<u>600125: MOOS Program for 2003</u> (includes 600024, 600026, 600027, 600031, 900245, 701125, 708125)

<u>Contents:</u>

<u>Appendices:</u>

1. MOOS Achievements in 2003, and MOOS Plans for 2003

(a) Two years into the MBARI Ocean Observing System program (the new MOOS projects, MOOS mooring, NMC, ISI and SSDS started in September 2000) we have made significant strides towards achieving the 3 year goals outlined in the MOOS Implementation plan that was presented to the MBARI Board in Nov 1999.

(b) By the end of 2002, we will have tested early prototypes of the new design MOOS mooring, with an OEM cable capable of delivering power and communications to networked benthic instruments. We will have tested satellite communications from a test mooring, an essential capability for remote observatory system deployments. Benthic nodes will have been designed and deployed in the Canyon, and cable laying procedures and associated hardware developed and tested, although we have experienced a recent set back due to the unexpectedly high dynamic nature of the canyon. The New Mooring Controller will have been deployed on M2. Early prototypes of the Shore Side Data System will have been developed and tested in support of the MOOS test mooring and NMC deployments. Many of the innovative concepts of the Instrumentation Software Interface project (ISI), that is a key enabling technology for operating extended networked observatories, will have been tested in support of the NMC program and in the lab. Significant science planning in 2002 has lead to definition of an interdisciplinary science experiment that will test many of the new MOOS technologies as an integrated observing system in 2004. As we move from prototyping and technology demonstration projects into system definition and planning, we are forming system based teams, starting with the software systems engineering group in 2002. We plan to form other system groups focusing on different system level issues at the appropriate times in 2003. By the end of the year a Dorado class AUV will have been built and handed over to Operations. Last, but not least, 2002 has seen MBARI involved as a full NEPTUNE partner, with funding ($7m) for the MARS test bed approved by the NSF. Much of this progress is due to the persistence and excellent work of the MOOS project managers, namely Mark Chaffey, Gene Massion, Duane Edgington, John Graybeal, Tom O'Reilly, and Bill Kirkwood and our Project Scientist John Ryan. This is not to underplay the outstanding work of all the team members in each of their projects, but the task of the project managers in such an extensive coordinated evolving program are significantly more complex than that of equivalent stand alone, independent projects, and so is worthy of note.

(c) Plans for 2003 will largely continue on from the work achieved in 2002. The MOOS project scientist, John Ryan has worked with many of the MBARI scientists and MOOS project managers to define a science experiment that will test many of the early innovative features of the MOOS mooring, controller, ISI, autonomous event detection and the SSDS systems. In 2003 we will design and build the sub-systems needed to support this science experiment, and aim by the end of the year, to have these subsystem designs undergoing sub system testing on shore ready for system integration in early 2004. Due to the location of the MOOS science experiment near Shepard Meander we will build a Tiburon cable laying toolsled in 2003. The cost of the deep ocean mooring, with an OEM cable servicing 3 networked benthic nodes, satellite communication, with profiling instruments is in the order of $680,000. The cost of instrumentation to support the MSE2003/4 science experiment (atmospheric, upper mid water and benthic instruments) is $308,000. Detailed costs are provided in the Appendices. Although these costs are high, they are necessary to test the first fully integrated MOOS system in support of an interdisciplinary science experiment.

(d) As a second priority to preparing for MSE2003/4 we would like to turn around the MOOS test mooring and re-deploy it to provide power and communications to the MOOS Canyon Dynamics science experiment. We will plan to do this, although cannot commit to a schedule as it must be undertaken as a lower priority to other planned activities.

(e) Although we are focusing on completing the first phase of the ocean observing system, we need to start early system level work, and risk mitigation planning on the next major technical advances that will enable us to achieve our goals for delivering advanced capability ocean observing systems, namely AUV docking. This capability is key to many of the use scenarios developed for MOOS, and are also highlighted as a critical enabling technology in the NRC report "Illuminating the Hidden Planet". Specifically we will identify functional requirements, develop detailed Use Scenarios, perform system level trades, identify high risk elements and start on a risk mitigation plan for a AUV docking mooring. In addition we will pursue discussions with industry on high power generation system for moorings, a capability needed to enable many of the AUV event response and remote synoptic mapping Use Scenarios for mooring based ocean observatories.

(f) MBARI's cabled observatory efforts in 2003 will be focused on planning and permitting for the MARS test bed in Monterey Bay and on participation in the NEPTUNE project ET and SET groups. Gene Massion will continue to contribute significantly to the NEPTUNE system engineering efforts. In 2003 John Graybeal's SSDS group will be working with the NEPTUNE DMAS team to generate common (to the maximum extent possible) system requirements and a coordinated development plan.

(g) Largely as a result of the NSF reviewers comments on the MARS proposal regarding the importance of education and outreach to our MARS observatory, this year we have included George Matsumoto's "EARTH" project in this proposal.

(h) Again it is anticipated that many of the subsystems being developed for the two observatory systems are common to a large degree, such as AUV docking, instrumentation software infrastructure, instrumentation interface, cable laying and connection, event detection and response, and particularly the shore side data systems.

(i) <u>MOOS Program Team for 2003</u>:

MOOS Steering Committee: Marcia McNutt, Jim Bellingham, Ken Johnson, Mike Pinto
MOOS Project Manager: Keith Raybould
MOOS Systems Engineer: Mark Chaffey
MOOS Software Sub-system Engineer: Tom O'Reilly
MOOS AUV Docking sub-system engineer: ?
MOOS Project Scientist: John Ryan

MOOS Sub-system Project Managers: Mark Chaffey, Gene Massion, Keith Raybould, John Graybeal, Duane Edgington, Bill Kirkwood, Larry Bird, George Matsumoto
MOOS Engineering Team: Jon Erickson, Lance McBride, Ed Mellinger, Mike Kelley, Craig Dawe, Zorba Pickerill, Wayne Radochonski, Tim Meese, Karen Salamy, Kent Headley, Craig Okuda, Michael Risi, Dan Davis, Brent Roman, Rich Schramm, Mike McCann, Kevin Gomes, Brian Schlinning, Dan Wilkin, Eric Nelson, John Ferriera, Hans Thomas, Mark Sibenac, Drew Gashler, Farley Shane, Duane Thomson, Paul McGill, Doug Au, Bethany Schaarschmidt, machine shop and ME/EE technicians)
MOOS Science team members: John Ryan, Charlie Paull, Ken Johnson, Bill Ussler, Rendy Keaton, Francisco Chavez, Jim Barry, Debra Stakes, Steve Haddock,

2. Scope of the MOOS Program for 2003

2.1 2003 MOOS Projects.

(a) In 2003, the program will consist of the following projects:

- MOOS Mooring and Vertical Profiler
- Instrumentation Software Infrastructure (includes Deployed and Operations software systems)
- MOOS Shore Side Data System
- Tiburon cable laying toolsled
- MOOS Science Experiment 2003/4 (MSE 2003/4)
- Dorado Docking System
- NEPTUNE/MARS
- EARTH

(b) In the main part of this proposal we have described each of these main projects. Included is

- a brief description of each project,
- a summary of the budget and resource needs, and
- priorities for the program in 2003.

(c) Details of each MOOS project is included in the Appendices.

2.2 MOOS Mooring and Vertical Profiler

(a) Work in 2003 will be directed toward two major goals. We will validate the MOOS mooring design by monitoring the performance of the test mooring deployed in 2002 and comparing the resulting data with values predicted in our design analysis and modeling efforts. The project team will also continue with the detailed design of the next mooring deployment configuration, the complete mooring system in the low power configuration with Benthic Instrument Nodes (BIN). This mooring design will meet the requirements of MSE2004 and interface and power both UWC and benthic instruments. When integrated with the efforts of the companion MOOS software development projects a complete offshore oceanic observatory capability will be created. The MSE2004 deployment is scheduled for the second qtr 2004.

(b) Efforts will be directed toward the following areas:

(i) Monitoring the performance and recovery of the test mooring.

- To validate the accuracy of the WHOI CABLE dynamics model used to predict the mooring riser cable configuration and cable loading.
- To test the design life of the cable terminations, bending/axial strain relief's, and other critical mechanical elements of the design.
- To test our ability to perform the ROV operations necessary for completing the connections between the riser cable and the seafloor mounted instrumentation.
- To validate the Globalstar satellite modem over-the-horizon communications design.

(ii) Design and model the mooring configuration for MSE2003/2004 site.

- Include high resolution profiling capability.
- Modifications to the design based on the results from the test deployment.

(iii) Completing the detailed designs and fabrication of the MOOS mooring subsystems not already being validated on the test mooring.

- Electrical power long haul delivery system.
- Mooring controller (extension of NMC).
- Two and optionally three seafloor mounted BIN's.
- Adapt NMC/MOOS controller to deep submergence housings and connectors and integrate wiring and mechanicals with current BIN mechanical design.

(iv) Integration of MOOS mooring hardware functions such as power switching, fault alarms, etc. with deployed and operational software systems for infrastructure monitoring and control.

(v) Integration of MOOS hardware with the specific instrument suite for MSE2004 and associated drivers developed as part of the deployed and operational software systems projects.

(vi) Complete fabrication of the mooring based observatory for MSE2004. This will include the low power version mooring system, two and optionally three BINs and an over-the-horizon data connection back to shore. The operating software will be an initial release of ISI software with proof-of-concept applications drivers to support the specific instrument suite specified in the target science experiment.

(vii) Research and evaluate advanced alternative mooring power sources that can provide an overall 100 Watt mooring power capability.

(viii) Work with AUV docking project on systems design and interface requirements.

(c) MOOS Mooring Engineering Team. Mark Chaffey (project manager, lead engineer), Ed Mellinger, Lance McBride, Wayne Radochonski, Jon Erikson, Mike Kelley

(d) MOOS Mooring Deliverables. CDR for test mooring #2 in support of a science experiment

2.3 Instrumentation Software Infrastructure, Deployed and Operational Systems

(a) MOOS software architecture can be partitioned into Deployed, Operations, and SSDS subsystems (see Figure 1). This section of the proposal deals with the Deployed and Operations subsystems

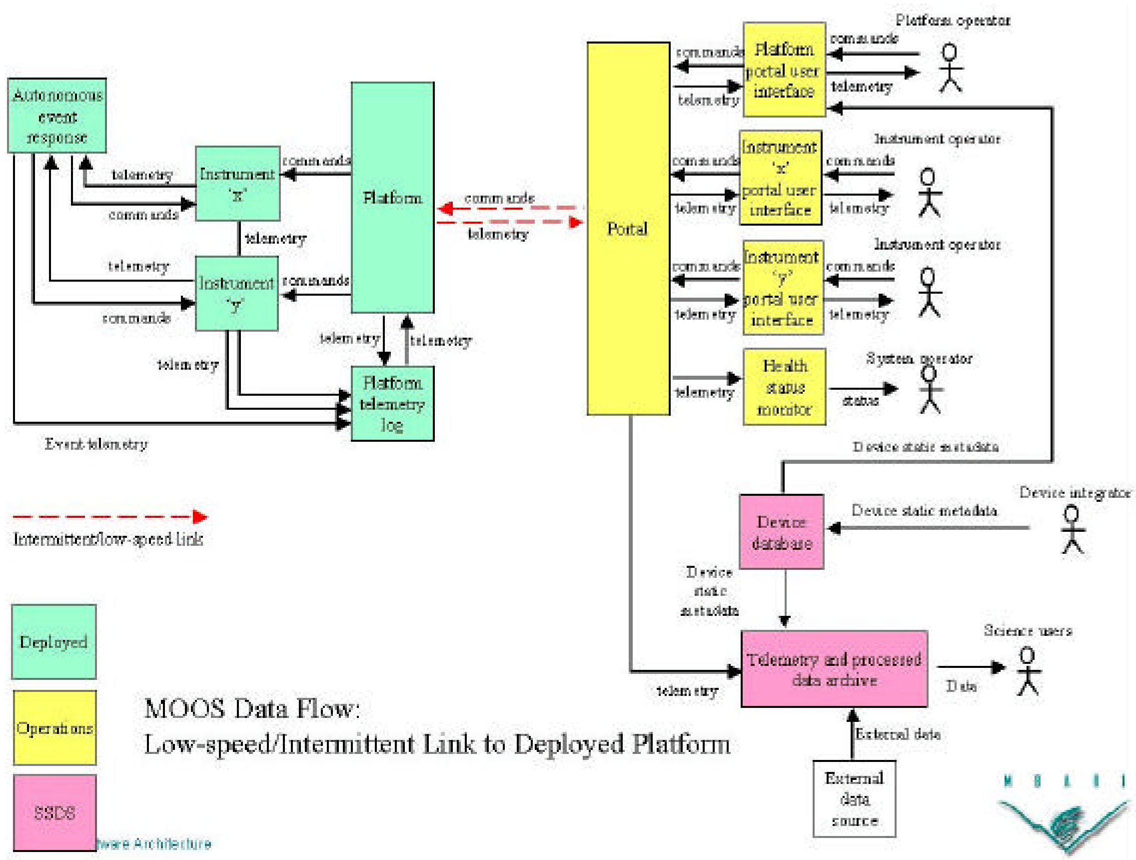

Figure 1: MOOS software architecture

2.3.1 Deployed Subsystem

(a) The Deployed subsystem includes those software elements that execute on at-sea computers. Responsibilities of the Deployed subsystem include, instrument services ("drivers" and their distributed interfaces), instrument metadata storage, plug-and-work capability (sensor "pucks"), platform infrastructure, platform services (including instrument data access), instrument data storage, data "snapshot" generation and autonomous event response applications

(b) Sensor pucks. The sensor puck is a small, low-power, low-cost device that is physically connected to an instrument; the puck persistently stores the instrument's "driver" software and metadata associated with the instrument. When the instrument and its puck are plugged into the mooring host, the host automatically retrieves metadata and driver software from the puck and starts the driver, thereby eliminating tedious error-prone manual configuration efforts. The puck concept has generated considerable interest within MBARI, the NEPTUNE project, and with numerous sensor vendors, and is an area where MBARI could make a major contribution to the oceanographic community. Proof of concept pucks have been demonstrated in MBARI labs; in 2003 we propose to design and build 30 pucks suitable for deployment on the MOOS mooring.

