600125: MOOS Program for 2002

Contents:

1. Long Term Plans for MOOS

(a) Long term plans for the MBARI Ocean Observing System program include both mooring based observatories and cabled observatory systems.

(b) The mooring observatory system will provide capabilities to instrument upper water column and benthic locations of scientific interest in various geographical sites. Advanced capabilities will include satellite based bi-directional communications, event detection and response, as well as integration and operation with other advanced platforms including AUV's and vertical profilers. It is envisaged that there will be three major deployment phases during the development program, the first being an engineering test program, the last two being tied closely to science programs. After the development program deployments, there may be other build and deployment programs that are part of science proposals to outside funding agencies.

(c) MBARI's cabled observatory interests are based on a cabled network in Monterey Bay located in areas of scientific interest. It will also function as a test bed for validating NEPTUNE technologies. MBARI is also a full partner in the NEPTUNE program.

(d) 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, data management systems, etc.

(e) In the early phases of the MOOS program, many of the subsystems will go through proof of concept development phases with relatively independent test programs. The later deployments of the MOOS mooring will be increasingly integrated to include many of these sub-systems.

1.1 Mooring Observing System

(a) There are three main deployment phases during the mooring observatory development program, the first being an engineering test program, the last two being tied closely to science programs.

(b) Engineering Deployment #1

This deployment is based on testing the high risk elements of the mooring system and will occur in late 2001/early 2002. The aim will be to verify the mooring dynamics, test the design life of the cable terminations, bending/axial strain relief's, and to verify our ability to perform the ROV between the riser cable and the seafloor mounted instrumentation.

(c) MOOS Mooring System Deployment #2

This mooring will include the final low power version power system, completed intra-node communications system and a 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. Early versions of the Shore Side Data System will be tested with this system. This deployment will likely be in 2003 with the science experiment selected by the end of 2001. The science experiment will determine the configuration of the Mooring System #2.

(d) MOOS Mooring System Deployment #3

This MOOS system will include many of the advanced mooring capabilities including autonomous AUV's with power recharge and data transfer. Satellite communications will allow bi-directional communications for remote deployments. Deployment is anticipated at the earliest in 2005, and will be tied closely into a science program that will benefit from these capabilities. Selection of the science experiment will not take place till after deployment #2.

1.2 Cabled Observatory

(a) MBARI is a full NEPTUNE partner, with the principal contributions being to:

- the systems engineering development of NEPTUNE, and
- installation of the NEPTUNE test bed in Monterey Bay (MARS)

(b) MARS CDR is scheduled for Q2 of 2003 with installation starting in Q4 of 2004.

2. Scope of the MOOS Program for 2002

2.1 Overview of the 2002 MOOS Projects.

(a) In 2002, six existing MOOS projects (listed below) will continue:

- Dorado/AUV
- MOOS Mooring and Vertical Profiler
- New Mooring Controller
- Instrumentation Software Infrastructure
- MOOS Shore Side Data System/ Data Management
- NEPTUNE

(b) If not completed by the end of 2001, the work proposed for the MOOS science experiment started in 2001, based on investigating Canyon processes, will be completed.

(c) New work in 2002 includes AUV docking, concept design evaluation of a Vertical Profiler for upper water column studies and planning for MARS.

(d) The next MOOS Science Experiment based on testing the capabilities of the MOOS mooring system will be planned by the end of this year.

2.2 AUV/Dorado

(a) The AUV Proposal is attached as Appendix A. The program is a continuation of a multi-year effort at MBARI and includes collaborations with the outside AUV community and industrial partners (MIT, Bluefin, FCT, SSI, PMEL and WHOI).

(b) AUV efforts at MBARI include five main activities in 2001:

- Completing the design and build of the Dorado vehicles, one will be an engineering test vehicle, the other will be for DMO operations. These vehicles should be completed by mid 2002.
- Engineering support to help identify and specify interface and other design considerations associated with the mooring riser and AUV docking capabilities
- AUV docking
- ALTEX, a partnership in a NSF funded program to trace the warm water intrusion under the Arctic Ice cap and to map that body of water (ALTEX). Most of the ALTEX work in 2002 will be associated with navigation system developments.
- Provide assistance with integrating science instruments into the Dorado vehicles and running science missions (this work will be done under other proposals that are not under MOOS, but the expertise and involvement of the Dorado/AUV team will be critical in the early stages to ensure a successful transition to operations.

(c) Of the above AUV activities, only the first three activities, completing the design and build of two Dorado vehicles, early work on AUV docking interfaces and design considerations, and the WHOI collaboration on developing an operational AUV docking system, fall under MOOS. The AUV team will support the MOOS mooring design team in defining interfaces and requirements related to AUV docking, to ensure that the mooring design is capable of incorporating of AUV docking capabilities at a later stage. In addition, a post doc may be hired (on Jim Bellingham soft money grant funds) to further investigation of AUV docking technologies in preparation of a larger design effort in later years. Collaborations for developing docking systems with WHOI or Bluefin are being evaluated.

(d) Year 2002 will be year 2 of 3 of the ALTEX program funded by a NSF grant for approximately $2.03 million dollars. This funding is intended to pay for the hardware spares, manpower, and various other requirements needed to complete and publish the results of the experiment. The grant has been approved [NSF 99-101 Grant Proposal].

