, etc.
- Scope
  - As relevant to the OOI CyberInfrastructure
  - From the viewpoint of your community

Current situation

- Please describe your current situation. We want to know how you work, what you do. Please describe your work and your basic goals, your institutional environment, the tools, systems and people you work with.
- What works particularly well in your environment? Exemplary tools, applications, portals, standards, technologies, etc?

- Please list the biggest challenges and impediments that currently exist for your work and/or the community. Please order and explain.
- What short-term improvements would make your life easier and your work more effective?

Expected changes

- Mid-term OOI perspective: What capabilities and properties do you anticipate and/or require from a cyberinfrastructure that efficiently supports your work in education or public outreach? Please order by importance.
- Longer-term OOI perspective: What capabilities and properties do you expect from a next generation cyberinfrastructure in the oceanographic domain that would benefit you and the education community most in the next decade? Please order by importance.

Education and Public Applications

- Which educational and public applications using (ocean or other) observatory data or real-time data streams are you working on or have you developed in the past? Please provide some background about the data sources you use, the models and analyses you apply, the visualizations and presentations. Example screen shots, documentation etc. are always helpful.
- Please describe the steps and responsibilities from the initiation of an educational or public outreach project, to design, development, deployment and to operation, for instance at a high school or a museum.
- Please describe a typical every-day scenario developing and/or using your educational applications.
- What CI capabilities would make your educational application development or day-to-day operation work more effective?

Data Sources and Transformations

- Which data sources, data formats and meta-data sources do you use? Which format transformations and data processing operations do you perform and how? Are steps automated?
- How do you find data sources of appropriate format, accuracy, meta-data annotation and availability for your work?
- Do you use specific configurations of data sets and processing tools for your applications? Do you apply any simplifications and generalizations for educational purposes? How?
- Dou you foresee using resource intensive (e.g. high bandwidth) data products, e.g. for public environments such as for HD video displays in museums?

Ocean Models and Visualizations

- Which models of the ocean or the environment do you currently use and/or develop? Please explain some important specifics of these models and any related tools. Where does the data come from?
- What would make your modeling/analysis and interactive visualization work more effective?
- To which extent would a pool of existing, configurable and adaptable ocean models and visualizations help you? Which configuration or parameterization options do you need?
- What visualization tools and technologies are you using? How do they interface with data

CI User and Application Interfaces

- Please identify the user interfaces with their visualization support and other capabilities that you envision and/or require of an effective and easy to use OOI cyber-infrastructure?
  - Interfaces and capabilities that help you to develop and configure applications
  - Interfaces and capabilities that support you in operating and monitoring education applications
  - Visualization and interactive user interface features that you can use out of the box in your applications
- What application interfaces do you require, if any

Deployment and Operation

- Please list the environments in which education and public outreach applications using the OOI observatory data will be used.
- What are the specific challenges in deploying and operating an application or project in education and public institutions and environments?
- How could the OOI cyberinfrastructure support the effective deployment and operation of such applications?
- How do you manage change of applications and of depending data sources, ocean models etc.?

Comments, Expectations, Suggestions

- What do you expect from the upcoming OOI CI requirements workshop?
- What have we missed? What didn't we ask you about that we should have?

Additional reading materials, References

- Are there any similar projects/communities that you like and/or that are technology-wise exemplary?
- Are there standards, other national or international efforts that the OOI design team should consider/evaluate?
- Is there anything that you want to add to this questionnaire?
- Please suggest further reading materials
- References

C List of Existing Requirements

The following table provides the list of CI science user requirements as of May 2008, resulting from the first two requirements workshops. For detailed explanations with each requirement, please refer to [CI-RWS2].

