900027: MOOS Program for 2001

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Appendices:

1. Scope of the MOOS Program for 2001

1.1 Projects. In 2001, five of the MOOS projects started in year 2000 will continue, and a science experiment, based on investigating Canyon processes, will test some of the high risk elements of MOOS. These programs are:

- AUV
- MOOS Mooring
- New Mooring Controller
- Instrumentation Software Infrastructure
- MOOS Data Management
- Canyon Dynamics Science Experiment

1.2 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, and PMEL).

(b) AUV efforts at MBARI include four main activities in 2001:
- Completing the design and build of the Dorado vehicles (two vehicles)
- Engineering support to help identify and specify interface and other design considerations associated with the mooring riser and AUV docking capabilities
- ALTEX, a partnership in an NSF funded program to trace the warm water intrusion under the Arctic Ice cap and to map that body of water (ALTEX)
- Integrating science instruments into the Dorado vehicles and running science missions.

(c) Of the above, only the first two activities, completing the design and build of two Dorado vehicles and early work on AUV docking interfaces and design considerations, fall under MOOS. The build of the two Dorado vessels was originally planned for the year 2000, but was postponed due to all of the approved resources being used to complete other tasks. 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.

(d) The ALTEX program is funded by a NSF grant for approximately $2.03 million dollars over the next three years. 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) Integration of science instruments into the Dorado vehicles and running science missions, are being proposed as individual projects, and will use the AUV assets (2 Dorado vehicles) when they are turned over to operations. This science use of MOOS developed capabilities will compete for shared resources in the same manner as other MBARI projects.

(f) AUV Engineering team. A core AUV team has been identified that will be tasked with AUV development work, including completing the two Dorado vehicles, undertaking the ALTEX program and AUV docking. This team comprises of Bill Kirkwood (project manager), Drew Gashler, Nicholle Suoja, Hans Thomas, ME, SE, EE 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 2001, two Dorado class AUV vehicles will be designed, built, tested, documented and handed over to operations ready for supporting science missions.

1.3 MOOS Mooring

(a) The MOOS Mooring proposal is attached as Appendix B. By the end of 2000 we will have completed the functional requirements and system level design requirements for the MOOS mooring and will have started the concept design studies. In 2001 we will undertake the following activities:

- Identify suitable collaborators in the oceanographic community
- Complete the concept design for the MOOS mooring. A concept design review will be held in the first quarter of 2001
- High risk elements of the MOOS mooring will be tested and mitigated with an engineering test program. Specifically an engineering field test program will evaluate the performance of the mooring riser and will be used to verify the mooring riser static and dynamic models. The field test will also be used to evaluate the methodology selected for deploying the mooring system and for the process of connecting the mooring riser to the benthic hub.

(b) MOOS Mooring Engineering Team. Mark Chaffey (project manager, lead engineer), Mark Greise, Ed Mellinger, Wayne Radochonski.

(c) MOOS Mooring Deliverables. Concept design review, deployed test mooring.

1.4 Instrumentation Software Infrastructure

(a) The Instrumentation Software Infrastructure proposal is attached as Appendix C. Plans for 2001 include:

- Specification of the overall objectives and requirements of the system
- Preliminary design review.
- System architecture design, including (a) instrument interface messages, services and data, (b) network requirements and characteristics, (c) implementation language(s) and tools, and (d) services to be provided by *MOOS Data Management* middleware, User Interface, and storage.
- Critical design review

- Initial release. Focus on demonstrating a fully executable system in the lab that captures the key elements of the system architecture, by satisfying selected use cases spanning selected instruments
- Iterative release #1. Iterative releases will progressively satisfy more use case scenarios and user requirements. Each iterative release will include maintenance/bug tracking, sourcefile configuration control, test cases that test functionality and bug fixes, system documentation, user documentation, and integration

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

(c) ISI Deliverables for 2001 include the following:

- Instrument software infrastructure system defining the communication interface to instruments, including (a) Software protocols for acquiring configuration information (operating modes, calibration data, modeling parameters, identification, etc.) (b) software protocols for acquiring measurement data (c) Interfaces for tools that use this information (these tools are not part of this project: data logging, display, and storage).
- Demonstration of a working executable system in the lab, together with selected instruments, interconnecting network, data logging, display and storage supplied by complementary MOOS projects.

1.5 New Mooring Controller

a) The New Mooring Controller proposal is attached as Appendix D and is a continuation of the 1999 and 2000 projects of the same name. The 1999 project was approved to start in July of 1999 as a two year project.