(c) Development tasks for the Deployed subsystem in 2003 include:

- Refining the service architecture
- Providing data “snapshot” capability
- Developing the platform infrastructure
- Implementing the instrument service/drivers (~15 instruments)
- Developing the instrument metadata container classes
- Providing the autonomous event response applications
- Developing deployable sensor puck from existing proof-of-concept (requires electrical engineering resource)

(d) It is expected that the Deployed development in 2003 will require 2.5 FTE software engineers. Since prototype hardware and software for sensor pucks have already been developed, effort to develop deployable pucks is believed to be relatively minor, requiring 25 days of software engineering, and 20 days of electrical engineering.

2.3.2 Operations Subsystem

(f) The Operations subsystem is shore-based, and provides an interface between shore users and the Deployed subystem. Responsibilities of the Operations subsystem include:

- Device user interfaces (device control and display)
- Bandwidth management and security to Deployed subsystem
- Shore-side command and telemetry buffering
- Health and status monitoring of Deployed elements

It is expected that the Operations development in 2003 will require 1 FTE software engineer.

(b) ISI Engineering Team includes Duane Edgington (project manager), Dan Davis, Tom 0’Reilly, Danelle Cline, Richard Henthorn, Brent Roman, Francisco Chavez, Christopher Scholin

2.4 MOOS Shore Side Data System/Data Management

(a) In 2003 MOOS Shore Side Data System will produce several iterated prototypes and early releases, leading to the first baseline release by the end of the year (for the MOOS Science Experiment 2004). The SSDS will complete support of its prototypes for the initial NMC deployments on M2 and M1, provide operational support for its 2002-delivered prototype supporting the MOOS Test Mooring, and provide data management for at least one other deployed instrument or system. As directed, we will coordinate SSDS design and implementation efforts with MARS and NEPTUNE projects.

(b) MOOS Data Management Team.

- The IAG team (John Graybeal, Mike McCann, Rich Schramm, Dan Wilkin, Brian Schlining) will be directly responsible for the work and deliverables described here.
- The Project Manager will be John Graybeal.
- Engineering Lead responsibilities will be assigned according to specific tasks.
- The Science Lead will be John Ryan.

Collaborations with Science Teams and Software Engineering are anticipated for many projects.

2.5 Tiburon Cable-laying Toolsled

(a) Due to the location of the science experiment in 2004 (see section 2.6), the cables connecting the BIN's will need to be laid by Tiburon. Larry Bird will be leading the design and fabrication of a Tiburon cable laying toolsled. This capability will also be needed for MARS in later years.

2.6 MOOS Science Experiment

(a) We have defined major science interests for applying new technological capabilities in the next MOOS Science Experiment (MSE), likely to begin in early 2004. Key new capabilities are provided by the MOOS mooring (power and communications to the seafloor, connected benthic nodes, enhanced upper water column capabilities), ISI and SSDS (connectivity to instruments and data streams), and vertical profiling (better resolution of water column structure). Within each science focus area, use cases for the new capabilities have been defined, and required measurements have been detailed. Relationships between MSE science interests and externally funded development efforts have been considered. As we progress toward the deployment, the science goals and priorities we defined for this MSE will be used to guide related MOOS development efforts. Acquisition and development of all components required to test the integrated mooring system are planned for 2003.

(b) We have identified a primary region of interest where interdisciplinary science from the air-sea interface to the seafloor can be pursued with integrated application of new MOOS capabilities. Selection of this location was based primarily on details of scientific goals. Because we sought to build the science around a single mooring location, it was essential to consider overlap between diverse scientific goals and flexibility of the infrastructure in applying new MOOS capabilities, e.g. the spatial scale of connected benthic nodes relative to the scales of processes. The location of the next MSE impacts its interdisciplinary nature, its relationship to externally funded activities, potential collaborations, and servicing of ocean-side infrastructure. The chosen location is 105 km (57 nautical miles) from Moss Landing along the western flank of Shepard Meander. This location provides a sound basis for interdisciplinary research. The primary deep-sea scientific motivation for this location choice is to study lateral flux of materials in lower Monterey Canyon and its consequences. The primary upper-ocean scientific motivation for choosing this location is to study upper-water-column variability in ecology and pelagic-benthic coupling in response to variation in atmospheric forcing and oceanic circulation.

(c) Details of scientific interests, technology applications and associated activities are summarized in the full planning report (http://www.mbari.org/~ryjo/mu/MSEplanning.doc). These details came from group discussions and answers to defining questions, and they serve as the basis for defining the scope of this MSE and related development efforts during 2003. Science and technology focus reports include: 1) upper/mid-water column and pelagic-benthic coupling, 2) canyon and fan processes, 3) seep processes and chemosynthetic biological communities, and 4) seismic studies.

2.7 Dorado Docking System

(a) Work will start in 2003 on AUV docking. This capability is key to many of the use scenarios developed for MOOS, and are also highlighted as a critical enabling technology in the NRC report "Illuminating the Hidden Planet". Specifically we will identify functional requirements, develop detailed Use Scenarios, perform system level trades, identify high risk elements and start on a risk mitigation plan for a AUV docking mooring.

(b) AUV Engineering team. A core AUV team comprises of Bill Kirkwood (project manager), Drew Gashler, Hans Thomas, Mark Sibenac, ME, SE, and a post doc and will, to the maximum extent possible, constitute a fixed level of resources throughout the year. Only two of these positions (ME, SE) are provided from the MOOS resources, the others are provided from Jim Bellingham's research positions. Resources needed for the program are shown in Table 1.

2.8 NEPTUNE/MARS

(a) Activities in 2003 are very similar to the tasks in 2002 and include:

- Systems Engineering. Gene is committed to providing 80d of his time to NEPTUNE systems engineering activities. Other engineers may need to be involved in design reviews etc as required.
- MARS. In 2003, activities on the Monterey Bay NEPTUNE test bed (MARS) will involve permitting, planning and managing the contract with MariPro
- Participation in NEPTUNE ET meetings and activities
- Participation in Neptune workshops.
- Integrating the data management efforts to the maximum extent that makes sense for DMAS and SSDS systems.

2.9 EARTH

(a) This project is presented as two parts (Option A and Option B) representing different scopes of work. The first part is associated with developing a web based portal to act as a educational website to distribute observatory data. The second part provides MBARI and MBA a means for incorporating real observatory data into the classroom. The ideal would be to undertake both of these parts in 2003, as they would present a complete outreach program than either could provide as stand-alone. The two are separated in this proposal for budget/resource reasons. The website has the potential to reach a large and diverse audience while the teacher institute program would directly benefit 30 teachers (with the hope that the indirect benefit will be much larger). In addition, included here is option C, which a very much descoped combination of Parts A and B.

2.9.1 Web-based Outreach Program

(a) We envision EARTH as serving as a portal to this wealth of data both archived and near-real-time. EARTH will be a long-term framework upon which other datasets can be distributed. This website will be an educational website with a focus on data distribution (near-real-time and archived) with some supporting curricula development. This project was initially funded as a scoping project for 2002. The completed milestones include a formal workshop (http://www.mbari.org/earth/login.asp) as well as the generation of a prototype website (www.mbari.org/education/EARTH) to serve as a test site to evaluate the usefulness of this presentation format and content.

(b) There are two primary objectives for 2003.

- The first would be to fully develop this mooring prototype site into a fully functional and useful educational framework (for community college and university students) that assembles and provides our mooring data (near-real-time and archived) into a format that could then be used for formal curricula (for K-16). This will include coupling to a model that assimilates the near-real-time data (working with colleagues from JPL). For example (for the upwelling case study), the distribution of temperature in response to a strong pulse of northwesterlies would be displayed. In 2003 we will work on developing collaborations for the curricula development as well as integration with national and state standards and testing (for K-16).
- The second objective would be to draw upon lessons learned with the mooring website and begin to develop an educational outreach framework for the MARS (Monterey Accelerated Research System) which is a test bed for a high-power, high-bandwidth, regional cabled observatory (http://www.mbari.org/mars/). The MARS website would serve as a prototype educational outreach site for other regional observatory programs (the two outreach sites outlined here are not exclusive and may well become one site). As the scientific projects are identified, we will work closely with the scientists to gather and disseminate appropriate data and information (e.g. case studies) via the web interface.

2.9.2 Teacher Institute Outreach Program

(a) EARTH provides MBARI and MBA an opportunity to incorporate real data into the classrooms. The research (science and engineering) ongoing at MBARI represents a wealth of content and experience that will be valuable in the classroom. This project was initially funded as a scoping project for 2002. The completed milestones include a formal workshop (http://www.mbari.org/earth/login.asp) as well as the generation of a prototype website (www.mbari.org/education/EARTH) to serve as a test site to evaluate the usefulness of this presentation format and content.

(b) MBA is renowned for their existing teacher institutes and is interested in working with MBARI to develop a national program. We will start with a three day workshop in July 2003 focusing on deep-sea research and ocean observatories (surface and benthic). EARTH could serve as a prototype educational outreach program for other regional observatory programs. As the scientific projects for MOOS and MARS are identified, we will work closely with the scientists to gather and disseminate appropriate data and information (e.g. case studies) via the teacher institutes and perhaps the prototype website developed earlier.

2.9.3 Descoped Education/Outreach Program

(a) As a less desirable option, MBARI could undertake the following option which would incorporate aspects of both Option A and Option B. This particular option would enable us to complete the prototype surface mooring site in that we could complete the 'virtual toolkit' functionality and incorporate some of the data visualization outputs that IAG is or will be working on in 2003. We would also design and develop the objectives and content for a Teacher Institute focused on Ocean Observatories (but not deliver the material to teachers). We would also work on incorporating material on Ocean Observatories (MOOS/MARS) into the existing and highly successful MBA *Live from Monterey Canyon* exhibit.
What we would not be able to do (with this limited budget) would be to evaluate the surface mooring site, specifically develop web-based outreach for MOOS/MARS, run and evaluate a national Teacher Institute. All of these are desirable objectives and would be addressed in future proposals.

(b) EARTH provides MBARI and MBA an opportunity to incorporate real data into the classrooms. The research (science and engineering) ongoing at MBARI represents a wealth of content and experience that will be valuable in the classroom. We envision EARTH as serving as a portal to this wealth of data both archived and near-real-time. EARTH will be a long-term framework upon which other datasets can be distributed. This website will be an educational website with a focus on data distribution (near-real-time and archived) with some supporting curricula development. This project was initially funded as a scoping project for 2002. The completed milestones include a formal workshop (http://www.mbari.org/earth/login.asp) as well as the generation of a prototype website (www.mbari.org/education/EARTH) to serve as a test site to evaluate the usefulness of this presentation format and content.