Cat.	Req-ID	Requirement
Resource Management		
	RWS2-R1	The CI shall notify registered users and applications when new resources are added to the system.
	RWS1-R3	The CI shall be extensible to allow the addition of new resources and applications to the OOI infrastructure.
	RWS1-R9	The CI shall provide a catalog listing all resources under CI governance.
	RWS1-R9A	The CI shall enable users to discover observatory resources together with their meta-data based on resource characteristics and user-defined search criteria.
	RWS1-R11	The CI shall catalog physical samples in the CI resource catalog.
	RWS1-R12	The CI shall support cross-referencing from CI governed resources to external re-source catalogs and metadata.
	RWS1-R16	The CI shall bind metadata to all resources under CI governance throughout the re-source life cycle.
	RWS1-R18	The CI shall provide standard OOI metadata descriptions that include, but are not limited to, a complete description of resource behavior, content, syntax, semantics, provenance, quality, context and lineage.
	RWS1-R19	The CI shall allow the discovery of all information resources that are based on a given original information resource.
	RWS1-R20	The CI shall provide information resource subscribers automatic and manual fallback options with similar characteristics in case the original resource becomes unavailable.
	RWS1-R26	The CI shall provide notification of resource state change to all resource subscribers.
	RWS1-R33	The CI shall collect and provide resource access statistics.
Data Management		
	RWS1-R21	The CI shall be capable of archiving all data and data products associated with an OOI observatory or other CI-governed information resource.
	RWS1-R22	The CI shall support the publication, distribution and archiving of different versions of the same data product.
	RWS1-R23	The CI shall ensure the integrity and completeness of all data products throughout the OOI life cycle.
	RWS1-R24	The CI shall ensure that all archived data products can be restored in their complete and most recent state.
	RWS1-R30	The CI shall publish new data products resulting from processing of existing data products.
	RWS1-R31	The CI shall enable users and applications to subscribe to information resources in the form of data streams.
	RWS1-R47	The CI shall provide a topic-based (publish-subscribe) data distribution infrastructure that supports real-time and near real-time delivery, guaranteed delivery, buffering and data streaming subject to resource availability.
Science Data Management		
	RWS2-R2	The CI shall interface with, ingest and distribute data from external data sources, databases, and data distribution networks of related scientific domains.
	RWS2-R3	The CI shall provide interactive and automated data quality control (QC) tools.

Cat.	Req-ID	Requirement
	RWS2-R4	The CI shall provide standard and user-defined methods to assess the quality of data.
	RWS2-R5	The CI shall facilitate the moderation and auditing of published data.
	RWS2-R6	The CI shall act as a broker for CI-managed data products.
	RWS2-R7	The CI shall provide access to CI-manage data products in standard formats and subsets.
	RWS2-R8	The CI shall act as a broker between information and processing resources.
	RWS2-R9	The CI shall make unprocessed raw sensor data available on request.
	RWS2-R10	The CI shall track data provenance and correspondence.
	RWS2-R11	The CI shall credit data publishers when data products are accessed.
	RWS2-R12	The CI shall create and distribute related data products from a given source data product that have different characteristics, such as resolution, level of detail, real-time form and quality,.
	RWS2-R13	The CI shall flag data stream state change.
	RWS2-R14	The CI shall support the provision of complete metadata by users.
	RWS1-R4	The CI shall support a standard set of data exchange formats.
	RWS1-R4a	The CI shall translate between the standard data exchange formats without loss of information.
	RWS1-R5	The CI shall allow the addition of user-defined data exchange formats and translators.
Research and Analysis		
	RWS2-R15	The CI shall provide capabilities and user/application interfaces for researching scientific materials and OOI-governed resources across disciplines.
	RWS2-R16	The CI shall suggest suitable data products, data transformations, observation resources, analysis tools, visualization tools and other OOI resources based on user-specified research questions in domain language.
	RWS2-R17	The CI shall support interactive and iterative analysis and visualization through infrastructure, tools and user interfaces.
	RWS2-R18	The CI shall provide tools, user interfaces and visualization for the analysis, combination and comparison of disparate, heterogeneous data sets..
	RWS1-R25	The CI shall provide a standard, extensible set of data product processing elements that provide data assimilation, alignment, consolidation, aggregation, transformation, filtering and quality control tasks.
Ocean Modeling		
	RWS2-R19	The CI shall enable the efficient configuration, execution, debugging and tuning of numerical ocean models.
	RWS2-R20	The CI shall support the interaction of model developers and non-expert model users.
	RWS2-R21	The CI shall provide facilities to develop and tune numerical models and their parameters.
	RWS2-R22	The CI shall provide a virtual model environment and simulator to determine optimal model inputs, parameterizations and outcome qualities.
	RWS2-R23	The CI shall enable the sharing of ocean modeling, data assimilation and visualization components, including the extension of models with new model components.
	RWS2-R24	The CI shall provide a repository and sharing capabilities for numerical model algorithms, model configurations, data processing tools and documentation.
	RWS2-R25	The CI shall archive numerical models under configuration control.
	RWS2-R26	The CI shall recompute model data products using archived models and workflows.
	RWS2-R27	The CI shall enable the modification of archived numerical models and and workflows.