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 developed by Radochonski which will presumably become the core processor for new instrumentation at MBARI and for MOOS. The software will use the VxWorks operating system, or embedded Linux, an emerging open source standard. The software will use object-oriented techniques.

c) The secondary goal is to coordinate 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 will experiment with forward-looking software design techniques, such as CORBA and distributed-object network architectures, in order to be a first step towards the architecture being developed for MOOS.

d) In 2000 the project suffered from inconsistent staffing, due to resignations of two key contributors. The requirement analysis and review were completed (March 21, 2000). Considerable design and architecture explorations have been performed, and the functional design document is being developed . In 2001 the controller will be completed ready for mooring applications, and a roadmap for its use in MOOS developed.

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

1.6 MOOS Data Management

(a) The MOOS Data Management proposal is included as Appendix E. In 2001 the team will
- Design and implement the first iteration of the MOOS data management system
- If viable, the first design iteration will be tested with the Canyon Dynamics Experiment.
- Hold a PDR 2/2001 and CDR 5/2001
- Deliver a test plan July 2001

(b) MOOS Data Management Team. Mike McCann (project manager), Rich Schramm, Dan Wilkin, Gerry Hatcher, Reiko Michisaki, Brian Schlining, Duane Edgington, Mike Matthews

(c) Deliverables. PDR, CDR, test plan, test plan review.

1.7 Vertical Profiler

(a) The first version of the vertical profiler will be tested during the MUSE experiment. Further work will be on hold until the MOOS mooring design has been developed to the level needed to identify the high level requirements and interface between the MOOS mooring riser and the vertical profiler. In addition, for 2001, design work on the vertical profiler will be on hold until we have made significant progress on the mooring design. Once the mooring design has made substantial progress, design resources will be moved back to vertical profiler development if available. The availability of resources for vertical profiler development will be reviewed in July 2001. If the resources are not available mid year development of the Vertical profiler will be started early the following year.

1.8 Canyon Dynamics Experiment

(a) The aim of this science program is described in the MOOS Functional Requirements as one of the Use Scenarios. The experiment will test some of the high risk elements of MOOS, namely the equipment, tools, techniques and processes that must be developed to support ROV cable laying.

(b) Two RINS (remote instrument nodes) and one BIN (benthic instrument node) will be designed, deployed and interconnected to develop the ROV cable laying and interconnection capability, as well as to evaluate the RIN and BIN design during actual field conditions whilst acquiring the initial CD data set. The instruments planned for this deployment all provide internal data logging and power. Ventana would visit the easily accessible BIN site on a 2 - 3 month basis to upload data from the RINs. Batteries packs would also have to be refurbished but on a less frequent basis. This deployment will be achieved with COTS instrumentation, network electronics and software allowing the majority of the MOOS engineering resources to be applied to developing the advanced systems required to support a fully functional MOOS.

(c) Cable selection is highly dependent on the MOOS functional and system requirements and is the critical decision that must be made by the MOOS Mooring team before this capability can be developed.

(d) The first deployment will likely be sited on a wide ledge on the wall of the canyon that is less than 1/2 hour off the Moss Landing entrance buoy, relatively protected from fishing and within 3 km of 2 sites identified for the Canyon Dynamics RINs. The instruments deployed may include ADCP, current meter, CTD, pressure gauge, transmissometer, seismometer, hydrophone, and other sensors as they become ready for testing (particularly chemical sensors such as ISUS). All the instruments have data storage sufficient for a 2 - 3 month deployment. The instruments also have internal power sufficient for approximately 6 months and up to 1 year in some cases. This deployment requires a Ventana dive on the benthic node every 2 - 3 months where Ventana would plug into the benthic node and upload the data from each of the instruments at the RINs. This would be accomplished by running the instrument vendors standard software from a computer on the Pt. Lobos communicating with the remote instruments through the standard Ventana telemetry system (possibly the existing spare Ethernet link), the benthic node and the ROV laid cable. Every 6 months (or so) Ventana would be scheduled to refurbish the battery packs. With the exception of the mechanical anchors and structural elements which will be designed to support the overall MOOS requirements, all this can be accomplished with COTS instruments, electronics and software.

1.9 NEPTUNE

(a) As MBARI becomes a full member of the Neptune consortium and funding gets approved, we will be increasingly involved in several NEPTUNE activities including:

- Planning, permitting and managing the installation of the NEPTUNE test bed facility in Monterey Bay. In 2001, activities will likely be limited to investigating permitting issues and discussions with the NEPTUNE design teams. The power and communication design and bench testing programs being performed at WHOI and at JPL need to be substantially complete before the bid package for installation of the test bed facility can be prepared.
- Participation in NEPTUNE meetings.
- Participation in Neptune workshops.
- Participation in design activities such as interface definition for instrumentation, communication standards etc.
- AUV docking. This is an area of interest for MBARI involvement in NEPTUNE, possibly in collaboration with another partner. As such, at the moment it is not an approved allocated

part of the NEPTUNE program. When, and if, approved, this activity will be closely coordinated with the AUV docking activities for the MOOS mooring. It is anticipated that this program would need a substantial level of resources which would be funded from the Foundation Grant, and that the Dorado AUV development activity would need to be ramping down in order to release the skilled engineering resources needed to support this program. Jim is considering hiring a post doc to evaluate technical approaches and start early work in preparation for when this activity starts to ramp up.