3. Resources for MOOS

(a) The MOOS cap limits resources to 50% of the shared resources. Groups where we are likely to reach this level include ME, SE, EE, and IAG engineers. It is unlikely that MOOS resources will exceed 50% of the resources available in other resource categories.

(b) This cap limits MOOS resources to 9.5 FTE from core engineering (EE, SE, ME), and 3.5 FTE from IAG, to be allocated to MOOS projects. The resource estimates for each of the projects are summarized in table 1 and are compared to the 50% of the shared resource.

(c) Each MOOS project has generated individual budgets. The MOOS general budget (600125) covers miscellaneous travel for Neptune workshops, NEPTUNE design reviews and progress meetings and travel for Raybould and Bellingham and others for NEPTUNE related activities.

The MOOS budgets are summarized below (line items only, personnel and internal ship time are not included here):

MOOS general budget (incl MARS)	600125	$35,000
Mooring Mooring	600027	$778,373
Instrumentation Software Infrastructure (not incl CIMT)	600026	$73,200
Tiburon Tool Sled	900389	$11,500
MOOS Shore Side Data System	600031	$46,000
MOOS Science Experiment 2003/4	900388	$308,510
Dorado/AUV docking	600024	$
NEPTUNE	(708125)	Ext Grant NOPP
EARTH	900245	$186,200

Table 1 MOOS Resources for 2003 (note: resources in parentheses are not shared resources)

	50% MBARI (does not include carryover/in-year increases)	**MOOS Total**	**MOOS Mooring**	**ISI/ CIMT**	**MOOS SSDS**	**MSE 2003/ 4**	**Dorado/ AUV Docking**	**Tiburon Tool Sled**	**Neptune**	**EARTH**	**Cont (10%)**
IAG											
SW Eng/SAD	440	495			465					30	
ENGINEERING											
Electrical Engineer	440	433	369	20			(320)				44
Mech Engineer	385	337	67				160		80		30
Software Engineer	680	796	76	560			160 (160)				
Post Doc							(320)				
Support Engineering											
DMO											
Ocean Obs Support		160	160								
Ops/CTD Tech											

4. Priorities for the 2003 Program

(a) High priority activities for 2003 include:

- (if not completed by 2002) finish the build and commissioning of the 2 Dorado vehicles and transition one of these vehicle to operations
- Complete the design and sub system testing of the MOOS mooring, ISI and SSDS sub systems ready for integration as a system in support of MSE2003/4
- Complete the early phases of the systems engineering of the MOOS AUV docking system including the requirements definition, familiarization with the current state of the art technologies in this field, identifying critical trade studies, identifying high risk elements and writing a risk mitigation plan
- Continued participation in Neptune systems engineering, and MARS planning and permitting

Appendix A: Dorado AUV Development

Project Manager: Bill Kirkwood

1. Based on the direction of the AUVUC will we be supporting the Multi-beam project and assisting with the integration and testing of this system. To accomplish this we will complete the engineering test platform AUV which is slated to be completed sometime at the end of 2002 or very early in 2003. The multibeam has a series of higher level requirements that are not in the DMO vehicle which will have been delivered prior to 2002 year end. Acoustic modem and integration of the INS along with a larger battery package are all required to support this system.

2. Docking will move up in priority this year. The engineering Post Doc will take the lead on requirements and concept of operations updates to create a functional specification for the docking system and the docking AUV. Preliminary studies to date have suggested looking at a smaller AUV cross-section (12.75) as a possible platform for this application so some amount of time will be spent in an engineering study that has not been completed in 2002 and cannot be completed until the requirements are defined more clearly and the systems are better understood. Engineering has made an offer to a Post Doc (June 14, 2002) who is targeted to begin this effort in 2002.

3. A third effort is the support of known opportunities and commitments. We have two currently known activities for 2003. One is a small effort in support of the AOSN II effort led by Paul Chandler most likely in the mid-summer time frame. This effort is expected to be relatively small for a cruise but will require the usual preparations and man-power that goes with a deployment. The second effort anticipated is preparing the ALTEX vehicle for it's next mission. It is not confirmed as yet but there is a possibility of a 2004 spring cruise to the Arctic to complete the ALTEX proposal. This will mean three mid to large scale efforts if the cruise is verified. First we will need to design, obtain, install and verify a power system for the 1500 km mission. A power system integration and test sequence will need to be accomplished early on to establish worthiness and if further work on vehicle sub-systems is warranted. Secondly, we will have to support, integrate, and test the buoy launcher and buoys. Based on experience this is anticipated to be two test series each of approximately 2 weeks. The last issue is high-latitude navigation. We have several options pending based on results from the previous Arctic cruise but one will have to be selected and proven prior to the cruise.

4. The AUV team will also be supporting the transfer of the DMO AUV and the eventual upgrade to a larger battery pack required for the M2 round trip missions.

NOTE: The AUV team is always actively looking for opportunities to seek outside funding for the betterment of MBARI and MBARI science through the proper application of AUVs in the greater Ocean Science community. Some amount of time and effort will be spent on pursuing these connections but the impact to MBARI cannot be determined at this time. The PI, Management, and the PCO will of course make the decisions about how much time will be used in support of these activities.

Appendix B: MOOS Mooring and Vertical Profiler

Project Manager: Mark Chaffey

(a) Work in 2003 will be directed toward two major goals. We will validate the MOOS mooring design by monitoring the performance of the test mooring deployed in 2002 and comparing the resulting data with values predicted in our design analysis and modeling efforts. The project team will also continue with the detailed design of the next mooring deployment configuration, the complete mooring system in the low power configuration with Benthic Instrument Nodes (BIN). This mooring design will meet the requirements of MSE2004 and interface and power both UWC and benthic instruments. When integrated with the efforts of the companion MOOS software development projects a complete offshore oceanic observatory capability will be created. The MSE2004 deployment is scheduled for the second qtr 2004.

(b) Efforts in 2003

Efforts will be directed toward the following areas:

(i) Monitoring the performance and recovery of the test mooring.

- To validate the accuracy of the WHOI CABLE dynamics model used to predict the mooring riser cable configuration and cable loading.
- To test the design life of the cable terminations, bending/axial strain relief's, and other critical mechanical elements of the design.
- To test our ability to perform the ROV operations necessary for completing the connections between the riser cable and the seafloor mounted instrumentation.
- To validate the Globalstar satellite modem over-the-horizon communications design.

(ii) Redeploy the test mooring hardware for the 2003/2004 winter season.

- To test ROV operations around the mooring base.
- Extend the fatigue cycle testing and generally gather more experience with the hardware.
- This deployment can be directed to supporting the basic power and communications functions of a simple science experiment such as connecting to the Canyon Dynamics in-place hardware.

(iii) Design and model the mooring configuration for MSE2004 site.

- Include high resolution profiling capability. Funds are included to deploy a commercial unit for evaluation as part of the MSE 2004 experiment.
- Modifications to the design based on the results from the test deployment.
- Work with AUV docking project on systems design and interface requirements.

(iv) Completing the detailed designs and fabrication of the MOOS mooring subsystems not already being validated on the test mooring.

- Electrical power long haul delivery system.
  - Electrical power hi-voltage step-up converter.
  - Electrical power hi-voltage step-down converter and distribution switching.
- Mooring controller (extension of NMC).
  - Optical communications card for the NMC chassis with network drivers.

Time-base distribution function.

- Fabrication of three seafloor mounted BINs.
- Adapt NMC/MOOS controller to deep submergence housings and connectors and integrate wiring and mechanicals with current BIN mechanical design.

(v) Integration of MOOS mooring hardware functions such as power switching, fault alarms, etc. with deployed and operational software systems for infrastructure monitoring and control.

(vi) Integration of MOOS hardware with the specific instrument suite for MSE2004 and associated drivers developed as part of the deployed and operational software systems projects.

(vii) Complete fabrication of the mooring based observatory for MSE2004. This will include the low power version mooring system, two and optionally three BINs and an over-the-horizon data connection back to shore. The operating software will be an initial release of ISI software with proof-of-concept applications drivers to support the specific instrument suite specified in the target science experiment.

(viii) Research and evaluate advanced alternative mooring power sources that can provide an overall 100 Watt mooring power capability.

(c) Summary Work Breakdown Structure (WBS) with resources.

Tasks	Scheduled Completion Date	Resources - days						
		EE	SE	ME	ETECH	MTECH	OSG	SHOP
		389	101	80	115	34	24	100
Project management	12/31/03	65						
Anchor system complete	5/13/03	8		18				20
Test mooring recovered and analyzed	6/24/03	21		7		7	7	
Deploy test mooring for winter 2003/2004	9/29/02	10		10		5	12	10
All MSE 2004 system on order	8/18/03	31		13		10	5	40
Power step-up converter complete	4/28/02	88	15	5	15			5
Power step-down converter complete	7/29/03	55	10	5	10			5
Mooring controller complete	5/14/03	67	76	5	30			5
BIN design complete	2/21/03	14		14				
BIN #1 fabrication complete	6/27/03			1	15	4		5
BIN #2 fabrication complete	7/25/03			1	15	4		5
BIN #3 fabrication complete	8/22/03			1	15	4		5
Research 100 W mooring power	12/31/03	20						
Start lab integration with instruments	10/27/03	10			15			

(d) MOOS Mooring Core Engineering Team.

Mark Chaffey (project manager, lead engineer), Jon Erickson, Mike Kelley, Lance McBride, Ed Mellinger, Wayne Radochonski.

Resource totals

389 days (2.4 FTE) electrical engineer
101 days (0.6 FTE) software engineer (SE and Wayne)
80 days (0.5 FTE) mechanical engineer
115 days Etech
34 days Mtech
24 days OSG
100 days Shop

(e) MOOS Mooring and Vertical Profiler high risk elements and risk mitigation plan.

(i) *The risk of premature failure of the riser cable due to environmental stress not predicted in the mooring design stage (requirements generation)*. This would require fundamentally re-examining the modeling effort and mooring configuration. The mitigation strategy would depend on our ability to determine the exact cause of failure and design around it. If a failure occurs the instrument suite and logging capability we have on the test mooring is designed to give us a reasonable chance of determining the cause.

(ii) *Premature failure of the riser cable due to the cable design and/or construction not meeting requirements.* Our extensive test program, both in the laboratory and at sea is designed to uncover any potential flaws in the cable design as early as possible in the development program. The cable itself is tightly specified with the onus on the vendor to satisfy the requirements of our application. Partial mitigation in this instance is to have the vendor manufacture a second cable that meets requirements. Alternate vendors have also been identified. We do not have a spare cable so a premature failure from any cause would have substantial schedule and possibly cost impact.

(iii) *Premature failure of the snubber assembly*. The snubber assembly is a simple concept for absorbing vertical wave energy in buoy systems, however it's successful application requires careful design and manufacturing work using fiber rope technology, optical cabling and rubber extruding and laminating technology. Our risk mitigation plan has three elements. First we have been working very closely with the developers of the technology (Walter Paul at WHOI and three separate manufacturers) to perfect the design. Secondly we are testing extensively both in the laboratory and at sea to uncover any design or manufacturing flaws. Finally we have spare units for each required element so a defective part can be readily exchanged with minimum schedule impact.

(iv) *Failure to provide high resolution vertical sampling in the upper water column.* If we are unable to provide high resolution vertical sampling in the upper water column the fallback capability is the current data collection system of using a fixed instrument cage at 10 meters and a series of SeaBird Microcat CTD samplers at intervals down to 300 meters.

(v) *Failure to meet the time-base distribution requirements*. Our requirement is to have 10 millisecond clock accuracy at any direct connected node in the MOOS network. If we fail to meet this requirement then each instrument that requires this level of accuracy will have to provide it's own local time source. The primary impact is on seismic work.

(vi) *Failure to meet hardware electrical low power consumption targets*. Our goal is to have 90% of the delivered power available for scientific instruments. This requires that all observatory infrastructure functions such as data logging and communications use 10% or less of the total delivered power. If we fail to meet this target it will reduce the available science power by a like amount, reducing the number of sampling systems and/or sampling rates.

(vii) *The risk of bankruptcy of Globalstar Communications Company*, our over-the-horizon communications service provider. We are actively testing a communications system using the Iridium satellite constellation as an alternate service provider in case of disruptions in Globalstar service.

(f) MOOS Mooring and Vertical Profiler critical dependencies on other projects.

(i) The MOOS mooring project is closely linked to the development of the "deployed" and "operational" software systems and to a lessor extent the "shoreside data system". Failure of these projects to meet their requirements on the proposed timeline directly impacts the functionality of the mooring system. It is anticipated that final "lab" integration of hardware and software needs to be well underway in the 4^{th} qtr 2003.