(e) Projects for integration of science instruments into the DMO Dorado vehicle and running science missions, are being proposed as individual projects, and will be reviewed by the AUVUC, AUV development team and the DMO operations team. This science use of MOOS developed capabilities will compete for shared resources in the same manner as other MBARI projects. Early midsection payloads will include multibeam sonar and CTD/fluorometer systems.

(f) <u>AUV Engineering team</u>. A core AUV team comprises of Bill Kirkwood (project manager), Drew Gashler, Nichole Tervalon, 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.

(g) AUV Deliverables. By the end of 2002, two Dorado class AUV vehicles will be designed, built, tested, documented and one of them handed over to operations ready to supporting science missions.

2.3 MOOS Mooring and Vertical Profiler

(a) Work in 2002 will include verifying the performance of the basic design by monitoring the test mooring and proceeding with the detailed design of the next deployment system. This second deployment will have the complete mooring system in the low power configuration and be able to power benthic instruments, and is currently scheduled for 2003.

(b) Efforts in 2002 will be directed toward the following

(i) Monitoring the test mooring performance.

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

(ii) Completing the preliminary and detailed designs of the MOOS mooring subsystems.

- Electrical power system.
- Mooring controller (extension of NMC).
- Integration with field test release of ISI.
- Local (intra-mooring system communications) design.
- Over-the-horizon communications design.
- Vertical profiler (concept design only)
- Modifications to the mechanical design based on the results from the test deployment.

(iii) Starting the fabricating of system #2. This mooring will include the final low power version power system, completed intra-node communications system and a 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.

(iv) Completing a literature search on development of Vertical Profilers and undertaking a feasibility study to incorporate a vertical profiler into the MOOS mooring system.

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

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

2.4 Instrumentation Software Infrastructure

(a) The Instrumentation Software Infrastructure proposal is attached as Appendix C. Work for 2002 includes planning for detailed implementation of core elements of ISI (the infrastructure itself), as well as "reference designs" and proof of concept of other pieces of the MOOS software system, that prove out ISI concepts:

- Prototype high risk implementation elements:
- Implement ISI framework
- Device drivers for selected instruments, which stress different parts of the design. This work will be coordinated with NMC device driver work (planning to share code and effort)
- Proof of concept communication infrastructure (low bandwidth radio to shore; satellite communication; high bandwidth cable communication). Not ISI product deliverables, but needed to test and prove out infrastructure.
- Proof of concept applications for local storage, data acquisition, metadata acquisition, shore-side archive. Again, these are not ISI product deliverables, but are all needed to prove out the infrastructure.
- Development of plug-and-work instrument interface electronics ("pucks") to prove concept.

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

(c) <u>ISI Deliverables</u> for 2002 include the following:

2.5 New Mooring Controller

a) The New Mooring Controller proposal is attached as Appendix D and is a continuation of the 1999, 2000, 2001 projects of the same name (but not staffed till mid 2000).

b) The primary goal is to replace the existing functionality supported by the OASIS controller, using modern hardware and software tools and techniques. It will use the StrongArm processor which will become the core processor for new instrumentation at MBARI and for MOOS. The software will use embedded Linux, an emerging open source standard. The software will use object-oriented techniques.

c) The project has been coordinating with the Instrumentation Software Infrastructure project and with MOOS, to serve as an incremental development toward the larger software architecture being proposed for MBARI. In this context, the program has experimented with forward-looking software design techniques and distributed-object network architectures.

d) 2002 is the year to move NMC to full operational status. The plan includes:
- Completion of software system (multiple housing configuration)
- Implementation of all drivers needed for actual deployment

- Full operational test in parallel to existing mooring or drifter

- Implementation and test of multiple electronics housing system system (up to 32 instrument configuration)
- Transfer of NMC system to Support Engineering and Operations
- Participate in build-up of operational NMC subsystems and components with Support Engineering and Operations
- Continued coordination with ISI and MOOS efforts to ensure easy migration of hardware and software from NMC into MOOS
- Coordination of NMC effort with any initiatives to upgrade or modify the shore-side data acquisition and processing system for mooring data
- Publication and presentation of NMC at appropriate
- conference

e) Project team Project Manager: Duane Edgington, Lead Engineers: Wayne Radochonski, Tim Meese, Science Advisors: Francisco Chavez,

f) List of deliverables
- Design documents
- User design-in document
- Inventory of 10 controller and support cards
- Presentation of work at selected conference or workshop

2.6 MOOS Shore Side Data System/Data Management

(a) The purpose of this project is to define and begin construction of the MOOS Shore-Side Data System (SSDS). In 2002 we expect to complete high-level requirements documentation and hold a review. The initial concept for the system will be developed and high-risk components will be investigated through initial prototype development and testing.

(b) These critical and high-risk functions include
- interfacing with the in-water data systems to obtain all the data and metadata,
- developing systems to automatically manage these data streams, and
- providing interoperability to support quality control, data blending, and other yet to be determined uses of the data.

(c) The implementation plan will coordinate with MOOS science field experiments as well as other MOOS sub-projects.

(d) 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.

(e) Deliverables.

(i) Completed SSDS Requirements document. (This document will evolve over time.)

(ii) Draft SSDS conceptual design.