2. 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. Of note:

- The original MOOS data management plans were scaled back to not exceed the 50% resource level
- Electrical engineering resources needed are 78d less than the 50% level
- Mechanical engineering resources needed are 70d over the 50% level, mainly due to the resources needed to support the Canyon Dynamics experiment
- Software engineering resources needed are 70d less than the 50% level
- To complete the New Mooring Controller requires an additional120d of SE in 2001 compared to the initial estimates. This current estimate is –50% +100%.

(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	900027	$47,500
Dorado	600024	$302,650
Mooring Riser	600027	$284,700
Instrumentation Software Infrastructure	600026	$76,300
New Mooring Controller	600029	$50,000
MOOS Data Management	600031	$57,000
Vertical Profiler	600028	$65,000
Canyon Dynamics Experiment	900030	$332,166

Table 1 MOOS Resources for 2001 (note: resources in parentheses are not shared resources)

	50% MBARI	**MOOS Total**	**AUV**	**MOOS Mooring**	**ISI**	**NMC**	**MOOS DM**	**Vertical Profiler**	**Canyon Processes**	**Neptune**	**Contingency (10%)**
RESEARCH											
Scientist											
Research Specialist											
Research Technician											
Post Doc Science											
Lab Assistant											
IAG											
Software Applicn's	440	444			4		440				
Software Engineer											
ENGINEERING											
Electrical Engineer	440	362	(320)	246	9	12			15	10	70
Mech Engineer	385	455	160	143					132	20	0
Software Engineer	680	610	160 (160)	40	170	120	20		20	10	70
Research Engineer											
Post Doc			(320)								
Support Engineering		40									
ITD											
Video Lab Support											
Web support											
Documentation											
CTD Data Tech											
Tech Transfer											
Sample Archiving											
DMO											
Director		15		10						5	
Deputy Director											
Ventana Pilot		17		2					15		
Tiburon Pilot		1		1							
Marine Ops Tech		10	(180)						10		
Ocean Obs Support		62		62							
Ops/CTD Tech											
Model Shop											
Diver											
TSD											
EE Tech		165	50	35	20	10			50		
ME Tech		110	40	40					30		
Machine Shop		265	160	30					75		
Computer Support											

3. Integration of Science Experiments and Field Tests for Evaluating MOOS Systems and Operating Procedures

(a) The Canyon Dynamics experiment has been formulated to allow an opportunity for MOOS subsystem testing, but at the same time allow valuable science data to be taken. The science experiment will provide an opportunity to:

- test one of the high risk elements of the MOOS program, cable pack laying
- test early prototypes of the MOOS data management system
- evaluate deployment procedures for the mooring benthic expressions
- evaluate ROV operating procedures for mating underwater connectors

(b) The mooring riser engineering deployment will provide an opportunity to:

- test high risk aspects of the riser design, in particular the reliability of the data and power connection between the mooring surface expression and the fixed anchor base.
- test ROV operating procedures for making a connection between the mooring base and a sea floor mounted instrumentation node

4. Priorities for the 2001 Program

(a) High priority activities for 2001 include the following

- Identify suitable collaborators for mooring development
- Complete the build of the 2 Dorado vehicles and transition the vehicles to Operations
- Complete the New Mooring Controller development project ready for upgrading the OASIS controllers
- Complete the prototype design of the mooring riser project, and test high risk aspects of the system before the end of 2001
- Perform fiber cable laying, mating underwater connectors, establish ROV operating procedures around benthic expressions
- Meet commitments of the Neptune project

Appendix A: Dorado

Project Manager: Bill Kirkwood

1. Project Objectives:

Objectives of the Dorado project are two fold:

- Develop two modular AUVs for general use by staff of MBARI R&D.
- Continue development of very long endurance AUVs

Work in 2001 will build on the accomplishments of 2000, that include:

- Demonstration of new software implementation architecture for AUV control code.
- Demonstration of prototype Dorado AUV
- Demonstration of a fuel cell on a modular Dorado.

1.1 MBARI General Use AUV

The primary goal for 2000 will be to develop two AUVs that will become institutional operational assets in 2001. The development of these vehicles will entail: review of the operational experience of 2000, redesign of selected portion of the existing vehicle, fabrication of new vehicles, and a transition period for passing the vehicles to operations.