(ii) The MOOS mooring project depends on the NMC hardware and software development efforts for generic mooring controller functionality. The MOOS project provides extensions to the core NMC system. A solid and dependable NMC core architecture and implementation is key to the success of the MOOS controller.

(iii) The ability to lay seafloor cable to BINS at depths of 3200 meters is critical for the overall program success. This capability is part of a separate "cable laying sled adaptation to Tiburon" project.

(g) MOOS Mooring and Vertical Profiler 2003 deliverables.

(i) Mooring based observatory system mechanical hardware for use in 3200 meters of water at the MSE 2004 target site. At the end of 2003 the mooring system hardware will be complete, including seafloor BIN hardware and interconnect cabling, and ready for final scientific instrument and software integration.

(ii) Power generation system that will provide 20 Watts from buoy solar and wind energy collection.

(iii) A fault tolerant power system with remote diagnostics capable of delivering up to 100 Watts to the seafloor (low power source will be 20 Watts).

(iv) Mooring controller based on the NMC architecture that operates as a network that includes one surface and three benthic nodes.

(v) Optical communications for connecting separate MOOS host nodes up to 10km apart.

(vi Electrical and communications infrastructure to support over-the-horizon deployment up to 300km from shore.

(h) MOOS mooring 2003 cost against WBS (costs also entered in web entry).

MOOS mooring 2003	**$809,473.25**
cable respooler Wagner Smith model RS-84x54-8	$5,255.25
McClain or Seahorse vertical profiler	$58,900.00
Test mooring total	**$25,400.00**
Recover test mooring	$11,200.00
Test deployed cable segment to failure	$3,000.00
Deploy test mooring for winter 2003/2004	$11,200.00
MSE 2004 mooring and BIN (3) total cost	**$719,918.00**
Mooring mechanical elements	**$299,118.00**
Snubber assembly	$51,000.00
Riser cable 4km@$44.20/meter	$189,618.00
Surface float	$11,000.00
Riser line floats	$25,000.00
Solar panels	$8,000.00
Tower and bridle	$14,500.00
Electrical power step-up converter	**$20,500.00**
power step up converter PCB	$10,000.00
power step up converter monitoring micro	$3,500.00
connectors and cabling	$7,000.00
Electrical power step-down converter	**$8,000.00**
power step down converter PCB	$4,500.00
distribution switching network	$3,500.00
Mooring controller	**$45,000.00**
optical communications PCB - 5 units	$7,500.00
backplane redesign	$2,500.00
Deployed electronic materials, compass, GPS	$12,000.00
Controller lab test hardware set	$10,000.00
Satellite communications hardware and use fee	$7,000.00
connectors and cabling	$6,000.00
BINs total	**$347,300.00**
Mechanical design of controller housing	$2,700.00
Wiring and connector design	$5,000.00
Fabricate BIN 1	**$123,600.00**
optical connectors	$62,400.00
electrical connectors	$5,000.00
electronic materials	$10,000.00

electronic housing and penetrator	$2,700.00
4 km seafloor cable @ $ 7.45 meter	$32,000.00
fab., materials & plating	$11,500.00
Fabricate BIN 2	**$123,600.00**
optical connectors	$62,400.00
electrical connectors	$5,000.00
electronic materials	$10,000.00
electronic housing and penetrator	$2,700.00
4 km seafloor cable @ $ 7.45 meter	$32,000.00
fab., materials & plating	$11,500.00
Fabricate BIN 3	**$92,400.00**
optical connectors	$31,200.00
electrical connectors	$5,000.00
electronic materials	$10,000.00
electronic housing and penetrator	$2,700.00
4 km seafloor cable @ $ 7.45 meter	$32,000.00
fab., materials & plating	$11,500.00

(i) **MOOS mooring descoping options.**

The following project descoping options are available to reduce the mooring initial cost and resource usage:

(i) Reuse surface float, bridle, solar panels and tower from previous deployments. Cost reduction $48,500. Resource reduction ME - 3 days, Mtech - 10days, Shop - 20 days. The impact would be to lose the ability to service the mooring as a swap rather than a turn-around. Most likely several months of data would be lost during the turn-around and there would be an additional cost of $ 23,000 in ship time for annual maintenance, partially offsetting the reduced initial cost.

(ii) Remove the third BIN from MSE 2004 deployment. Cost reduction $ 123,600. The cost reduction over the amount budgeted for BIN 3 is because it also allows the removal of one set of optical connectors from BIN 2. Resource reduction Shop - 10 days, Etech - 15 days, Mtech - 2 days. The impact would be on the MSE 2003 science objectives.

Appendix C: Instrumentation Software Infrastructure

Project Manager: Duane Edgington

MOOS system software

MOOS software architecture can be partitioned into Deployed, Operations, and SSDS subsystems (see Figure 1). This section of the proposal deals with the Deployed and Operations subsystems.

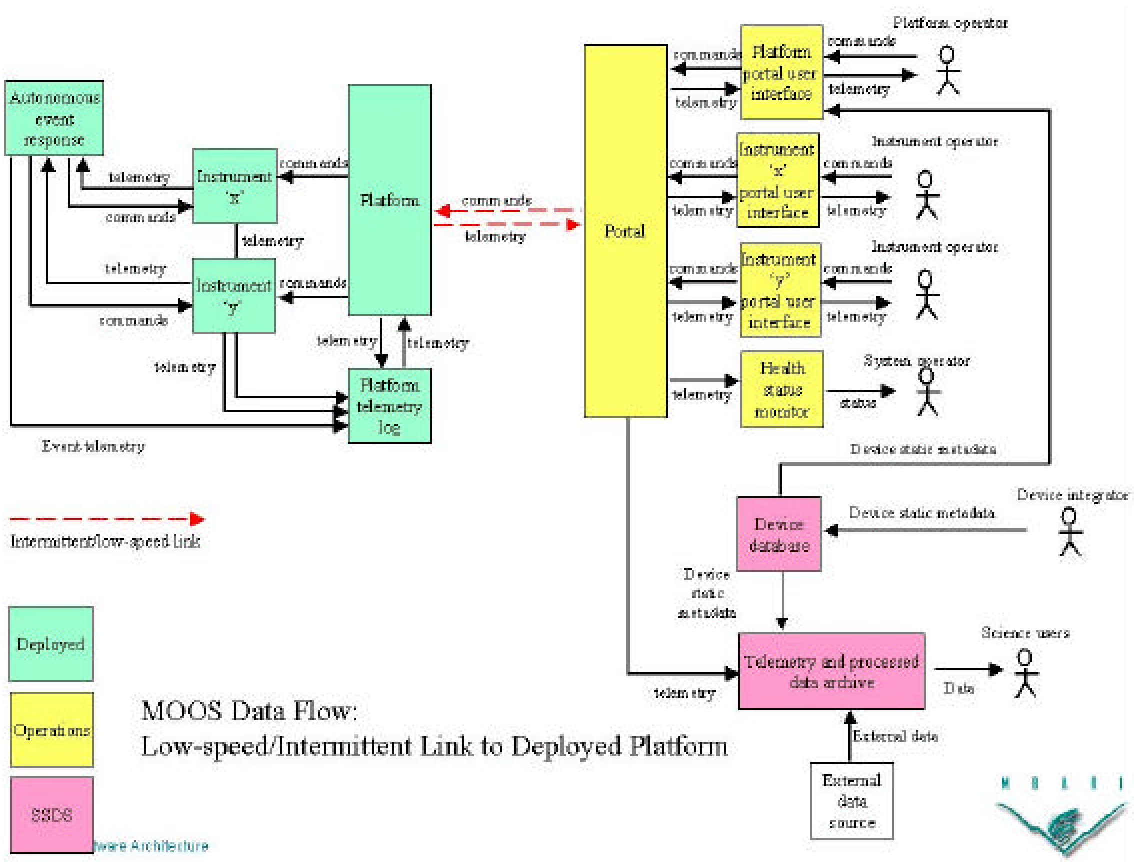

Figure 1: MOOS software architecture

Deployed subsystem

The Deployed subsystem includes those software elements that execute on at-sea computers. Responsibilities of the Deployed subsystem include:

- Instrument services ("drivers" and their distributed interfaces)
- Instrument metadata storage, plug-and-work capability (sensor "pucks")

- Platform infrastructure
- Platform services (including instrument data access)
- Instrument data storage
- Data “snapshot” generation
- Autonomous event response applications

Sensor pucks

The sensor puck is a small, low-power, low-cost device that is physically connected to an instrument; the puck persistently stores the instrument’s “driver” software and metadata associated with the instrument. When the instrument and its puck are plugged into the mooring host, the host automatically retrieves metadata and driver software from the puck and starts the driver, thereby eliminating tedious error-prone manual configuration efforts. The puck concept has generated considerable within MBARI, the NEPTUNE project, and with numerous sensor vendors, and is an area where MBARI could make a major contribution to the oceanographic community. Proof of concept pucks have been demonstrated in MBARI labs; in 2003 we propose to design and build 30 pucks suitable for deployment on the MOOS mooring.

Development tasks for the Deployed subsystem in 2003 include:

1. Refine service architecture
2. Data “snapshot” capability
3. Platform infrastructure
4. Instrument service/driver implementations (~15 instruments)
5. Instrument metadata container classes
6. Autonomous event response applications
7. Develop deployable sensor puck from existing proof-of-concept (requires electrical engineering resource)

It is expected that the Deployed development in 2003 will require 2.5 FTE software engineers. Since prototype hardware and software for sensor pucks have already been developed, effort to develop deployable pucks is believed to be relatively minor, requiring 25 days of software engineering, and 20 days of electrical engineering.

Operations subsystem

The Operations subsystem is shore-based, and provides an interface between shore users and the Deployed subystem.

Responsibilities of the Operations subsystem include:

- Device user interfaces (device control and display)
- Bandwidth management and security to Deployed subsystem
- Shore-side command and telemetry buffering
- Health and status monitoring of Deployed elements

It is expected that the Operations development in 2003 will require 1 FTE software engineer.

Deployed and Operations development personnel

Project manager: Duane Edgington
Lead engineer: Tom O'Reilly
Software engineers: Dan Davis, Michael Risi, Wayne Radochonsky, Kent Headley
Electrical engineer: Lance McBride

Relations to other projects

It is expected that MOOS software will leverage considerably from New Mooring Controller implementation, and benefit greatly from "lessons learned" during the NMC project.

Operations subsystem will depend on the SSDS project to provide certain components, such as the device database and perhaps persistent storage software for use in the Operations "portal".

Budget

Science instruments for driver development (one set for lab, one for deployment	2 x 10,000
Development systems	3 x 5,000
Lab stock	5,000
Logic analyzer for puck development	6,000
Mechanical parts and supplies for puck fabrication	4,000
Dedicated puck programming equipment and software tools	5,000
Puck hardware development	5,000
Books, journal subscriptions	200
Results presentation at 2 conferences	2 x 4,000
JavaOne conference for 2 people, 5 days	2 x 2500

Appendix D: MOOS Shore-Side Data System (SSDS)

Project Manager: John Graybeal

1. Abstract

In 2003 MOOS Shore Side Data System will produce several iterated prototypes and early releases, leading to the first baseline release by the end of the year (for the MOOS Science Experiment 2004). The SSDS will complete support of its prototypes for the initial NMC deployments on M2 and M1, provide operational support for its 2002-delivered prototype supporting the MOOS Test Mooring, and provide data management for at least one other deployed instrument or system. As directed, we will coordinate SSDS design and implementation efforts with MARS and NEPTUNE projects.