(iii) Preliminary SSDS interface documents:

- standard data submission format definition
- data presentation interfaces definition

(iv) Metadata specification document

- list of required and desirable metadata information (‘tags’) for data submission
- format specification (DTD or equivalent)

(v) Working (prototype) SSDS software supporting ISI interface

(vi) White paper or other summary documents reflecting completed investigations and prototypes (includes subject, conclusions, and lessons learned)

2.7 Canyon Dynamics Experiment

(a) The Canyon Dynamics experiment was scheduled to be completed in 2001 and may still achieve this deadline. However if there are elements of the program that remain unfinished at the end of this year, the MOOS program will complete these items.

2.8 NEPTUNE

(a) MBARI is a full member of the Neptune partnership. Activities in 2002 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 2002, activities on the Monterey Bay NEPTUNE test bed (MARS) will likely be limited to investigating permitting issues and planning.
- Participation in NEPTUNE meetings.
- Participation in Neptune workshops.
- Participation in design activities such as interface definition for instrumentation, communication standards etc.

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 covers travel for Neptune workshops, design reviews and progress meetings. The MOOS budgets are summarized below (line items only, personnel and internal ship time are not included here):

MOOS general budget	600125	$20,500
Dorado	600024	$414,000
Mooring Riser	600027	$325,000
Instrumentation Software Infrastructure	600026	$
New Mooring Controller	600029	$
MOOS Data Management/ Shore Side Data System 600031		$35,500
Canyon Dynamics Experiment	900030	

<u>Table 1 MOOS Resources for 2002</u> <u>(note: resources in parentheses are not shared resources)</u>

	50% MBARI (does not include carryover /in-year increases)	**MOOS Total**	**AUV**	**MOOS Mooring (incl dissolved O2 power cell devel)**	**ISI**	**NMC**	**MOOS SSDS/DM**	**Canyon Dynamics Exper**	**Neptune**	**Contingency (10%)**
IAG										
SW Eng/SAD	440	380					380			
ENGINEERING										
Electrical Engineer	440	349	(320)	289		60				
Mech Engineer	385	466	160	206		20			80	
Software Engineer	680	770	160 (160)	25	330	255				
Post Doc			(320)							
Support Engineering										
Inst EE Tech		198	60	138						
Inst ME Tech		155	90	65						
Machine Shop		136	30	106						
ITD										
Video Lab Support										
Web support										
Documentation										
CTD Data Tech										
Tech Transfer										
Sample Archiving										
DMO										
Ocean Obs Support		160		160						
Ops/CTD Tech										
COO										
Computer Support										

<u>4. Priorities for the 2002 Program</u>

(a) High priority activities for 2002 include:

- Completing the build of the 2 Dorado vehicles and transitioning one of these vehicle to operations
- Completing the New Mooring Controller and transitioning to operations
- Completing the Canyon Dynamics installation
- Completing the design of the MOOS low power Mooring
- Meeting our commitments to the Neptune partnership

Appendix A: Dorado (ALTEX) AUV Development

Project Manager: Bill Kirkwood

1.0 Abstract

The goals of this program for 2002 are to develop and deliver two Dorado vehicles to operations. In addition the program will support the ALTEX development, assist Dave Caress with his Mapping Payload, begin the MOOS AUV docking effort in earnest with the Mooring team, and prepare for support and operations in the Sea of Cortex for early 2003. Furthermore, there are data and publication efforts for the ice sonar and data collected on the Fall 2001 Arctic cruise. Below is an attached note explaining some of the tasks in an outlined form. At the time of this writing we are being approached about other AUV collaborations and proposals which are likely to be 2002 submittals for funding in 2003 and beyond.

Note Attachment:

First, there is the basic Dorado vehicle delivery. We have two vehicles to deliver to Ops and another to build for engineering at a maximum. The difference in this work might be the building of one less total system, but I think Jim had a good point about the systems and what was required to keep Ops up and running.

Secondly, the mapping payload. We are going to be building the housing and internal payload structures. Then integrating it and testing it. You can imagine this will not be a simple thing to accomplish. Then there are some longer sea trails and eventually the 2003 Guyamus trip that will need support. I don't see operations being ready to handle it alone and besides my team would like to be included in these cruises.

We have the continuation of Altex. Next year will be mostly local stuff but a lot of advancing systems and sub-systems. Navigation will be a real key part of the year. We have the arctic cruise in 2003 (we think, depends on NSF planning) and it may cause a two team condition with Guyamus support. Docking will be spinning up. We have several irons in the fire at the moment and one of them will probably take off. Within this arena there is a Post Doc we are currently looking for and will most likely have on board by years end. This will support the in-house docking efforts at a minimum but the likelihood is we will have some outside (soft money) involvement too. WHOI is a likely partner but Bluefin is also talking to me about a collaboration.

As for the Ice Sonar project stuff, I'd like to continue with that area too and probably a very small background effort (maybe a new Post Doc depending on current Post Doc decisions). I see it picking up again more in the 2003 year as a program if we win a proposal and of course get MBARI buy-in prior to submitting the proposal. This one is popular with the current team, NSF, ONR, and socially relevant etc. ... so it could be bigger than I think but my guess is it is one for us to select the size on. My main concern is to not let it die here and another institution (US or International) get the lead on this.

There are a couple other proposals being considered also. I have to talk to Jim about what we can and would support. Obviously we have to contain ourselves from taking on too much but there is also the real condition now that is MBARI is a player in the AUV community (science and otherwise) and it's an opportunity we need to consider how to handle.