The MBARI general use AUVs are expected to support a number of proposed science activities. Examples of such activities can be drawn from this years abstracts, including:

- Seafloor Mapping
- AUV CTD time-series measurements
- AUV Quantitative Imaging
- Docking development (MOOS.)
- Discrete Autonomous Fluid (DAF) Sampler
- Future MUSE experiment (MOOS)

Support of such a broad range of missions is possible because Dorado is a modular AUV design. Most of the core AUV systems are contained in the tail, while payload and batteries are contained in one or more forward sections. The Dorado program is primarily concerned with developing a robust, versatile AUV tail section along with the fundamental building blocks for battery and payload sections. Development of specific payloads for the AUV will be the subject of R&D proposals rather than the province of the Dorado program.

The tentative model of AUV operations is that DMO will maintain and operate AUV tail sections. The forward, payload portions of the AUV, may be operated by specialists from engineering or science. Integration of

1.2 Very Long Endurance AUV (ALTEX)

Extended operations are enabled by the development of a semi-fuel cell. Initial motivation is the need for extended operations in the Arctic basin. This program was first funded through a NOPP grant to MIT that started in 1998, to which MBARI became a party in 1999. Starting in summer 2000, funding for the very long endurance AUV will come primarily through NSF.

Objectives of 2001 for this portion of the activity include:

- Accomplish long endurance runs for the AUV with a semi-fuel cell section in Monterey Bay
- Integrate communications section on AUV and demonstrate locally.
- Engage in trial runs of AUV from USCG vessel Healey in Arctic, tentatively scheduled for October 2001.

The objective of the NSF funded effort is to greatly increase access to the Arctic Ocean by creating and demonstrating a safe and economical platform capable of basin-scale surveys. Specifically, we are developing an Autonomous Underwater Vehicle (AUV) for Arctic research with unprecedented endurance, and the capability to relay data through the ice to satellites. We call the vehicle the ALTEX AUV, for the Atlantic Layer Tracking Experiment that motivates its development.

Contributing organizations, lead personnel, and general project responsibilities are identified below.

James G. Bellingham	MBARI	Lead PI
William Kirkwood	MBARI	Project Manager
James E. Overland	Pacific Marine Environmental Lab.	Arctic Science
John Stannard	Fuel Cell Technologies, Ltd.	Fuel Cells
Peter J. Stein	Scientific Solutions, Inc.	Through-ice Communications
Dana Yoerger	WHOI	Navigation,Communication

2. Resources

Of these three new vehicles, two will be paid for from MBARI funds obtained through the Dorado Project and one will be paid for through outside funding from NSF (proposal #). The funding for the outside vehicle also includes funding for additional technical labor to build and test the platform prior to launch in the Arctic. A list of spare parts and other material resources are also included in the outside proposal with all ship time being supplied by NSF.

3. Project Team

Principal Investigator Jim Bellingham (40%)
Project Manager Bill Kirkwood (50%)
ME (1 FTE) Farley Shane
SE (2 FTE) Rob McEwen, Hans Thomas, SE
EE (2 FTE) Ed Mellinger (50%), Drew Gashler, EE (50%)
PostDoc (2 FTE) Nicole Suoja, (*new hire*)
Machine Shop (1 FTE)
Technicians (0.5 FTE) Herb Lundin

Appendix B: MOOS Mooring

Project Manager: Mark Chaffey

Rev.
1.0 7JUL00 mrc
1.5 10AUG00 mrc

1. Detailed work breakdown structure:

Enclosed as separate document.

2. Resource estimates –

Included in WBS except as noted below.

a. Labor resources – Submitted via web input.
b. Ship time - Submitted via web input.
c. Budget - Submitted via web input.

3. Review dates:

Draft System Design Requirements Review Sept. 2000
Benthic Cable specification review Dec. 2000
Concept Design Review Feb. 2002

Note: Individual hardware designs such as interface boards, power distribution system, power source selection, etc. will be reviewed at the concept design, preliminary design, and critical design levels during the project year.

4. Draft test plan for 2001.

<u>Revision 3: 9AUG00 minor changes. mrc</u>

4.1 Purpose of the test program.

The MOOS Mooring riser project has several high risk technical challenges that must be successfully resolved for the complete system functionality to be realized. To mitigate these risks tests of concept designs in the areas identified as being high risk are being undertaken early in the overall MOOS Mooring development program. This approach protects against pursuing a mooring design beyond the concept stage that has a substantial risk of ultimately to failing to meet the system functional requirements.
The areas that have been identified as technically high risk are:

- The reliability of the data and power connection between the mooring surface expression and the fixed anchor base of the mooring.

- The reliability of the connection hardware and the feasibility of ROV operational procedures for making a physical connection between the mooring base and a sea floor mounted instrumentation "Benthic Instrument Node" or BIN (note: the procedures and equipment for BIN to BIN cable connections are being developed under the Canyon Dynamics experiment).