2. Proposal

2.1 WBS, Resources, Timeline

End-to-End, General, and Investigative Development	<200>
Metadata tool development (releases at milestone dates)	40
Catalog: investigation/survey [May 03]	15
Catalog: prototype 2 [Mar 03]	15
Catalog: prototype 3 [Nov 03]	20
Data Access: Integrated Vis prototype for Haddock [Aug 03]	40
Data Access: Integrated Vis investigation/survey [Jul 03]	20
Documentation: System Architecture [Jun 03]	5
Documentation: Interface Definition [prel.: Jun 03, V1: Dec 03]	10
Documentation: Test Plan [Jun 03]	5
Documentation: Test Procedures [Dec 03]	10
Documentation: User's Guide (preliminary) [Dec 03]	10
Documentation: Operator's Guide (outline) [Dec 03]	5
Review Preparations and Activities	20

M1 NMC Prototype (continued from Oct 2002) [Mar 2003]	<35>
Metadata definition and entry (completed 2002)	0
Ingest/Archive (completed 2002)	0
Data/Device/Deployment Index	5
Data Access: Data Downloads (mostly completed 2002)	10
Data Access: Quick Look	15

MOOS Test Mooring [Jun 2003]	<45>
Metadata definition and entry (mostly completed 2002)	5
Ingest/Archive (mostly completed 2002)	10
Data/Device/Deployment Index	10
Data Access: Data Downloads (mostly completed 2002)	10

Data Access: Quick Look	10

AUV CTD Data [V 1: Feb 2003; V 2: Aug 2003]	<70>
Metadata definition and entry (V1 half-completed 2002)	15
Ingest/Archive (V1 completed 2002)	20
Data/Device/Deployment Index (V1 mostly completed 2002)	15
Data Access: Data Downloads (mostly completed 2002)	10
Data Access: Quick Look	10

Production NMC System Oct	<50>
Metadata definition and entry	10
Ingest/Archive	10
Data/Device/Deployment Index	15
Data Access: Data Downloads	5
Data Access: Quick Look	5

MSE 2004 Dec	<65>
Metadata definition and entry	10
Ingest/Archive	5
Data/Device/Deployment Index	15
Data Access: Data Downloads	15
Data Access: Quick Look	15

Of the resources outlined, 225 days will need SE-level work, while 240 days are SAD-level work. These resources will be allocated among specific tasks as needs warrant.

3. Reviews

3.1 Stakeholder Reviews

Stakeholder reviews will be held on specific tasks throughout the year. Almost all the SSDS tasks will be performed with respect to existing projects or data streams, and at least one user or customer will be identified to review and comment on progress in each case. These reviews will occur throughout the performance of each task.

3.2 Internal Design Walkthroughs

At least once each quarter, we plan to hold a walkthrough of the design that is open to interested MBARI technical staff. This will be an informal review of four hours or less, with minimal custom materials preparation. The goal will be to communicate the status of the ongoing design work, as well as notable project discoveries, and to receive knowledgeable critical feedback.

3.3 System Design Review

To validate the adopted MOOS SSDS system design, we will hold a review and workshop with 1-2 external participants during the latter half of 2003. The design review will include presentations and comments from both science and software engineering representatives. The goals will be to confirm that the system design is capable of meeting the requirements, and that the design and selected implementation approaches are compatible with science expectations and needs. This will be the last design review held before release of the system for use with the MSE 2004.

The design review will take one day, with morning and afternoon sessions divided into the Science and Software Development agendas.

4. Preliminary Test Plan

A Test Plan and Test Procedures will be developed for the SSDS this year. They will be reviewed at the System Design Review, and used to establish and verify minimum expected behaviors of the final system.

5. High risk items

5.1 MOOS Software Architecture/ISI Development

The development of software and designs in support of MOOS and ISI is critical to accomplishing SSDS goals. The possibility that resources will not be available to sufficiently support these efforts is the highest-risk item for the SSDS. We encourage that maximum resources be made available to ensure successful continuation of MOOS, ISI, and SSDS development.

SSDS-defined requirements for MOOS and ISI have been documented, and SSDS development is proceeding on the basis that those requirements will be met. Thus, any changes to these requirements will now result in rework of SSDS elements, which will be progressively more expensive as changes occur later in the project.

In addition, SSDS development progress is now contingent on ISI development progress. SSDS functionality will be ever more dependent on ISI capabilities over the next 18 months. To the extent those capabilities are delayed or unavailable, SSDS progress will be delayed or reversed.

Finally, iterative exchange of design understanding and improvements is critical in a highly interdependent system such as SSDS and ISI/MOOS. While SSDS can continue to develop interfaces in response to delivered/deployed functionality, overall system developments will be much more efficient if sufficient time can be devoted to up-front planning and accommodation of design improvements as development progresses.

5.2 MARS/NEPTUNE

The progress of MARS and (particularly) NEPTUNE development is not clear. If those projects begin serious technical work within the next 6 months, but do not effectively integrate with work already performed for SSDS, much of the existing SSDS work is at risk of being made irrelevant. Conversely, if those projects do not begin for 6 months or longer, much of the SSDS work runs some risk of not being suitable for them, because their requirements and customers were not represented.

The ability of IAG staff to mitigate these risks is limited. It will be important that MBARI management appreciate them, and work closely with all parties to ensure common expectations and understanding of each other’s needs.

5.3 Training/Expertise

With the hire of a new senior data systems developer (Kevin Gomes) this year, IAG is much better positioned to complete all SSDS goals on schedule. Our primary limitation in engineering skills is with anticipated technologies, particularly in XML and Catalog systems and architectures. However, the focus of IAG experts on these areas, combined with hiring outside consultants as needed, should address those areas thoroughly.

As described last year, the following steps will continue to be most effective for short- and long-term development needs on the SSDS project:

- emphasis on prototypes as a learning and testing method;
- appreciation that some tasks will not be successful in the short term, but that we will quickly learn from them and apply those lessons to the overall problem;
- regular evaluation of our progress on overall MOOS problems to ensure that we are on track;
- strong training and personal development program, to allow staff to fully appreciate and make use of potentially useful technologies and tools; and
- contracting with senior consultants, with expertise in particular specialties, as needed to round out our own team's expertise.

By mixing these elements appropriately, a successful outcome can be assured.

6. List of deliverables

For each of the following subsystems, provide iteratively advancing Ingest, Metadata, and Access functions. Most project-specific costs will be allocated to that project, but functions that are general to SSDS will be supported under the MOOS umbrella.

- M1 NMC prototype (from Oct 2002) [completion Mar 03]
- MOOS Test Mooring (from Dec 2002) [completion Jun 03]
- AUV data ingest [Version 1: Jan 03; Version 2: Aug 03]
- NMC data ingest [Oct 03]
- MSE 2004 (base release, pre-tested for MSE 2004 system) [Dec 03]

Subsystem list:

- Ingest/Archive
- Data/Device/Deployment Index
- Data Access: Data Downloads
- Data Access: Quick-Look Visualization

Investigations and prototypes will be produced for the following subsystems:

- Catalog
- Integrated Visualization

A metadata tool, or set of tools, will be developed to maximize the entry and use of metadata by SSDS.

Documentation will be provided as follows:

- System Architecture Definition [Jun 03]
- Interface Definition Document [preliminary: Jun 03; 1st release: Dec 03]

- Test Plan [Jun 03]
- Test Procedures [Dec 03]
- User's Guide (preliminary) [Dec 03]
- Operator's Guide (outline only) [Dec 03]

7. Dependencies on other projects

7.1 MOOS Systems Architecture
(See High Risk Items, above.) The requirements definition, and visionary development of MOOS prototypes, require a coherent, reasonably complete MOOS Systems Architecture. Development of this product must be kept on track throughout 2003.

7.2 ISI
(See High Risk Items, above.) Several prototypes are closely linked to ISI development and progress, and must be closely coupled with the ISI product schedules. We are coordinating our work closely with the ISI team.

7.3 Science Projects and Core Data Streams (general)
Most SSDS MOOS products will be tuned meet the needs of particular science projects, core data streams, or MBARI data management infrastructure (according to the selected development tasks). These will be coordinated on a task-by-task basis. Participation from the affected user or customer base will be key to success on these projects.

7.4 MOOS Science Project
It is possible that elements of the MOOS Science Project's implementation could impact some of these plans. As of now it appears the capabilities of the MOOS Science Project can be handled routinely by planned SSDS development. However, to the extent additional resources must address previously unconsidered Science Project needs, deliverables and schedules will be affected.

7.5 MARS/NEPTUNE
(See High Risk Items, above.) While data support for these projects will be led by the Canadian participants, a close collaboration will be essential for the success of MARS, NEPTUNE, and MBARI activities. If IAG does not pro-actively ensure a mutually beneficial collaboration, and possibly even if IAG does do so, the technical effects could strongly hurt SSDS development.

7.6 MBARI Projects
The MBARI projects that SSDS will support in 2003 will all impact SSDS functionality and timeliness. Throughout the year the SSDS Project Manager and staff will have to monitor and respond to events and needs in the supported projects. Our expectation is that this can be done collaboratively and in cost-effective ways, with valuable products resulting.

8. Project team

The IAG team (John Graybeal, Mike McCann, Rich Schramm, Dan Wilkin, Brian Schlining, and Kevin Gomes) will be directly responsible for the work and deliverables described here.

The Project Manager will be John Graybeal. Lead Engineer responsibilities will be assigned according to specific tasks. The Lead Scientist will be John Ryan.

Collaborations with Science Teams and Software Engineering are anticipated for many projects.

9. Budget

Software Development tools	$25,000
Dedicated operations support computer system (OS TBD)	$4,000
Funding for Review held at MBARI	$4,500

morning, afternoon break provisions @ 20*$25=$500
1 working lunch @ 25*$20=$500
travel expenses for 1 days for 2 sponsored attendees (if needed)
(airfare, car, hotel, per diem) @ 2*1500=$3000
one TBD event (breakfast, reception, or other) @ $500

Training: classes in development methods/tools	$2,500
Training: developer conferences (Fees, travel, meals)	$3,000
Texts and Journal to support project	$1,000
Expert consultation	$6,000

Appendix E MOOS Science Experiment

Project Manager: John Ryan

1. Overview

1.1 MSE Planning Process

We have defined major science interests for applying new technological capabilities in the next MOOS Science Experiment (MSE). Key new capabilities are the MOOS mooring (power and communications to the seafloor, connected benthic nodes, enhanced upper water column capabilities), ISI and SSDS (connectivity to instruments and data streams), and vertical profiling (better resolution of water column structure). Within each science focus area, use cases for the new capabilities have been defined, and required measurements have been detailed. Relationships between MSE science interests and externally funded development efforts have been considered.

We have identified a primary region of interest where interdisciplinary science from the air-sea interface to the seafloor can be pursued with integrated application of new MOOS capabilities. Selection of this location was based primarily on details of scientific goals. Because we sought to build the science around a single mooring location, it was essential to consider overlap between diverse scientific goals and flexibility of the infrastructure in applying new MOOS capabilities, e.g. the spatial scale of connected benthic nodes relative to the scales of processes.

As we progress toward the deployment, likely to be in early 2004, the science goals and priorities we define for this MSE will be used to guide related MOOS development efforts.

1.2 MSE Location: Surface to Seafloor Science

The location of the next MSE impacts its inter-disciplinary nature, its relationship to externally funded activities, potential collaborations, and servicing of ocean-side infrastructure. The location chosen is 105 km (57 nautical miles) from Moss Landing along the western flank of Shepard Meander (Figure 1).

Figure 1. Bathymetry maps illustrating the location of the next MSE. In the map at left, “SM” identifies Shepard Meander, and the white box shows the MSE region that is detailed in the map at right. Possible locations for benthic nodes are shown as red circles in map at right.

The chosen MSE mooring location provides a sound basis for interdisciplinary research. The primary deep-sea scientific motivation for this location choice is to study lateral flux of materials in lower Monterey Canyon and its consequences. The primary upper-ocean scientific motivation for choosing this location is to study upper-water-column variability in ecology and pelagic-benthic coupling in response to variation in atmospheric forcing and oceanic circulation. Three benthic nodes are shown in Figure 1 (red circles), however the exact location and number will be considered further as additional observations of the region are made during 2002 and 2003. These additional observations should also serve to constrain the possible science areas that this MSE can encompass. Science drivers for this MSE are detailed in the next section.

2. Science Focus Reports

Details of scientific interests, technology applications and associated activities are summarized below in focus reports. These reports came from group discussions and answers to defining questions, and they serve as the basis for defining the scope of this MSE and related development efforts during 2003. Science and technology focus reports include: 1) upper/mid-water column and pelagic-benthic coupling, 2) canyon and fan processes, 3) seep processes and chemosynthetic biological communities, and 4) seismic studies. In this summary, only the science goals and technology applications are summarized. The full report (http://www.mbari.org/~ryjo/mu/MSEplanning.doc) further details instrumentation, use of other platforms and supporting infrastructure, and relationships to externally funded projects.

2.1 Focus: Upper/Mid-Water Column & Pelagic-Benthic Coupling

2.1.1. Science Drivers:

Pelagic-benthic coupling is an important topic for this focus and refers to the downward vertical flux of organic matter from the upper water column by processes including sinking, subduction (advection), and mixing. This can be distinguished from lateral/vertical fluxes that occur along the continental slope and through Monterey Canyon (section 2.2). The relative importance of these transports is spatially and temporally variable, and the MOOS mooring and benthic nodes will be arranged to study both transport pathways. For MSE design, it will be critical to understand location-specific horizontal scales of lateral flux from the canyon relative to the separation distance possible between benthic nodes, i.e. to compare regions experiencing different flux processes. Cruise efforts during 2002 include sampling around Shepard Meander to study these scales (section 2.2).