Cat.	Req-ID	Requirement
	RWS2-R28	The CI shall provide an environment for the development of community numerical models under community process support.
	RWS2-R29	The CI shall provide a non-restricted environment for the development of independent numerical models.
	RWS2-R30	The CI shall support nesting of ocean models at different geographical scales.
	RWS2-R31	The CI shall provide a framework for the adaptation of model resolution to the available resources.
	RWS2-R32	The CI shall support model ensemble definition, execution and analysis.
	RWS2-R33	The CI shall publish both elements and aggregated ensemble data products.
	RWS2-R34	The CI shall support flexible high performance model execution.
Visualization		
	RWS2-R35	The CI shall provide a uniform and consistent for numerical model output visualization and analysis in 2D, 3D and 4D.
	RWS2-R36	The CI shall provide interactive visualization of the 3D and 4D ocean.
	RWS2-R37	The CI shall support the integration of external visualization and analysis tools.
Computation and Process Execution		
	RWS2-R38	The CI shall support the execution of large scale numerical ocean models across different locations on the network.
	RWS2-R39	The CI shall support workflows for automated numerical model execution, including just-in-time input data preparation, model computation, output post-processing, and publication of results.
	RWS2-R40	The CI shall enable the one-time and recurring execution of numerical models on any networked computational resource with quality-of-service guarantees based on contracts and policy.
	RWS1-R27	The CI shall provide uniform and easy-to-use interfaces to computational resources with varying characteristics to define executable processes.
Sensors and Instrument Interfaces		
	RWS2-R41	The CI shall provide flexible and reliable access to remote resources.
	RWS2-R42	The CI shall provide real-time monitoring of remote sensors.
	RWS2-R43	The CI shall provide continuous collection of scientific data during extreme weather events.
	RWS2-R44	The CI shall provide discovery for the number and characteristics of sensors deployed on an instrument platform.
	RWS2-R45	The CI shall support adaptive observation.
Mission Planning and Control		
	RWS2-R46	The CI shall provide capabilities and user/application interfaces for mission planning and control.
Application Integration and External Interfaces		
	RWS1-R1	The CI shall provision an integrated network comprised of distributed resources, applications and users.
	RWS1-R2	The CI shall enable non-persistent connection of resources, users and applications.
	RWS1-R6	The CI shall provide application program interfaces (APIs) to all CI services.
	RWS1-R7	The CI shall provide a synoptic time service with an accuracy of TBD to all resources connected to the OOI observatories.
Presentation and User Interfaces		
	RWS2-R47	The CI shall provide "one stop shopping" interfaces that provide and collocate relevant information regarding scientific research using OOI resources.

Cat.	Req-ID	Requirement
	RWS2-R48	The CI shall provide annotation, commenting, ranking and rating services for resources.
	RWS2-R49	The CI shall provide project and user workspace capabilities and user interfaces.
	RWS2-R50	The CI shall provide long-term and ad hoc social networking and collaboration capabilities.
	RWS1-R34	The CI shall provide homogeneous, intuitive, easy-to-use web-based interfaces to all CI services and resources.
	RWS1-R35	The CI shall provide the capability to make OOI-standard metadata human readable.
	RWS1-R38	The CI shall provide extensible configurable visualization capabilities for selected types of data streams.
	RWS1-R49	The CI shall provide real-time analysis and visualization for data resources.
Security, Safety and Privacy Properties		
	RWS2-R51	The CI shall provide interfaces to define security and policy for information managers at participating institutions.
	RWS2-R52	The CI shall provide secure operations.
	RWS2-R53	The CI shall only permit authenticated and authorized users to access OOI resources.
	RWS1-R43	The CI shall provide mechanisms to enforce user privacy policies.
	RWS1-R44	The CI shall enable any authenticated party to share their resources.
	RWS1-R44A	The CI shall grant or restrict resource access subject to use policy.
Quality Properties		
	RWS1-R46	The CI infrastructure shall provide services and deliver messages with reliability and accuracy that is comparable to that of distributed Internet applications.
Education and Outreach		
	RWS2-R54	The CI shall facilitate the creation of publicly available idealized numerical ocean models with a limited choice of modifiable parameters for educational purposes.
Documentation		
	RWS1-R41	The CI IO shall make all source code for the OOI CyberInfrastructure implementation and drivers publicly available, subject to applicable licenses.
	RWS1-R42	The CI shall provide documentation for all components of the CI, including all application program interfaces (APIs) to CI services.
	RWS1-R39	The CI IO shall provide all documentation in web-based formats.
Development Process		
	RWS2-R55	The CI IO shall circulate CI requirements and designs within and outside the OOI community so that comparable infrastructures can adopt them.
	RWS1-R8	The CI shall utilize open standards and open source software to the maximum possible extent.
	RWS1-R40	The CI IO shall provide a process for submitting and incorporating user-suggested changes to the CI.
	RWS1-R48	The CI shall provide for the flexible and transparent extension of CI services and interfaces to incorporate user-provided processes, user and application interfaces, applications and resources.