4.2 Major components to test.

The mooring power and data riser design

- The viability of the chosen mooring riser design as it affects **cable integrity**.
  Verify static and dynamic design load models for the mooring riser.

4.3 Schedule and configurations for testing.

4.3.1 Mooring deployment scheduled for August 2001

4.3.1.1 Engineering test objectives

- Test the riser cable design. Test ISI system if possible.

4.3.1.2 Science experiment objectives – none.

4.3.1.3 Mooring location.

- test mooring location is TBD.

4.3.1.4 Deployment duration.

- approximately 3-6 months.

4.3.1.5 Hardware configuration

- Surface expression – Standard Atlas/MBARI toroid or equivalent Surfoam flotation with solar power system, "new mooring controller" if available, and packet radio or Freewave modem connection to MBARI.
- Mooring riser – Based on chosen concept design and incorporating power and data transfer elements. Connected to stand alone "Benthic Instrument Node" at base. Strain gauges are mounted at the base of the surface float bridle and at the anchor attachment point for engineering data collection.
- "Benthic Instrument Node" – If available, a solitary duplication of the units fabricated by the Canyon Dynamics project. Electronics – if available - are a minimum configuration of the 'New Mooring Controller".
- Power – Prototype power system with switched low voltage connection to the "Benthic Hub". Subsea power available only for "Benthic Instrument Node" mounted "New Mooring Controller" if installed and temporary low data rate communications link to the surface expression.

- Communications – Standard surface float to MBARI data communications channel using VHF packet radio or Freewave modem. “Benthic Hub” to surface float communications utilize a temporary data multiplexer for communications with the “Benthic Hub” controller (which can read the anchor base strain gauge).
- Data storage – Not promised, data must be stored in data collection instrument and retrieved when recovered.

4.3.2 Mooring deployment scheduled for 2002

4.3.2.1 Engineering test objectives

TBD

4.3.2.2 Science experiment objectives

The science experiments that utilize the test mooring will be finalized during the year 2001 proposal process. The goal is to select experiments that are enhanced by the test mooring configuration of a point-to-point communications link through the vertical riser and data link to shore but do not absolutely depend on it for good scientific results.
Selected data can be transmitted to shore during the experiment as long as the mooring system itself remains fully operational.

4.3.2.3 Mooring location

TBD.

4.3.2.4 Deployment duration.

TBD

4.3.2.5 Hardware configuration

TBD.

5. High risk items:

a) The two major design risks are the vertical riser cable physical integrity and the inter-controller networked communications scheme. For the riser cable the risk is being addressed through consultation with acknowledged experts in the field of buoy cable dynamics and an aggressive test program for verifying our design models. Communications system design risks are addressed by fully utilizing in-house experts such as Wayne Radichonski, working closely with the ISI project, as well as extensive laboratory and field design verification.

b) The first two years of the Mooring Riser section of the overall MOOS program are specifically directed toward addressing the high-risk elements that have a significant impact on MOOS.

6. Deliverables: See WBS

7. Dependencies:

This project develops the "DCON" and benthic "BINS" specification and design and the specification for the inter-BIN connection cable, all used by the Canyon Dynamics experiment.

The Benthic Cable specification is due 12/4/00
The Benthic DCON specification is due 12/27/00

The New Mooring Controller / SideARM implementation is an important foundation for the MOOS mooring controller. The New Mooring Controller needs to be completed in early 2001 to allow design work to begin on the MOOS mooring controller expansion.

8. Project Team:

Project Manager: Mark Chaffey
Chief Engineer: Mark Chaffey
Power system design: Ed Mellinger
Mechanical riser and buoy design: Mark Greise.
Mechanical design of BIN and inter-BIN cable connections: Gene Massion
Communications design: Wayne Radichonski and Mark Chaffey
RF communications design: TBD

Observatory support team member: Tentatively Mike Kelly but TBD

Appendix C: Instrumentation Software Infrastructure

Project Manager: Duane Edgington

1. Abstract

The goal of this project is to develop an institutional standard software architecture for MBARI for interface to scientific instruments. The software standard interface, the subject of this proposal, would define the communication interface to instruments: software protocols for acquiring configuration information (operating modes, calibration data, modeling parameters, identification, etc.) and measurement data. The software part of the standard would also define object interfaces and services for data logging, display, and storage.

This infrastructure project would focus on several core instruments, and coordinate with ongoing projects including *New Mooring Controller*, Aquatic Autosampler (a.k.a. *Genosensor 2000*), *Dorado*, *MOOS Mooring System*, and *SideARM Application Specific Hardware*. The infrastructure would be designed to be developed incrementally, to serve multiple instrumentation projects, and designed to be extendable, using modern proven software development methodology and tools, including object-oriented analysis, design and implementation, and distributed-object network architecture.