Dynamics and ecology of the coastal transition zone, where coastal upwelled waters merge with the California Current, form a second important research area. For this research it is essential that the mooring be outside the zone of recently upwelled waters for a significant portion of the deployment so that the ebb and flow of the transition zone in response to changes in wind forcing and circulation can be studied. Defining the structure of this transition zone is thus central to considering mooring location, and we have consider *in situ* and satellite observations for this purpose. These data show that placement of the mooring near Shepard meander will allow the MOOS mooring to sample outside the zone of recently upwelled water and within the greater California Current for a sufficient period of the annual cycle.

***Science questions*:**

1. What is the magnitude of vertical flux from the pelagic to the benthic environment and how does it depend upon zone (recently upwelled water shoreward of the first transition versus "aged" upwelled water between the first and second transition)?
2. Is vertical transport of phytoplankton enhanced in the frontal zones through subduction and mixing? Do frontal processes influence flux to the seafloor or just re-distribute plankton within the upper water column? If frontal processes do enhance flux to the seafloor, how do these fluxes compare with integrated fluxes over larger non-frontal regions?
3. How do plankton assemblages differ between different zones and how do different assemblages influence export of biomass from the upper water column to the seafloor?
4. How does the phytoplankton species composition within a zone respond to changes in the physical forcing and environment?

2.1.2. New Technology and Capabilities:

Combination of RIN and BIN will be essential to studying major flux processes from a single mooring. This operational scenario depends on studies later this year regarding carbon source gradients near the canyon (section 2.2). **Connectivity to mooring instrumentation** leveraging ISI and SSDS developments would be used to activate or modify the sampling characteristics of instrumentation (ESP) and possibly platforms (single-profile float release) and identify critical periods for more intensive sampling from ship. The mooring would act as a 2-D (1-D spatial and temporal) survey of evolving conditions in different zones and through fronts between the zones. The combination of mooring and satellite data may be used to characterize the upper water column location of the transition zones and their movement for informed deployment of additional sampling resources. For upper water column studies, **vertical profiling** will advance understanding of the physical and biological environment of different zones and coupled responses of the upper ocean to changes in wind forcing and ocean currents within transition and frontal zones. Fine-scale structure including plankton layer phenomena and processes will be explored. Goals for profiling the deep water column are described in section 2.2.

2.2 Focus: Canyon & Fan Processes

2.2.1 Science Drivers

Material Transport from Monterey Canyon to the Monterey Fan

Monterey Canyon is the largest submarine canyon incising the continental margin of western North America, and undoubtedly plays a large role in the transport of sediment and carbon from inshore habitats to the abyssal plain. While its role in material transport is certain, we know little about the rates, variability, and processes dominating material transport, or the influence of lateral carbon transport on the biology and ecology of the canyon ecosystem. Long-term observations of sediment transport and biological response are required to capture chronic low-volume transport processes and episodic events. The relative importance of these modes of material transport remains unclear both in terms of the geomorphology of the canyon and their effects on its biology and ecology.

Geological Background

The occurrence of huge volumes of material derived from the continent within deep-sea fans that emanate from the mouth of Monterey Canyons attest to the scale of sediment transport (Shepard, 1981; Normark and Gutmacher, 1988). Deep-sea fan deposits include thick sands and other coarse material that require high-energy transport events (Piper and Normark, 2001). Although it is clear that submarine canyons are sediment conduits connecting terrestrial sources with deep-sea fan deposits, we know little about the periodicity of the sediment transport through canyon systems. The stratigraphy of known deep-sea fans suggests that most of the sand that ultimately leaves submarine canyon systems occur in graded turbidite layers. The frequency of these thick sand layers suggests that major gravity flow events transport significant volumes of sand through submarine canyon systems onto the fan with recurrence intervals that range from one hundred to several thousand years (Howell and Normark, 1982; Goldfinger et al., 1999). However, the fine sediments that accumulated in between the periodic sand horizons are volumetrically more important and contain appreciable amounts of organic mater. Less is known about how this material arrives onto the fan.

Biology Background

Coupling of deep-sea benthic biological processes with primary production in the euphotic zone is complex near continental margins where lateral down-slope or down-canyon carbon transport augments the vertical sinking flux of material. Jahnke et al. (1987) showed that carbon utilization by benthic fauna near the continental margin is approximately 3 times higher than the sinking flux of carbon measured from overlying waters, suggesting that material transported laterally must be fueling benthic processes. Smith et al (1992) found that the temporal scale of flux measurements confuses such measures, but also indicated a significant contribution of down-slope carbon.

Submarine canyons may act as rapid conduits for carbon transport to the deep-sea, but few measurements have been made concerning either carbon transport or associated faunal responses. Harrold et al. (1998) estimated that drift kelp contributes 20 to 83% of the total particulate organic carbon reaching the sea floor in Carmel Canyon. Okey (1997) documented shifts in shallow benthic communities associated with the seasonal flushing or organic debris from the mouth of Monterey Canyon, showing that turbidity flows resulted in disruption of the benthic community and persisted in a state of recovery and recolonization between flushing events. Vetter and Dayton (1998) found higher species diversity and higher biomass of benthic megafauna and macrofauna to depths of 700 m within submarine canyons off southern California, compared to similar depths on the continental slope.

Because of its size and position, Monterey Canyon is a useful model system for studies of the role of submarine canyons on material transport and carbon cycling along continental margins. The flux of organic material through Monterey Canyon may be very high and account for a large fraction of the organic carbon budget on its fan and the adjacent abyssal plain.

***Material Fluxes in lower Monterey Canyon*:**

Installation of a MOOS mooring in the lower canyon at the Shepard Meander (Figure 1) will allow comparison of 2 or perhaps 3 classes of sites, including “canyon-axis”, “non-canyon”, and perhaps “canyon-influenced” locations. Although the most robust comparison would include Monterey Canyon axis, Monterey Fan, and a distant site not influenced by canyon transport processes, the distances between ideal locations precludes their comparison with a single MOOS mooring. The Shepard Meander region is effectively at the mouth of Monterey Canyon where the channel is opening onto Monterey Fan, and is an excellent choice considering the benthic processes of interest and logistic constraints. Due to the low frequency of major canyon transport events (> 100 years), this experiment will focus on establishing ambient conditions and relating these to events detected at shallow depths in upper Monterey Canyon.

Material transport is expected to be most active in the main axis of Monterey Canyon. Depending upon seafloor topography, adjacent sites may receive some spillover during transport events that would fuel the productivity of benthic communities by enhanced carbon deposition. A site not influenced by the canyon is also available adjacent to Shepard Meander above its 300 m high western sidewall. Thus, the Shepard Meander offers opportunities for comparison of nearby sites expected to have vastly differing levels of erosion and carbon flux.

Our principal hypothesis is that the primary supply of carbon to benthic organisms in lower Monterey Canyon is via lateral injection of organic material rather than vertical settling of surface derived carbon. Physical processes (current speeds, variability, deep-water profiling), material fluxes (sediment traps, optical sensors, acoustic sensors), and faunal patterns (ROV surveys, remote digital cameras), and rates (sediment community oxygen consumption, faunal behavior, elemental fluxes), will be measured at each location, allowing comparison of sites expected to be dominated by chronic (erosive?) lateral transport processes (canyon-axis), lateral depositional episodes (canyon-influenced) and vertical flux (non-canyon). We assume that lateral carbon flux near, but outside Shepard Meander, is minimal, but we are planning studies for later this year to assess the carbon sources at the proposed sites. Techniques to distinguish material dominating vertical carbon flux from the principal lateral flux components (e.g. kelps) will include analyses of pigments, carbon isotopes, fluorescence, and biotracers found in sediments.

***Science questions*:**

1. What is the magnitude and variability of particulate organic carbon flux (POC) in lower Monterey Canyon?

1.a). How does the POC flux vary over time and space (compare with upper canyon?)?

1.b). What is the relative contribution of lateral and vertical transport of POC to the total flux?

1.c). What are the major sources of down-canyon POC flux?

2. What is the response of the bentho-pelagic and benthic faunal communities to POC fluxes in lower Monterey Canyon?

2.a). How do the composition, complexity, and productivity of benthic communities vary with respect to the Monterey Canyon carbon flux?

   i. Canyon axis – location of active material flux.
   ii. Canyon-influenced – receives some material flux, but not part of the main Monterey Canyon transport channel
   iii. Non-Canyon site – not influenced by Monterey Canyon material flux

2.2.2 New Technology and Capabilities:

Connectivity to instrumentation on benthic nodes would be used to both see data from deep deployment sites and perhaps control benthic sample collection based on the data returned to shore. **Cable laying with Tiburon** (depths greater than 1800 m), if possible, would employ capabilities developed for a previous MOOS Science Experiment / existing MBARI Project (Canyon Dynamics). **Combination of BIN and RIN(s)** would be essential to studying lateral and vertical fluxes from a single mooring. In the canyon, where particle transport may extend tens to <300 m above bottom, **deep vertical profiling** will be critical to studying lateral fluxes through combining particle concentration measurements from a profiling platform and velocity measurements from a RIN ADCP.

2.3 Focus: Seep Processes & Chemosynthetic Biological Communities

2.3.1. Science Drivers:

Chemical, biological and physical processes are of interest in this research area. The Canyon Dynamics project recently found a seep and CBC appropriate to study both for its depositional sedimentary nature and its scale, i.e. it would support science without being destroyed by it. This is the primary consideration for possible seep studies. Between now and the time benthic node arrangement must be finalized for this MSE, it is possible that a CBC site having appropriate characteristics will be found near the Shepard Meander MSE location and allow for seep studies.

Science Questions:

1. What are the spatial and temporal scales of variability in the conditions around seeps and the chemical fluxes from seeps?
2. What are the spatial and temporal dependencies of the microbial community and biogeochemistry in both the sediments and the water column?
3. What are the local circulation characteristics; how variable is the local circulation; how does local circulation relate to the topography and the background flow patterns; and how do these circulation patterns influence reproductive ecology and dispersal of seep species?
4. How does spatial and temporal variation in sulfide and other bioreactive compounds affect the recruitment, growth, survival, and productivity of seep organisms?

2.3.2 New Technology and Capabilities:

Studying the variability at a seep and the distinction of its chemical and dynamical environment from the adjacent seafloor requires **instrumented benthic nodes within and outside the seep**. Determination of the distance between BIN and RIN would have to be determined based on the science drivers and interconnect distance capabilities. Daily measurements relayed to shore would serve important scientific purposes while testing **connectivity and event response** that may be autonomous or human-aided: 1) Threshold levels/duration of chemical changes could be used to increase sampling rates of instruments. 2) A peak in the particle size distribution in the size range of eggs or sperm could be used to modify the activity of a deep ESP instrument. Daily measurements may be time series or statistics. **Profiling** hydrography or chemistry of the deep water column is not a goal of this group for MSE 2003/4 because the basic questions of variability have yet to be answered before justifying the need for profiling. Current profiles from ADCP are assumed to be part of the standard instrumentation for the benthic node so that circulation can be studied.

2.4 Focus: Seismic Studies

Inclusion of seismic studies in this MSE may be possible if RIN(s) can be placed on a flat region outside the canyon. Although the chosen MSE location (Figure 1) does not permit seismic studies originally outlined for the region of the San Gregorio Fault, science and testing of new MOOS capabilities could be carried out with seismic studies in the chosen MSE region.

2.4.1 New Technology and Capabilities:

Connectivity: The value of the seismic data would be increased if it could be accessed and downloaded immediately following a significant event. Although a broadband seismic sensor would be most appropriate for the far offshore site, the shortperiod sensor shares a common data logger and can thus be used to investigate the data download issues. **Networked Nodes**: This could be our first attempt to not only network a pair of seismometers on different RINS but also to integrate the data from the different sensors.

Cost summary for MOOS Mooring Instrumentation Purchases in 2003; in preparation for the 2004 Moos Science Experiment deployment

This instrument listing includes those instruments requested for the 2004+ MSE that require integration and testing during 2003 with the MOOS mooring system, ISI, and SSDS. Additional components will be need to be purchased in 2004 to complete the system (additional microcats for string, instruments for multiple benthic nodes, sediment traps).