D Workshop Agenda

Day 1, May 13, 2008 (Tuesday)

Time	Presenter(s)	Topics
08:30am	Cheryl Peach	Welcome from the organizers; Introductions of the participants
08:40am	Oscar Schofield	OOI Science Background
09:00am	Cheryl Peach	OOI CI Education and Public Outreach
09:20am	Michael Meisinger	Purpose and intent of this meeting, outcome expectations; OOI CI user requirements elicitation process
09:40am	Sage Lichtenwalner, Memorie Yasuda, Liesl Hotaling	Background Presentations by the invited participants: 3 Presentations at 15 minutes each with time for discussions
11:00am	Bob Collier, Deb Kelley, Andrea Thorrold	Background Presentations by OOI participants: 3 Presentations at 15 minutes each with time for discussions
1:00pm	CI ADT	Education and public engagement use cases scenarios: Current day education and public outreach applications.

Day 2, May 14, 2008 (Wednesday)

Time	Presenter(s)	Topics
08:30am	Michael Meisinger	Proposed CI infrastructure for the OOI
09:00am	CI ADT	Education and public engagement use cases scenarios: Future education and public outreach applications for the OOI Integrated Observatory, facilitated by the CI. Non-scientist user interfaces and data products. Boundaries and interfaces between the cyber-infrastructure and scientist and education users.
10:45am	CI ADT	Education and public engagement use cases scenarios: Future education and public outreach applications for the OOI Integrated Observatory, facilitated by the CI. Interfaces to a visualization and data processing function.
12:30pm	Cheryl Peach	Wrap-up and feedback

E List of Participants

Name	Organization	Project Role
Lorraine Brasseur	Ocean Leadership	
Bob Collier	Oregon State University	
Claudiu Farcas	UCSD/Calit2	CI System Modeler
Deborah Kelley	Univ. Washington	
Liesl Hotaling	Beacon Institute	
Sage Lichtenwalner	Rutgers	
Michael Meisinger	UCSD/Calit2	CI Requirements Analyst
Cheryl Peach	SIO	CI EPO Manager
Oscar Schofield	Rutgers	CI Project Scientist
Alex Talalayevsky	Ocean Leadership	
Andrea Thorrold	WHOI	
Shelby Walker	NSF	
Memorie Yasuda	SIO	

F Abbreviations

Abbreviation	Meaning
AUV	Autonomous Underwater Vehicle
CGSN	OOI Coastal/Global Scale Node
CI	OOI CyberInfrastructure
CI ADT	OOI CyberInfrastructure Architecture and Design Team
CI IO	OOI CyberInfrastructure Implementing Organization
FDR	Final Design Review
IOOS	Integrated Ocean Observing System
NODC	National Oceanographic Data Center
OOI	Ocean Observatories Initiative
PDR	Preliminary Design Review
RSN	OOI Regional Scale Node
SCCOOS	Southern California Coastal Ocean Observing System

G References

Reference	Citation
[CI-CARCH]	CI conceptual architecture and initial requirements, available at http://www.orionprogram.org/organization/committees/ciarch
[CI-DPG-WEB]	OOI CI Requirements Elicitation Workshop, Data Product Generation. Website available at: http://www.ooici.ucsd.edu/spaces/display/WS/RWS-DPG
[CI-IOM-WEB]	OOI CI Requirements Elicitation Workshop, Integrated Observatory Management. Website available at: http://www.ooici.ucsd.edu/spaces/display/WS/RWS-IOM
[CI-OOP-WEB]	OOI CI Requirements Elicitation Workshop, Ocean Observing Programs. Website available at: http://www.ooici.ucsd.edu/spaces/display/WS/RWS-OOP
[CI-EPE-WEB]	OOI CI Requirements Elicitation Workshop, Education and Public Engagement. Website available at: http://www.ooici.ucsd.edu/spaces/display/WS/RWS-EPE
[CI-PAD]	OOI CI Architecture Document, PDR Final version, 16-Nov-2007
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