The project would draw broadly from specialists in both engineering and science to create an institutional standard. The project would span two or more years of development, with a goal of a working demonstration system running in the lab, encompassing one or more instrument types, data logging, data display, and data storage, followed by a deployment of a production system in MOOS. The intent is that the final infrastructure would set the standard for instrumentation design at MBARI, be used within new vehicles at MBARI (for example, Dorado and follow-on AUVs), and be exportable to other scientific institutions.

2. Proposal

2.1 Work Breakdown Structure, resource estimate, timeline

a) Specification of the overall objectives and requirements of the system. Detailed coordination plan with related MOOS and engineering projects. Preliminary design review. Documentation to IEEE Std. 830-1998.

• Explore technology alternatives			
• Prototype CORBA ORB	SE	20d	Q4 2000
• Evaluate VxWorks COM implementation	SE	10d	Q4 2000
• Evaluate Jini Surrogate Architecture/RMI bridge	SE	20d	Q4 2000
• SOAP/XML messaging	SE	20d	Q4 2000
• Complete Software Requirements Document	SE	20d	Q42000
• Instrumentation list			
• Interface/protocol to Data Services			

- Communications Bandwidth Requirements
- Data requirements
- Metadata* requirements
  (*Metadata is: information about the origin of data; structured data about a resource
- Use Cases

• Plan coordination with other MOOS projects	SE	5d	Q42000
• Preliminary Design Review	SE	10d	Jan 2001
	EE	2d	
	IAG	2d	

b) System architecture design, including 1) instrument interface messages, services and data, network requirements and characteristics, 3) implementation language(s) and tools, and 4) services to be provided by *MOOS Data Management* middleware, User Interface, and storage. Critical design review.

• Complete Systems Architecture	SE	20d	Q1 2001
• Develop prototypes to flesh out architecture	SE	40d	Q1 2001
• Critical Design Review, incorporate changes	SE	20d	Q1 2001

c) Initial release. Focus on demonstrating a fully executable system in the lab that captures the key elements of the system architecture, by satisfying selected use cases spanning selected instruments.

• Implementation	SE	60d	Q3 2001
• Collect and interface instruments in lab	SE	10d	Q3 2001
	EE	5d	Q3 2001
	Tech	10d	Q3 2001
• Implementation Review	SE	10d	Q3 2001
	EE	2d	Q3 2001
	IAG	2d	Q3 2001

d) Iterative release #1. Iterative releases will progressively satisfy more use case scenarios and user requirements. Each iterative release will include maintenance/bug tracking, sourcefile configuration control, test cases that test functionality and bug fixes, system documentation, user documentation, and integration. The schedule of releases is determined by addressing the prioritized functionality requirements and identified risks. We will establish the iteration frequency in the system specification process with customers of the system and cooperative projects; the frequency is typically 2-6 months.

• Implementation	SE	60d	Q1 2002
• Lab test	SE	10d	Q3 2002
	EE	5d	Q3 2002
	Tech	10d	Q3 2002
• Implementation Review	SE	10d	Q3 2002
	EE	2d	Q3 2002

e) Iterative release #2, with deliverables as described in milestone 4.

f) Iterative release #3, with deliverables as described in milestone 4.

g)…

h) Final system delivery and maintenance plan. The final release focuses on minor modifications and tuning. A maintenance plan and document is delivered, and maintenance staff and procedures are finalized.

2.2 Design Reviews

- Straw man architecture review. Present 1st cut architecture for commentary and discussion.
- Preliminary design review. Present design alternatives and select candidates for further evaluation. Present design partitioning vs. other interrelated projects.
- Critical design review.
- Initial release design review (first laboratory demonstration).
- Iteration 1 design review (first deployable system).
- Iteration 2 design review
- Final delivery and maintenance plan review.

2.3 Preliminary test plan

2.4 High risk items

- Distributed-object network architecture: Designing and deploying an effective distributed-object networked software system is a significant engineering effort, requiring specific tools and training. Budget items for staff training and for software development tools are required. The VIMS project at MBARI, as well as the Dorado/ALTEX projects are distributed-object software systems, and we will benefit from the design and experiences of those projects, as well as from design and architecture work on new mooring controller project in 2000. Since those projects are concurrent with this project, we will need our own tools and training for staff members who have not participated in this kind of project before.
- Object-oriented design: Object-oriented software development is a different way of engineering, compared to the structured “C” programming of earlier significant software engineering at MBARI. Most of the staff members on this project have training in OO software design, and some have real project experience. Budget for professional development to strengthen individual OO skills will reduce the risk of poor design or protracted development.
- Project coordination: A significant feature of this project is its high coupling to other concurrent projects. Ample time for project coordination and planning will be key to mitigating the risk of missing key functionality requirements from the other projects.