Air-Sea Package

ASIMET: Information Resources: 1) Tornado/Engineering/NMC/Asimet documentation; 2) http://frodo.whoi.edu/asimet/index.html; http://kuvasz.whoi.edu/uophome/asimet/asimet.html.

Item	Description	Cost	Q=1	Q=3	Total
			Calibration	**Calibration**	**W/WHOI fee**
1	Relative Humidity/Air Temp	6,425	765	345	$ 8,270
2	Barometric Pressure	5,675	195	145	$ 6,750
3	Wind Speed/Direction	7,325	270	270	$ 8,735
4	Precipitation	6,585	185	105	$ 7,785
5	Shortwave Radiation	7,215	415	415	$ 8,775
6	Longwave Radiation	8,230	995	995	$ 10,610
7	Mounting Bracket	350	n/a	n/a	$ 402

Total ASIMET cost estimate: $51,327

Upper/mid-water Instrumentation

Instrument #	Description	Cost
1	Microcat string infrastructure development: SBE 37-IM microcat $3950 + $950 for pressure sensor + $1050 for Smodem-1 (buoy type controller) + $500 NRE cost for custom inductive cable coupler housing + $130 for MCC molded core cable + $200 extra for	$ 6,780
2	Hydroscat-2	$ 16,500
3	ISUS (parts only)	$ 8,000
4	RDI Long Ranger ADCP	$ 49,900
5	Fluorometer	$ 4,000
6	Oxygen sensor	$ 4,000
7	Hydrorad-2	$ 20,000
8	PCO2 instrument parts	$ 5,000
9	Hydrorad-4	$ 30,000

Total Upper/mid-water instrumentation cost estimate: $ 144,180

Deep-Sea Seafloor Instrumentation

Instrument #	Description	Cost
1	CTD: Seabird SeaCat 19 $8250 + $1250 for deep housing; $4100 for Oxygen sensor; $3500 for fluorometer; $300 for cables; 5T pump $500	$ 17,900
2	ADCP: RDI Sentinel 300 kHz (6000 m rating); Instrument $23,300 (there will be a 15% volume discount for N>1) + $6,500 for deep pressure case	$ 29,800
3	Hydroscat-2, deep rated	$ 16,500
4	Particle sensor for profiling system, LISST-100 or simpler	$ 35,000

Total Seafloor instrumentation cost estimate: $ 99,200

BIN Testing: current meters planned canyon BIN site, tested in 2003 with a single low-cost BIN: Instrumentation integrated with NOBSCA current meters:

1 each MAVS-3SD Direct Reading, RS-232, 7000 meter $7,500.00
1 each Persistor Card for the Compact Flash memory 500.00
1 each Persistor Memory 16 Mbyte 128.00
1 each Lithium Battery Pack 250.00
1 each External Temperature sensor 350.00
1 each Conductivity Sensor 2,525.00
1 each Seapoint Turbidity Sensor 1,300.00
1 each Integration of Turbidity sensor 750.00
1 each Tilt Sensor 350.00
1 each Freight 150.00
Total instrument costs for test BIN: $13,803

Total All: $ 308,510

Appendix F: Education and Research: Testing Hypotheses (EARTH)

Project Manager/Scientist: George I. Matsumoto
Project Engineer: Brian Schlining

The project is presented with two options representing different scopes of work. The ideal would be to combine the two options, as they would present a more complete outreach program than either as a stand-alone. I have separated the two for budget/resource reasons. The website has the potential to reach a large and diverse audience while the teacher institute program would directly benefit 30 teachers (with the hope that the indirect benefit will be much larger).

[OPTION A] THE GOALS FOR THIS WEB-BASED OUTREACH PROGRAM IN 2003

We envision EARTH as serving as a portal to this wealth of data both archived and near-real-time. EARTH will be a long-term framework upon which other datasets can be distributed. This website will be an educational website with a focus on data distribution (near-real-time and archived) with some supporting curricula development. This project was initially funded as a scoping project for 2002. The completed milestones include a formal workshop (http://www.mbari.org/earth/login.asp) as well as the generation of a prototype website (www.mbari.org/education/EARTH) to serve as a test site to evaluate the usefulness of this presentation format and content.

There are two primary objectives for 2003.

- The first would be to fully develop this mooring prototype site into a fully functional and useful educational framework (for community college and university students) that assembles and provides our mooring data (near-real-time and archived) into a format that could then be used for formal curricula (for K-16). This will include coupling to a model that assimilates the near-real-time data (working with colleagues from JPL). For example (for the upwelling case study), the distribution of temperature in response to a strong pulse of northwesterlies would be displayed. In 2003 we will work on developing collaborations for the curricula development as well as integration with national and state standards and testing (for K-16).
- The second objective would be to draw upon lessons learned with the mooring website and begin to develop an educational outreach framework for the MARS (Monterey Accelerated Research System) which is a test bed for a high-power, high-bandwidth, regional cabled observatory (http://www.mbari.org/mars/). The MARS website would serve as a prototype educational outreach site for other regional observatory programs (the two outreach sites outlined here are not exclusive and may well become one site). As the scientific projects are identified, we will work closely with the scientists to gather and disseminate appropriate data and information (e.g. case studies) via the web interface.

1. Objectives for 2003

1.1. Complete the “virtual toolkit” which is the interactive tool that will enable the user to interact with near-real-time data.

1.2. Link to the real-time modeling capability (for satellite-derived surface vector winds) that JPL is developing and work with JPL and Jeff Paduan on the appropriate data visualization tools.

1.3. Work with IAG and integrate existing and future projects into this outreach effort as possible. The decision regarding which projects will be based on what is ready and available during the website development period.

1.3.1. MOOS Data Management. Shore Side Data System/Data Management Project. The focus of this effort will be on the challenges of managing, using, and understanding the data that are collected via MOOS. A high priority will be to develop tools that enable end user participation in data management and quality control.

1.3.2. 3D Data Visualization Project - McCann

1.3.3. MOOS Science Experiment - Ryan

1.3.4. Integrated Data-Exploration Application (IDEA) - Haddock

1.3.5. MARS Vertical Array (MVA) - Robison

1.4. Work on developing grades 5-16 collaborations to integrate the content (present and future) into the formal curricula.

1.4.1. Collaboration with John Ryan (900326 – Observations of Open Ocean and Coastal Upwelling Systems in Ocean Process and Climate Research and Education) would be a natural beginning point.

1.4.2. George is also organizing a special session at ASLO 2003 entitled *Leave No Scientist Behind: How to Get Aquatic Sciences Into K-12 Classrooms* where input on the mooring website as well as the developing MARS website will be solicited.

2. Proposal

2.1. Work Breakdown Structure, Resource Estimate, Timeline

2.1.1. Work breakdown/Timeline

2.1.1.1. Completion of surface mooring site by February 2003

2.1.1.2. Testing of surface mooring site during the first six months of 2003

2.1.1.3. Initial concept review for the subsurface mooring

2.1.1.4. Development of prototype for MOOS/MARS by August 2003

2.1.2. Resource estimates

2.1.2.1. IAG time: ~25 days

2.1.2.2. George I. Matsumoto: ~25 days

2.1.2.3. Todd Ruston/IS support: ~ 5 days (web support)

2.1.2.4. Nancy Barr: ~ 5 days (web support)

2.1.2.5. Todd Walsh: ~ 6 days (video for site)

2.1.2.6. Scientists: ~5 days (content review and material)

2.1.2.7. Science tech time: ~ 5 days (content review and material)

2.2. Design Reviews

2.2.1. Review of the surface mooring site will take place in the classroom with the end users (using MPC as a testbed site).

2.2.2. Review of the MOOS/MARS site will have two components.

2.2.2.1. An initial concept review (in April 2003).

2.2.2.2. A prototype review in August 2003 prior to the next proposal round.

2.3. List of Deliverables

- 2.3.1. Completion of surface mooring website (http://www.mbari.org/earth/login.asp). This will include:
  - 2.3.1.1. additional data visualization modes (e.g. CODAR movies on different time scales)
  - 2.3.1.2. links to real-time modeling efforts (JPL and NPS).
- 2.3.2. Testing of the surface mooring website in the college classroom.
- 2.3.3. Development of the MOOS/MARS site based on feedback on the surface mooring site as well as on content and datastreams available.
- 2.3.4. Development of collaborations with MBA and grade 5-16 educators in order to integrate MBARI's educational outreach effort with existing national and state standards and to work on curricula and other activities.

2.4. Dependencies on other projects

- 2.4.1. The surface mooring site progress will depend upon the real-time modeling development by JPL.
- 2.4.2. The MOOS/MARS site will depend upon progress of the various components.
  - 2.4.2.1. We will start with the technology development drawing upon the content already available.
  - 2.4.2.2. The MSE 2003 project will become the first case study for this site. Capabilities that can be incorporated into the Educational Outreach site include:
    - 2.4.2.2.1. MOOS Mooring
      - 2.4.2.2.1.1. Benthic Instrument Node
      - 2.4.2.2.1.2. Remote Instrument Node
    - 2.4.2.2.2. Vertical Profiler
    - 2.4.2.2.3. Shore Side Data System (SSDS)
- 2.4.3. MARS development
  - 2.4.3.1. 2003 schedule calls for the following capabilities which can be incorporated into the EO site:
    - 2.4.3.1.1. Bench testing of the prototype power module
    - 2.4.3.1.2. Bench testing of the prototype communications module
    - 2.4.3.1.3. Bench testing of the prototype command/control system
    - 2.4.3.1.4. Integration and testing of dry and wet node prototype
    - 2.4.3.1.5. Survey of the cable route

2.5. Project Team

- 2.5.1. George I. Matsumoto (Education and Research Specialist, MBARI-ITD)
- 2.5.2. Nancy Barr (Publications Coordinator, MBARI-ITD)
- 2.5.3. Brian Schlining (Software Applications Developer, MBARI-IAG)
- 2.5.4. Annette deCharon (Bigelow Laboratory for Ocean Sciences)
- 2.5.5. Michelle A. Youngers (CEO ScienceMedia, Inc.)
- 2.5.6. Andres Durstenfeld (Biology Chair, Monterey Peninsula College)
- 2.5.7. Rita Bell (Education Manager, Monterey Bay Aquarium)
- 2.5.8. Yi Chao (Jet Propulsion Laboratory)
- 2.5.9. Jeff Paduan (Naval Postgraduate School, MBARI Visiting Scientist)
- 2.5.10. Additional team members

2.5.10.1. John Graybeal, Rich Schramm, Mike McCann, Keith Raybould, Todd Ruston, Francisco Chavez, Todd Walsh, John Ryan, John Kindle (JPL), Kevin Raskoff (MPC), Monterey Bay Aquarium staff.

3. **Budget for Option A** [$100,550]

Conference Fees / Registration	Registration fee for Matsumoto to present at ASLO	$ 500
Outside Srvc - General	contract with Bigelow Laboratory or other for web graphics/presentation effects * see below for a rough estimate of costs from Annette deCharon	$30,000
	contract with ScienceMedia or other for web graphics/presentation effects ** see below for a rough estimate of costs from ScienceMedia. I am estimating $70,000 based on the objectives of finishing up the surface mooring site ($15,000), development of the MARS introduction ($15,000), and full development of a near-real-time toolkit ($15,000). The additional $5,000 is for additional programming as needed.	$60,000
Supplies - Food	Food for workshops (~$30/person. 15 people for 2 days)	$1,000
Travel - Domestic	Lodging at ASLO - Matsumoto	$ 750
Travel - Domestic	Lodging for workshop participants	$2,000
Travel - Domestic	Meals/Incidentals ASLO	$ 300
Travel - Domestic	Transportation ASLO	$ 1,000
Travel - Domestic	Travel costs for participants	$ 4,000
Supplies - Computer	Software costs	$500
Supplies - General		$500

*/**
Costs for the prototype web site represented only a small fraction of the actual costs incurred by the outside contractors.
Annette deCharon was paid $2465 for work that would cost $5455
ScienceMedia was paid $5535 for work that would have cost $19,350.

[OPTION B] THE GOALS FOR THIS TEACHER INSTITUTE OUTREACH PROGRAM IN 2003

EARTH provides MBARI and MBA an opportunity to incorporate real data into the classrooms. The research (science and engineering) ongoing at MBARI represents a wealth of content and experience that will be valuable in the classroom. This project was initially funded as a scoping project for 2002. The completed milestones include a formal workshop (http://www.mbari.org/earth/login.asp) as well as the generation of a prototype website (www.mbari.org/education/EARTH) to serve as a test site to evaluate the usefulness of this presentation format and content.