I hope this is the quick draft you asked for outlining planned and possible activities. As you can see there is no lack of fulltime involvement for many of the folks. In short order I can say the team as it is would be fully employable again on AUVs. We have support of Ops with the Zephyr (build and test), MOOS docking, Navigation overall, and science payloads that I know will come but don't have a clear vision of yet. I have heard of some science staff asking about when AUVs will be available and with what equipment. So, that avenue is also starting to spin-up and I haven't even addressed it really since I have no direct knowledge. Jim is probably being approached by science on that front or maybe yourself.

2.0 Proposal

2.1 Work Breakdown Structure, resource estimate, timeline

Dorado Build for MBARI Operations and Science (done in conjunction with ALTEX mods).

Complete modifications per design review of fall 2001: ME 50d, SE 50d, EE 50d, AE 50d, AUV Ops 50d
Q1 2002

Build of cable harnesses EE Tech 30d
Q1 2002

Build of MVC Spheres EE Tech 30d, ME Tech 5d
Q1 2002

Machine of Hull Components, Shop 30d, ME Tech 10d
Q1 2002

Assembly of Hull Sections, ME Tech 10d
Q1 2002

Dorado Assembly Build, ME 10d, SE 20d, EE 10d, AE 10d, AUV Ops 10d , ME Tech 10d
Q2 2002

System Integration and Lab test, ME 5d, SE 10d, EE 10d, AE10d, AUV Ops 10d,
Q2 2002

Sea Trials ME 5d, SE 10d, EE 10d, AE 10d, AUV Ops 10d
Q2 2002

System delivery to Operations Q3 2002 with some AE and Ops Tech Support.

Mapping Payload Support

Dorado support and integration for MBARI Operations and Science

Integration and test, ME 15d, SE 30d, EE 20d, Q3 2002, AE 30d, AUV Ops 10d,
Q3 2002

Docking support for MOOS (possibly WHOI and Bluefin also depending on outside grants).

Design concepts and background research, Post Doc 50d, SE 5d, EE 5d, AE 5d, AUV Ops 5d
Q1 2002

Design assistance, Post Doc 30d
Q1 2002

Build assistance, Post Doc 30d, ME Tech 25d
Q1 2002

Lab / Tank tests, Post Doc 10d, ME Tech 10d
Q2 2002

Dorado Docking Modifications, ME 40d, SE 20d, EE 10d, AE 20d, AUV Ops 10d, ME Tech 10d
Q3 2002

Dorado Navigation Modifications, SE 20d, EE 10d, AE 20d, AUV Ops 10d, ME Tech 10d
Q3 2002

System Integration and Lab test, ME 5d, SE 10d, EE 10d, AE 10d, AUV Ops 10d
Q4 2002

Sea Trials ME 15d, SE 30d, EE 30d, AE 30d, AUV Ops 30d
Q4 2002

Data and Publication Payload Support

Dorado support and integration for MBARI Operations and Science

Integration and test ME15d, SE 20d, EE 20d, AE 20d, Post Doc 60d
Q3 2002

Fuel cell test support AE 40d, AUV Ops, 40d, AUV Ops 2 40d
Q1-4 2002

2.2 Design Reviews

- Concept designs for docking
- Fuel Cell design review
- MOOS AUV Docking Mooring review
- Preliminary Dock Design Review
- Critical Dock Design Review
- Dorado "as built" review for operations hand-off

2.3 Preliminary Test Plan

Currently there are plans for 2 weeks of testing per quarter for fuel cells. An additional week per quarter for other payload and ALTEX tests is anticipated (no details as yet). Finally the docking tests in the 4th quarter and mapping payload tests will combine with the fuel cell tests to occupy 4 -5 weeks of testing if everything arrives on time.

2.4 High Risk Items

The fuel cell is a very high risk item because of the current status, it is non-operational with no funds to re-design and re-build the unit for further development in 2002. Funding from ONR is required at this point to carry this project forward (however, a recent cost share possibility has also come from the Canadian government but no details as yet).

Docking is a high-risk item because of the two outside parties, WHOI and Bluefin. Both have plans to include in their projects and we have our own internal docking ideas. Hopefully this will all dovetail well but WHOI already has a design based on our vehicle and Bluefin is pursuing a design to address several variations of vehicles. The Bluefin proposal offers funding to MBARI while the WHOI proposal plans on using our mooring efforts at no cost to them or funding for us. We have a joint proposal to ONR with Bluefin and an MOU with WHOI.

2.5 List of Deliverables

- Two Dorado class vehicles with additional mid sections, one battery mid-body and one empty shell for general payloads.
- Docking involvement in concept, design, build and test for MOOS moorings.
- Several papers on high-latitude vehicle performance (arctic cruise data), performance of vehicle with an Ice Draft capability, CTD / water analysis paper of arctic AUV data, vehicle performance in cold waters, data buoy performance, etc. (along with the associated presentations)
- Mapping payload operations in Monterey Bay
- Support for Zephyr launch and recovery (no manpower but during testing of vehicles)

2.6 Dependencies on other projects

Yes - the ALTEX development, mapping system, Sea of Cortez expedition, and others internal and external

2.7 Project Team

Same as pervious years with the exception of a new Post Doc for docking.