2.5 List of deliverables

- Instrument software infrastructure system defining the communication interface to instruments: (a) Software protocols for acquiring configuration information (operating modes, calibration data, modeling parameters, identification, etc.). (b) software protocols for acquiring measurement data (c) Interfaces for tools that use this information (these tools are not part of this project: data logging, display, and storage).
- Demonstration of a working executable system in the lab, together with selected instruments, interconnecting network, data logging, display and storage supplied by complementary MOOS projects.
- Presentation of the system to selected conferences.
- Presentation of the system to engineering teams responsible for other Ocean Observing Systems, including Neptune and Martha's Vineyard Coastal Observatory.
- An article describing the system architecture and implementation issues will be submitted for publication.

2.6 Dependancies on other projects

yes…

2.7 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

3. Budget

SideArm processor boards for lab system and development 5x $1000	$5,000
StrongArm development systems 3x $2000	$6,000
VxWorks maintenance license	$3,000
Linux lab systems 2x $3000	$6,000
Distributed objects software licenses	$10,000
Software Development tools	$5,000
Fees, travel, meals, JavaOne developer conference 2x $4000	$8,000
Texts and Journal to support project	$500
Conference fees, travel, lodging, meals for presenting work 2x $4000	$8,000
Travel to experts for consulation and technology transfer 2x $3000	$6,000
Instruments for first deployment trial	$10,000
Training classes in OOD 3x $3,000	$9,000

Appendix D: New Mooring Controller:

Project Manager Duane Edgington

1. Abstract

The New Mooring Controller proposal is a continuation of the 1999 and 2000 projects of the same name. The 1999 project was approved to start in July of 1999 as a two year project. The goal is to replace the existing OASIS mooring controller.

The OASIS mooring controller has been in service since January 1992. It has been successful in supporting data collection to study the biogechemistry of Monterey Bay (M1, M2, M3), mullti-institutional shipboard experiments (IronEx 1 & 2, COOP cruises, ShiftUp cruises), and deployed on the TOGA/TAO array for opto-biological and chemical measurements (EqPac 1 & 2).

However, the OASIS hardware and software is quickly becoming obsolete and unsupportable. We have only 8 controller boards remaining. The boards are old and showing wear in their mechanical and electrical interfaces. There are numerous circuit modifications which are fragile and subject to failure in harsh environments. The software is equally old, built from software tools that haven't been updated in years.

This project has primary and secondary goals. 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 developed by Radochonski which will presumably become the core processor for new instrumentation at MBARI and for MOOS. The software will use the VxWorks operating system, as used on Tiburon and for the Nav processors on the Western Flyer and Pt Lobos, or embedded Linux, an emerging open source standard. The software will use object-oriented techniques similar to the application frameworks used by O'Reilly on Tiburon and Cline on Genosensor. In summary, the primary goal is to replace existing functionality with modern components and tools.

The secondary goal is to coordinate 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, we would like to experiment with forward-looking software design techniques, such as CORBA and distributed-object network architectures, in order to be a first step towards the architecture being developed for MOOS.

In 2000 the project suffered from inconsistent staffing, due to resignations of two key contributors. We did manage to complete requirement analysis and review (New Mooring Controller Functional Requirements, dated March 21, 2000). We have done considerable design and architecture explorations, and are now working on a functional design document. This proposal outlines work in 2001 to bring the controller to completion for mooring applications, with a roadmap for its use in MOOS.

2. Proposal

a) Work Breakdown Structure, resource estimate, timeline

1) Specification of the overall objectives and implementation of the system. Detailed coordination plan with related MOOS and engineering projects. Preliminary design review.

• Technology exploration and selection			
(a) Updated Tornado tool-chain/ BSP (Tornado 2.0.1/assabet BSP)	SE	5d	Q3 2000
(b) VxWorks BSP / Angel firmware	SE	5d	Q3 2000
(c) Build a Linux boot image Build x86-linux2/ARM tool-chain Build bootable image Mass storage (compact flash)	SE	10d	Q3 2000
(d) Intra-mooring networking (Arcnet) or interface(RS232)	SE	20d	Q3 2000
• Instrument Control Protocol NMC-to-instrument communication interface	SE	20d	Q3 2000
• Complete implementation plan	SE	20d	Q4 2000
• Plan coordination with other MOOS projects includes coordination with ISI and MOOS riser	SE	5d	Q4 2000
• Preliminary Design Review	SE	10d	Q4 2000
	EE	2d	
	IAG	2d	

2). System architecture design, including (a) StrongARM IBC card, (b) embedded software, (c) communications cards, and (d) interface. Critical design review.

• StrongARM IBC card critical design review	SE	5d	Q4 2000
	EE	2d	Q4 2000
• Complete Systems Architecture	SE	20d	Q4 2000
• Compose Software Validation Plan	SE	10d	Q4 2000
• Develop prototypes to flesh out architecture	SE	20d	Q4 2000
• Critical Design Review, incorporate changes	SE	10d	Q4 2000
	EE	2d	Q4 2000

3) System implementation, lab test and system bring-up.