MBA is renowned for their existing teacher institutes and is interested in working with MBARI to develop a national program. We will start with a three day workshop in July 2003 focusing on deep-sea research and ocean observatories (surface and benthic). EARTH could serve as a prototype educational outreach program for other regional observatory programs. As the scientific projects for MOOS and MARS are identified, we will work closely with the scientists to gather and disseminate appropriate data and information (e.g. case studies) via the teacher institutes and perhaps the prototype website developed earlier.

1. Objectives for 2003

- 1.1. Design and develop an Ocean Observatory Teacher Institute for 2003 in collaboration with Aquarium staff.
  - 1.1.1. Determine objectives of the institute
  - 1.1.2. Decide on the program content (focusing on grade level-appropriate science concepts and processes as identified in the National Science Education Standards and the AAAS Benchmarks.
  - 1.1.3. Develop the elements and activities with the assistance of MBA staff and some outside contractors.
  - 1.1.4. Advertise for participants nationwide
    - 1.1.4.1. George is also organizing a special session at ASLO in February 2003 entitled *Leave No Scientist Behind: How to Get Aquatic Sciences Into K-12 Classrooms* where input on the mooring website as well as the teacher institute will be solicited.
  - 1.1.5. Run the program during July 2003
  - 1.1.6. Evaluate the program (using an external evaluation team)
- 1.2. Analyze the results of the evaluation and decide on the next steps for outreach.
- 1.3. Integrate video clips regarding MOOS/MARS into the existing MBA Live from Monterey Canyon program. We will be revising the program in 2003 with a 2004 implementation and being able to reach over 300,000 visitors/year with information about MOOS/MARS will be a valuable outreach effort.

2. Proposal

2.1. Work Breakdown Structure, Resource Estimate, Timeline

2.1.1. Work breakdown/Timeline

2.1.1.1. Design and develop an Ocean Observatory Teacher Institute for 2003 in collaboration with Aquarium staff.

2.1.1.1.1. Determine objectives of the institute by January 2003

2.1.1.1.2. Decide on the program content (focusing on grade level-appropriate science concepts and processes as identified in the National Science Education Standards and the AAAS Benchmarks by January 2003

2.1.1.1.3. Develop the elements and activities with the assistance of MBA staff and some outside contractors. (March-June 2003)

2.1.1.1.4. Advertise for participants nationwide (starting in Feb. 2003)

2.1.1.1.4.1. George is also organizing a special session at ASLO in February 2003 entitled *Leave No Scientist Behind: How to Get Aquatic Sciences Into K-12 Classrooms* where input on the mooring website as well as the teacher institute will be solicited.

2.1.1.1.5. Run the program during July 2003

2.1.1.2. Evaluate the program (using an external evaluation team) (July/August 2003)

2.1.1.3. Integrate video clips regarding MOOS/MARS into the existing MBA *Live from Monterey Canyon* exhibit. We will be revising the program in 2003 with a 2004 implementation. Jan-Dec 2003.

2.1.2. Analyze the results of the Institute evaluation and decide on the next steps for outreach. August 2003

2.2. Resource estimates

2.2.1.1. MBA staff

2.2.1.1.1. Rita Bell: ~12 days

2.2.1.1.2. Cynthia Vernon: ~ 2 day

2.2.1.1.3. Additional staff TBD: ~90 days

2.2.1.2. Outside services

2.2.1.2.1. 1-2 contracted employees (March – June) to assist in the development of the institute elements and activities.

2.2.1.2.2. Evaluation team

2.2.1.3. IAG time: ~5 days

2.2.1.4. George I. Matsumoto: ~12 days

2.2.1.5. Todd Ruston/IS support: ~ 2 days (web support)

2.2.1.6. Nancy Barr: ~ 2 days (web support)

2.2.1.7. Todd Walsh: ~ 6 days (video documentation and development)

2.2.1.8. Scientists: ~5 days (content review and resource material)

2.2.1.9. Science tech time: ~ 5 days (content review and resource material)

2.3. List of Deliverables

2.3.1. Teacher Institute run in July 2003 for 30 teachers (3 day workshop)

2.3.2. Develop images and content to incorporate information regarding Ocean Observatories into the MBA *Live from Monterey Canyon* exhibit.

2.4. Project Team

2.4.1. George I. Matsumoto (Education and Research Specialist, MBARI-ITD)

2.4.2. Nancy Barr (Publications Coordinator, MBARI-ITD)

2.4.3. Brian Schlining (Software Applications Developer, MBARI-IAG)

2.4.4. Rita Bell (Education Manager, Monterey Bay Aquarium)

2.4.5. Additional team members

2.4.5.1. John Graybeal, Rich Schramm, Mike McCann, Keith Raybould, Todd Walsh, John Ryan, Kevin Raskoff (MPC), MBARI scientists, Monterey Bay Aquarium staff.

3. Budget for Option B [$85,650]

Budget costs were based on similar Teacher Institutes being run by MBA. For 40 regional teachers in 2002/2003, workshop costs (excluding salaries) were ~$50,000.

Conference Fees / Registration	Registration fee for Matsumoto to present at ASLO	$ 500
Outside Srvc - General	Evaluation team	$15,000
	Consultants to assist in the development of institute elements and activities (integration with national standards). Two part-time hires for 4 months at $2000/month.	$16,000
	Stipend for participants ($300/person, 30 people).	$9,000
Supplies - Food	Food for workshops (~$30/person, 30 people for 3 days)	$8,100
Travel - Domestic	Lodging at ASLO - Matsumoto	$ 750
Travel - Domestic	Lodging for workshop participants ($100/person, 30 people for 3 nights)	$9000
Travel - Domestic	Meals/Incidentals ASLO	$ 300
Travel - Domestic	Transportation ASLO	$ 1,000
Travel - Domestic	Travel costs for participants ($500/person, 30 people)	$15,000
Supplies - General	Materials for activities, resources (~$200/person)	$6,000
Supplies – General	Recruiting materials	$1,500
Supplies – General	program equipment/field supplies	$2,500

[OPTION C] THE GOALS FOR THIS EDUCATION/OUTREACH PROGRAM IN 2003

As a less desirable option, MBARI could undertake the following option which would incorporate aspects of both Option A and Option B. This particular option would enable us to complete the prototype surface mooring site in that we could complete the ‘virtual toolkit’ functionality and incorporate some of the data visualization outputs that IAG is or will be working on in 2003. We would also design and develop the objectives and content for a Teacher Institute focused on Ocean Observatories (but not deliver the material to teachers). We would also work on incorporating material on Ocean Observatories (MOOS/MARS) into the existing and highly successful MBA *Live from Monterey Canyon* exhibit.

What we would not be able to do (with this limited budget) would be to evaluate the surface mooring site, specifically develop web-based outreach for MOOS/MARS, run and evaluate a national Teacher Institute. All of these are desirable objectives and would be addressed in future proposals.

EARTH provides MBARI and MBA an opportunity to incorporate real data into the classrooms. The research (science and engineering) ongoing at MBARI represents a wealth of content and experience that will be valuable in the classroom. We envision EARTH as serving as a portal to this wealth of data both archived and near-real-time. EARTH will be a long-term framework upon which other datasets can be distributed. This website will be an educational website with a focus on data distribution (near-real-time and archived) with some supporting curricula development. This project was initially funded as a scoping project for 2002. The completed milestones include a formal workshop (http://www.mbari.org/earth/login.asp) as well as the generation of a prototype website (www.mbari.org/education/EARTH) to serve as a test site to evaluate the usefulness of this presentation format and content.

1. Objectives for 2003
    - 1.1. Complete and promote the surface mooring site.
    - 1.2. Work with IAG and integrate existing and future projects into this outreach effort as possible. The decision regarding which projects will be based on what is ready and available during the website development period.
        - 1.2.1. 3D Data Visualization Project - McCann
        - 1.2.2. MOOS Data Management. Shore Side Data System/Data Management Project. The focus of this effort will be on the challenges of managing, using, and understanding the data that are collected via MOOS. A high priority will be to develop tools that enable end user participation in data management and quality control.
            - 1.2.2.1. Integrated Data-Exploration Application (IDEA) - Haddock
        - 1.2.3. MOOS Science Experiment - Ryan
    - 1.3. Work on developing grades 5-16 collaborations to integrate the content (present and future) into the formal curricula.
        - 3.1.1. Develop the elements and activities for potential Teacher Institutes with the assistance of MBA staff and some outside contractors.
        - 1.3.1. Collaboration with John Ryan (900326 – Observations of Open Ocean and Coastal Upwelling Systems in Ocean Process and Climate Research and Education) would be a natural beginning point.
        - 1.3.2. George is also organizing a special session at ASLO 2003 entitled *Leave No Scientist Behind: How to Get Aquatic Sciences Into K-12 Classrooms* where input on the mooring website as well as the developing MARS website will be solicited.
    - 1.4. Integrate video clips regarding MOOS/MARS into the existing MBA *Live from Monterey Canyon* exhibit. We will be revising the program in 2003 with a 2004 implementation and being able to reach over 300,000 visitors/year with information about MOOS/MARS will be a valuable outreach effort.
2. Proposal
    - 2.1. Work Breakdown Structure, Resource Estimate, Timeline
        - 2.1.1. Work breakdown/Timeline
            - 2.1.1.1. Completion of surface mooring site by August 2003

3.1.1.1. Design and develop a template for an Ocean Observatory Teacher Institute in collaboration with Aquarium staff.

3.1.1.1.1. Determine objectives of the institute by January 2003

3.1.1.1.2. Decide on the program content (focusing on grade level-appropriate science concepts and processes as identified in the National Science Education Standards and the AAAS Benchmarks by January 2003

3.1.1.1.3. Develop the elements and activities with the assistance of MBA staff and some outside contractors. (March-June 2003)

2.1.2. Resource estimates

2.1.2.1. IAG time: ~25 days

2.1.2.2. George I. Matsumoto: ~25 days

2.1.2.3. Todd Ruston/IS support: ~ 5 days (web support)

2.1.2.4. Nancy Barr: ~ 5 days (web support)

2.1.2.5. Todd Walsh: ~ 6 days (video for site)

2.1.2.6. Scientists: ~5 days (content review and material)

2.1.2.7. Science tech time: ~ 5 days (content review and material)

2.1.2.8. MBA staff: 80 days

2.2. List of Deliverables

2.2.1. Completion of surface mooring website (http://www.mbari.org/earth/login.asp).

2.2.2. Development of collaborations with MBA and grade 5-16 educators in order to integrate MBARI's educational outreach effort with existing national and state standards and to work on curricula and other activities.

2.2.3. Development of elements and activities necessary for a Teacher Institute focusing on Ocean Observatories.

2.2.4. Develop images and content to incorporate information regarding Ocean Observatories into the MBA *Live from Monterey Canyon* exhibit.

2.3. Dependencies on other projects

2.4. Project Team

2.4.1. George I. Matsumoto (Education and Research Specialist, MBARI-ITD)

2.4.2. Nancy Barr (Publications Coordinator, MBARI-ITD)

2.4.3. Brian Schlining (Software Applications Developer, MBARI-IAG)

2.4.4. Annette deCharon (Bigelow Laboratory for Ocean Sciences)

2.4.5. Michelle A. Youngers (CEO ScienceMedia, Inc.)

2.4.6. Rita Bell (Education Manager, Monterey Bay Aquarium)

2.4.7. Additional team members

2.4.7.1. John Graybeal, Rich Schramm, Mike McCann, Keith Raybould, Todd Ruston, Francisco Chavez, Todd Walsh, John Ryan, John Kindle (JPL), Kevin Raskoff (MPC), Monterey Bay Aquarium staff.

3. Budget for Option C [$51,050]

Outside Srvc - General	contract with Bigelow Laboratory or other for web graphics/presentation effects	$10,000
Outside Srvc - General	contract with ScienceMedia or other for	$20,000

	web graphics/presentation effects I am estimating $20,000 based on the objectives of finishing up specific portions of the surface mooring site ($5,000) and full development of a near-real-time toolkit ($15,000).	
Outside Srvc - General	Consultants to assist in the development of institute elements and activities (integration with national standards). Two part-time hires for 4 months at $2000/month.	$16,000
Supplies – General	program equipment/field supplies	$2,500
Conference Fees / Registration	Registration fee for Matsumoto to present at ASLO	$ 500
Travel - Domestic	Lodging at ASLO - Matsumoto	$ 750
Travel - Domestic	Meals/Incidentals ASLO	$ 300
Travel - Domestic	Transportation ASLO	$ 1,000