3.0 Budget

MVC 2 x $1500.00	$3000.00
Pressure Housings (spheres - mat'l TBD) 6Al-4V est. 4 x $15,000.00	$60,000.00
DVL (RDI Workhorse) 2 x $40,000.00 (newest version)	$80,000.00
Crossbow AHRS 2 x $1,500.00	$3,000.00
LBL head and board set 2 x $3,000.00	$6,000.00
Navitech Beacon and Flasher 2 ea x $1,500.00	$6,000.00
GPS Boards 2 x $1000.00	$2,000.00
GPS / Freewave antennae 2 x $3500.00	$7,000.00
Connectors 2 sets x $25,000.00	$50,000.00
Wiring and Tubing misc.	$15,000.00
Li Polymer / Ion batteries 2 ea plus (primary and turnaround)	$140,000.00
Power boards 2 sets 2 x $2,000	$4,000.00
Comms set / networking hubs 2 x $1,500.00	$3,000.00
Junction boxes 2 x $1,000.00	$2,000.00
Tracking beacon (ORE) 2 x $2,500.00	$5,000.00
QNX Os license 2 x $2,500.00	$5,000.00
Misc. hardware / materials to build 2 Dorados	$5,000.00
Conferences and Presentations (reg and hotel etc.) 2 x 2 people	$10,000.00
Travel 2 x 2 people averaging east coast distance	$8,000.00

Appendix B: MOOS Mooring

Project Manager: Mark Chaffey

Rev. 1.0 14AUG01 mrc

(a) Project plan for 2002 is to verify the viability of the basic mooring system design by monitoring the test mooring and proceed with the detailed design of the next deployment target. The test mooring is currently scheduled for field deployment in the Fall of 2001, however this may take place in early 2002. The second mooring field deployment will have the complete mooring system in the low power configuration and be able to power benthic instruments. This deployment is currently scheduled for early 2003.

1. Efforts in 2002 will be directed toward the following:

(a) Monitor the test mooring performance.
- To verify the accuracy of the WHOI CABLE dynamics model used to predict mooring riser cable configuration and cable loading.
- To test the design life of the cable terminations, bending/axial strain relief's, and other mechanical elements of the design.
- To verify our ability to perform the ROV operations necessary for completing the connections between the riser cable and the seafloor mounted instrumentation.

(b) Complete the preliminary and detailed designs of the MOOS mooring subsystems.
- Electrical power system.
- Mooring controller (extension of NMC).
- Integration with field test release of ISI.
- Local (intra-mooring system communications) design.
- Over-the-horizon communications design.
- Modifications to the mechanical design based on the results from the test deployment.

(c) Plan for the fabrication and deployment of system #2 at a selected MOOS target location in 2003. This mooring will include the final low power version power system, completed intra-node communications system and a 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.

2. Work breakdown structure:

2.1 Monitor test mooring performance and verify performance.

(a) Compare the test mooring performance to WHOI CABLE dynamics model. Verify that the maximum static and dynamic loads on the riser cable are similar to the model results for a given sea state. Monitor the performance of any bending and axial strain relief elements. Monitor the performance of mechanical splices and terminations. Actively monitor the performance of the optical and electrical riser cable elements by looping through connections at the benthic termination. Document results.

Monitor test mooring performance	ME 15d	EE 25d	OBS 10d

Significant Milestone: Deploy test mooring Oct. 29 2001

<u>2.2 Design and fabricate Low Power mooring system</u>

<u>a) Overall System Design and Project Management</u>

PDR on overall LP mooring design, March 15 2002	EE 20d
CDR on overall LP mooring design, June 15 2002	EE 20d

<u>b) Mechanical</u>

Design effort to rework test mooring	ME 30d	MS 15d
Mooring tower design	ME 20d	MS 15d
Benthic release/anchor assembly	ME 30d	MS 20d
Benthic instrument node (BIN)	ME 5d	MS 25d
Documentation of deployment 2 configuration	ME 10d	

Budget

Misc. materials	$ 25k
EOM steel riser cable	$ 35k
EOM fiber riser cable	$ 80k
Benthic instrument node	
Materials	$ 25k
UW connectors	
For riser base	$ 50k

<u>c) Power system</u>

Electrical power source and system	ME 27d, EE 54d, ET 30d, MT 17d, MS 30d
Power up-converter	EE 40d, ET 30d
Power down-converter	ME 5d, EE 30d, ET 25d, MS 5d

Budget

Solar panels	$ 15k
Batteries and regulators	$ 10k
Misc. materials	$ 15k
Wind generator	$ 5k
PCB layout X 2	$ 6k

d) Mooring controller

Upgrade to NMC for mooring	EE 30d, ET 25d
Modify DCON housing design for mooring	ME 10d, MT 5d, MS 15d

Budget

Misc. materials	$ 12k
Titanium for UW housing	$ 10k

e) System communications

Node-to-node communications network	EE 35d, ET, 25d, SE 20d
Mooring-to-shore comms.	EE 15d, ET 10d, MT 5d, SE 5d

Budget

Misc. materials	$ 10k
PCB layout	$ 3k
Line-of-sight modem	$10k
Sat com modem	$ 8k
Sat com use fee (1 year)	$ 6k

f) Advanced mooring power systems concept design

Dissolved Oxygen Power Cell	ME 14d, EE 80d, ET 25d, MT 9d
(note: 50% EE and ME time paid by external grant)	
Wave and engine power sources concept design	EE 40d

MOOS Mooring Project Year 2002 totals

EE – 389d
ME – 166d
SE – 25d
Etech – 160d
Mtech – 47d
Observatory support (OBS)– 40d
Machine shop (MS)– 105d

Budget - $ 325k

3. Resource estimates – included in WBS above except as noted below.

Ship time.

Pt. Sur – Two days staging time and two sea days for mooring deployment. Note: The target location for the deployment is dependent on the coupled science experiment. The deployment schedule is late 2002. This date could slip into 2003 depending on resource levels and test mooring results.

Pt. Lobos/Western Flyer – Two days staging time and three days for subsea BIN installation and ROV hook-up of Benthic instrumentation (assuming science target includes Benthic site). Use of Pt. Lobos vs. WF is dependent on location selected.

4. High risk items:

(a) The three major design risks are the vertical riser cable physical integrity, the ability to reliably make connections to Benthic instruments by ROV cable laying and the inter-controller networked communications scheme. For the riser cable the risk is being addressed through a consultation arrangement with Walter Paul and Mark Grosenbaugh from WHOI, acknowledged experts in the field of buoy cable dynamics, as well as through a laboratory and field test program for verifying our design models. Most of the Benthic cable laying work is part of the Canyon Dynamics experiment. If technical difficulties laying cable are encountered in that program then additional work may have to be performed (under MARS program or Mooring project?) or the system specifications revised to not support instrument deployments an extended distance from the mooring base. Communications system design risks are addressed by fully utilizing in-house experts such as Wayne Radochonski, working closely with the ISI project, as well as extensive laboratory and field design verification.

5. Dependencies:

(a) The New Mooring Controller / SideARM implementation is an important foundation for the MOOS mooring controller. The New Mooring Controller design needs to be completed in Fall 2001 to allow design work to begin on the MOOS mooring controller communications interface expansion in 2002.

(b) The MOOS ISI subproject provides the software system infrastructure necessary for implementing MOOS functionality. Specific software applications also have to be developed to enable mooring hardware and infrastructure functions, i.e. store and return science instrument and mooring engineering data. An initial "end-to-end" ISI and application test implementation is planned for the second mooring deployment to return data from the specific instruments on this deployment. There is a major hardware/software interdependency in this area in terms of executing the appropriate functionality on the required time schedule.

(c) The Mooring riser project is providing the hardware test bed for ISI proof-of-concept end-to-end test exercises. The mooring riser project needs to stay synchronized with the ISI schedule so this hardware is ready when ISI needs it.

6. Project Team:

Project Manager: Mark Chaffey
Chief Engineer: Mark Chaffey
Power system design: Ed Mellinger

Mechanical riser and buoy design: Jon Erickson
Mechanical design of BIN and inter-BIN cable connections: Gene Massion
Communications design: Wayne Radochonski and Mark Chaffey
RF communications design: TBD
Observatory support team member: Mike Kelly

Appendix C: Instrumentation Software Infrastructure

Project Manager: Duane Edgington

1. Work Breakdown Structure of MOOS project plans

2002 Plan: 2002 is largely planned for detailed implementation of core elements of ISI (the infrastructure itself), as well as "reference designs" and proof of concept of other pieces of the MOOS software system, that prove out ISI concepts:

a) Prototype high risk implementation elements:

1) Communications needs — 20d SE
2) Bandwidth overhead of protocols — 15d SE
3) Puck plug and work experiments — 20d SE
4) Interface to SSDS via XML — 35d SE

b) Implement ISI framework — 120d SE

c) Device drivers for selected instruments, which stress different parts of the design. We expect this work to be coordinated with NMC device driver work (planning to share code and effort) — 40d SE

d) Proof of concept communication infrastructure (low bandwidth radio to shore; satellite communication; high bandwidth cable communication). Not ISI product deliverables, but needed to test and prove out infrastructure. — 30d SE

e) Proof of concept applications for local storage, data acquisition, metadata acquisition, and shore-side archive. Again, these are not ISI product deliverables, but are all needed to prove out the infrastructure. — 30d SE

f) Proof of concept development of plug-and-work instrument interface electronics ("pucks"). — 20d SE

g) Our work in 2002 could scale from 2 – 4+ person years, depending upon how much of progress we need to make for any planned field trial or deployment. In particular, the project would benefit from assignment of EE and ME talent to move Puck development ahead more quickly, for alignment with MARS and NEPTUNE project timeline.

I am concerned that if we only do proof of concept work on the puck concept in 2002, with no allocated EE or ME time, that MARS and NEPTUNE will seek other solutions to the similar problem those systems face, and thus lower the potential positive impact of our own efforts.

2. Test plan:

a) Bench test with NMC instruments

b) Proof of concept test communication infrastructure, in lab, and at sea in collaboration with Ops

c) Bench test proof of concept integrated system with test-rigged i) local storage, ii) platform applications, iii) platform to shore communication, and d) shore-side archive and interface.

d) Bench test plug-and-work “puck” simulator/proof of concept prototype.

3. Deliverables:

a) Documented infrastructure

b) Documented proof-of-concept test results

c) Presentation at national conference

4. Dependencies:

MOOS mooring (communications)

NMC (drivers, core architecture,platform)

Ridge Observatory (test bed of ISI concepts)

MARS/NEPTUNE (plug-and-work; platform for ISI)

MOOS Data Management (shore-side data system; user of ISI API)

5. Project Team

Project Manager: Duane Edgington
Lead Engineers: Dan Davis, Tom 0’Reilly
Developers: Danelle Cline, Richard Henthorn, Brent Roman
Science Advisors: Francisco Chavez, Christopher Scholin

Appendix D: New Mooring Controller:

Project Manager Duane Edgington

1. Work Breakdown Structure

2002 is the year to move NMC to full operational status. The plan includes:

a) Completion of software system (multiple housing configuration)	60d SE
b) Implementation of all drivers needed for actual deployment	40d SE
c) Full operational test in parallel to existing mooring or drifter	20d SE 10d EE
d) Implementation and test of multiple electronics housing system system (up to 32 instrument configuration)	20d SE 20d EE 15d ME
e) Transfer of NMC system to Support Engineering and Operations	20d SE 15d EE
f) Participate in build-up of operational NMC subsystems and components with Support Engineering and Operations	20d SE 15d EE 5d ME
g) Continued coordination with ISI and MOOS efforts to ensure easy migration of hardware and software from NMC into MOOS	40d SE
h) Coordination of NMC effort with any initiatives to upgrade or modify the shore-side data acquisition and processing system for mooring data	20d SE
i) Publication and presentation of NMC at appropriate conference	15d SE

Our work in 2002 is on the order of 2 person years.

2. Test Plans

a) Test single enclosure configuration on M1, parallel to OASIS deployment, Spring 2001

b) Test multiple enclose configuration, Summer 2001
First full deployment, Fall 2001

3. Deliverables:

Completed Hardware design
Completed Software design
Transfer package, to Ops and Support Engineering (Documentation, test procedures)
Presentation and publication of final system at national oceanographic conference

4. Dependencies:

a) NMC is tightly linked to ISI project (sharing core architecture and device driver architecture).

b) NMC is linked to 2001 SideARM applications project.

Appendix E: MOOS Shore-Side Data System (SSDS)/ Data Management

Project Manager: John Graybeal

1. General

(a) The purpose of this project is to define and begin construction of the MOOS Shore-Side Data System (SSDS). In 2002 we expect to complete high-level requirements documentation and hold a review. The initial concept for the system will be developed and high-risk components will be investigated through initial prototype development and testing.

(b) These critical and high-risk functions include
- interfacing with the in-water data systems to obtain all the data and metadata,
- developing systems to automatically manage these data streams, and
- providing interoperability to support quality control, data blending, and other yet to be determined uses of the data.

(c) The implementation plan will coordinate with MOOS science field experiments as well as other MOOS sub-projects.

2. WBS, Resources, Timeline

2.1 End-to-End Development

Catalog server investigation		
Catalog server survey of existing solutions	10	Q1 2002
Catalog server conceptual design (may include prototype)	40	Q4 2002
end-to-end prototype managing a changing data stream	35	Q3 & Q4 2002
prototype handling shipboard data streams where: sensors like HDTV disappear; calibrations change frequently; and data delivery changes (e.g., microwave goes out of range).	20	Q4 2002
metadata format evaluations (may include prototypes): XML, FGDC, DODS, HDF, …	10	Q2 & Q4 2002
Infrastructure support (i.e., system admin)	15	ongoing
architectural development of SSDS	10	Q2 2002
review and documentation support (diagrams etc.)	15	ongoing

2.2 Data Ingest

Develop/refine data file converters (e.g. AUV data into netCDF)	15	Q2 2002
Instrument object to data system interface (ISI coordination)	8	ongoing
Instrument object to SSDS interface (data ingest prototype)	12	Q3 2002
Investigate metadata maintenance for data-specific pipelines	10	Q2 2002

2.3 Storage and Metadata

management of multiple storage objects (files, DBs, tables) -- explore connection to DODS server	10	Q3 2002
metadata content proposal for data (real required/optional tags)		
data set format (describes stream format—ints, floats,…)	3	Q1 2002
data descriptors (describes data's physical characteristics) units, source, descriptive name, platforms	7	Q1 2002
metadata content proposal for catalogs (filesystems, storage)		
format	20	Q3 2002
descriptions – summary info about what's in each file (tags, data content (e.g., location, time, key values))	10	Q3 2002
file system storage evaluations: DBs, netCDF, …	15	Q4 2002

2.4 Extraction and Presentation

Server-side data access improvements (e.g. prototype SQL/DODS server)	30	Q3 2002
Client-side data access improvements		
develop one (or more) DODS client prototype	15	Q3 2002
develop Web-based DODS data access prototype	20	Q4 2002
install generic web plotting interface for stored data (e.g., ferret, OceanDataViewer, or other)	20	Q4 2002
GIS integration		
ArcView access to MOOS/existing data	20	Q2 2002
3D Vis use of MOOS/existing data	20	Q3 2002
evaluate and prototype data formats for extracting stored data ASCII (CSV or other), netCDF, XML, …	10	Q4 2002

(d) Of the resources outlined, 150 days will need SE-level work, while 250 days are SAD-level work. These resources will be allocated among specific tasks as needs warrant.

(e) The total hours indicated represent an overbooking of the IAG staff. (To complete all these tasks as independent projects would require the addition of two full-time equivalents to the IAG staff. Although this corresponds to IAG's historical staffing level, we do not anticipate being staffed at that level throughout 2002.) The expectation is that some of these tasks will be accomplished as part of other IAG-supported projects, and it will prove feasible to blend some others. Remaining tasks will be prioritized throughout the year so as to fully accomplish MOOS goals and milestones. In total, we expect to bill 300 IAG days to MOOS data system activity.

3. Reviews

3.1 Stakeholder Reviews

Stakeholder reviews will be held on specific tasks throughout the year. Roughly half of these tasks will be performed with respect to existing projects or data streams, and at least one user or customer will be solicited to review and comment on progress. These reviews will occur often during the development of each task.

3.2 Internal Design Walkthroughs
At least once each quarter, we plan to hold a walkthrough of the design review which 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 Formal Requirements Review
Throughout the remainder of this year and (to a lesser extent) the first 6 months of 2002, IAG will make a short list of high-level requirements for the Shore Side Data System. (These requirements will be refined from the requirements identified in the MOOS Data Workshop.) In June 2002, IAG will hold a formal review of those requirements for all MOOS SSDS customers. (This will be coordinated with an informal review of the overall MOOS systems architectural concept.)

3.4 External Design Review/Workshop
To validate the technical approaches being considered for the MOOS SSDS, we will hold a review and workshop with external pariticipants during the latter half of 2002. Approximately 6-8 data systems developers representing 4 to 5 other institutions will be invited to attend, for the purposes of both critiquing the IAG concepts for the SSDS, as well as presenting their own work for review by the group. Institutions from both oceanographic and astronomical observatories will be invited.

Two days of meetings are planned, to include both a roundtable of presentations and discussion, and a somewhat more in-depth review of MBARI plans. Since the goal will be to perform significant technical review in a short period of time (2 days), active MBARI-wide participation will not be possible. However, interested MBARI developers will be encouraged to attend the proceedings, which in many cases will be of general interest.

4. Preliminary Test Plan

A project-wide test plan is not applicable, since these tasks are for the most part preliminary investigations.

5. High risk items

5.1 Scope
Given current staffing levels, the optimal solutions for MOOS data management will not be achievable on the same schedules anticipated for other project elements. Therefore, functionality must be appropriate downscoped, and/or development stretched out, so that overall MOOS goals are not compromised. In addition, it is tempting to try to solve all existing MBARI data management issues (as well as MARS?NEPTUNE goals) during MOOS development. The lessons learned from previous ‘monolithic database solution’ development efforts at MBARI must be wisely applied, and

It will be important to manage this work such that:
- the overall scope remains manageable,
- progress toward long-term objectives is clear and demonstrable,
- resources are used efficiently, and yet

- intermediate goals (IAG, MOOS, MBARI science, and external) can be effectively met.

Wise selection of individual tasks should allow us to satisfy these 4 criteria. Each task will build toward the overall goal, while adding value to MBARI's data management capabilities in the short-term.

5.2 Training/Expertise

Although MBARI has a cadre of experienced database developers and data management professionals, the MOOS SSDS presents challenges beyond the normal software development team's capabilities. At the same time, finding and hiring a uniquely qualified senior database architect is not a likely solution (for both cost and applicable expertise reasons). As a result, the team will have to step up to an advanced level of engineering productivity.

This team is well positioned to do so, but will require some assistance to be fully effective. The following steps will provide MBARI with the most effective development team:

- 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

6.1 Completed SSDS Requirements document. (This document will evolve over time.)
6.2 Draft SSDS conceptual design.
6.3 Preliminary SSDS interface documents:

- standard data submission format definition
- data presentation interfaces definition

6.4 Metadata specification document

- list of required and desirable metadata information ('tags') for data submission
- format specification (DTD or equivalent)

6.5 Working (prototype) SSDS software supporting ISI interface
6.6 White paper or other summary documents reflecting completed investigations and prototypes (includes subject, conclusions, and lessons learned)

7. Dependencies on other projects

7.1 MOOS Systems Architecture

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 2002.

7.2 ISI

Several prototypes are closely linked to ISI development and progress, and must be closely coupled with the ISI product schedules. We intend to meet regularly with the ISI team to ensure these interactions are well coordinated.

7.3 Science Projects and Core Data Streams (general)

Many 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 selection of the MOOS Science Project could impact some of these plans. As of now it appears the timeline of the MOOS Science Project is sufficiently long that no immediate impact will occur. However, to the extent additional resources must address previously unconsidered Science Project needs, deliverables and schedules will be affected.

7.5 MARS/NEPTUNE

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, the technical effects could strongly hurt MOOS development.

8. Project team

The IAG team (John Graybeal, Mike McCann, Rich Schramm, Dan Wilkin, Brian Schlining) will be directly esponsible 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.

9. Budget

Software Development tools	$5,000
Dedicated testbed computer system (OS TBD)	$4,000
Funding for workshop/review held at MBARI	$10,000

morning, afternoon break provisions @ 20*$25=$500
1 working lunch @ 25*$20=$500
1 offsite lunch @ 20*$25=$500
travel expenses for 2 days for 4 sponsored attendees (if needed)
(airfare, car, hotel, per diem) @ 4*2000=$8000
one TBD event (breakfast, reception, or other) @ $500

Training: classes in development methods/tools	$5,000
Training: developer conferences (Fees, travel, meals)	$5,000
Texts and Journal to support project	$500

Expert consultation	$6,000

Appendix F: Canyon Dynamics Experiment

Project Manager: Gene Massion