• Implementation	SE	40d	Q1 2001
• Preparation, Lab test and system bring-up	SE	20d	Q1 2001
	EETech	10d	Q1 2001
• Execute Software Validation Plan	SE	10d	Q1 2001
• Implementation Review	SE	10d	Q1 2001

	EE	2d	Q1 2001

4) Release.

• Documentation, maintenance plan	SE	10d	Q2 2001
• Field test	SE	10d	Q2 2001
	EE	5d	Q2 2001
	EETech	10d	Q2 2001
• Deployment Review	SE	5d	Q3 2001
	EE	1d	Q3 2001

1) Communication

• Prepare paper or poster of work	SE	10d	Q4 2001
• Present work at conference or workshop	SE	5d	Q4 2001

Totals 2001	SE	120d
	EE	12d
	EETech	20d

Resource estimates are –50%/+100% accurate

b) Design Reviews

1. Preliminary design review. Present design alternatives and select candidates for further evaluation. Present design partitioning vs. other interrelated projects.
2. Critical design reviews: IBC Card, peripherals interface, software design, System.
3. Laboratory demonstration.
4. Implementation review (first deployable system).
5. Final delivery and maintenance plan review.

c) Preliminary test plan

d) High risk items

e) List of deliverables

1. Design documents
2. User design-in document
3. Inventory of 10 controller and support cards
4. Presentation of work at selected conference or workshop

f) Dependancies on other projects

yes…

g) Project team

- Project Manager: Duane Edgington
- Lead Engineers: Wayne Radochonski, Tim Meese
- Developers:
- Science Advisors: Francisco Chavez,

3. Budget 2001

1. Inventory of IBC SideArm processor boards; interface cards 10x$1000	$10,000
2. Fabrication of IBC SideArm processor boards, interface cards	$15,000
3. StrongArm development systems	$2,500
4. VxWorks maintenance license	$10,000
5. Linux lab systems	$2,000
6. Flash cards, adapters	$600
7. Software Development tools	$2,000
8. Hardware Development tools (Licenses)	$5,000
9. Texts and Journal to support project	$200
10. Conference fees, travel, lodging, meals for presenting work	$2,500
11. Misc. h/w for lab bringup	$200

Appendix E: MOOS Data Management

Project Manager: Mike McCann

1. Abstract

The purpose of this project is to design and implement a first iteration of the MOOS data management system. Following on the work done in 2000 to identify and state requirements, the 2001 effort will begin the design and development effort. The implementation plan will coordinate with the annual MOOS science field experiments by providing iterative releases.

2. Proposal

a) Work breakdown structure

For this work breakdown structure some examples are provided of what the actual work might be. As we have not yet written the requirements or done the design I prefer to keep the descriptions as general as possible so as to not prematurely influence the design effort. (Note: client-side data access improvements and GIS integration have been removed to stay under the 50% cap of IAG time.)

All of these estimates have an accuracy of about +/- 25%.

Activity	Engineer/Developer	Est. Time (Days)
1) Design		
a) Specify and prototype initial instrument object interfaces	Rich Schramm	20
b) Server-side data access improvements	Dan Wilkin	10
c) Data file converters, e.g. AUV data into netCDF	IAG Hire #1	15
d) Client-side data access improvements, e.g. SQL/DODS server	IAG Hire #2	0
e) GIS integration, e.g. ArcView access to MOOS data	Gerry Hatcher	0
f) Catalog server survey & design	Mike McCann	40
g) Instrument object to data system interface (ISI coordination)	Rich Henthorn	10
Design subtotal		85
2) Preliminary Design review		
a) Conduct the review	Mike McCann	5
b) Incorporate suggestions into the design	Project team	20
PDR subtotal		25
3) Critical Design review		
a) Conduct the review	Mike McCann	5
b) Incorporate suggestions into the design	Project team	20
CDR subtotal		25
4) Test plan & review		

a) Coordinate with Canyon Dynamics experiment data providers & end users	IAG Hire #1	20
b) Write the test plan	IAG Hire #2	10
c) Conduct review	IAG Hire #1	5
Test plan subtotal		35
5) Implementation		
a) Instrument object to data system interface (ISI coordination)	Rich Schramm	10
b) Server-side data access improvements, e.g. SQL/DODS server	Dan Wilkin	50
c) Data file converters, e.g. AUV data into netCDF	IAG Hire #1	50
d) Client-side data access improvements	IAG Hire #2	0
e) GIS integration, e.g. ArcView access to MOOS data	Gerry Hatcher	0
f) Catalog server	IAG Hire #1	50
g) Infrastructure support (system administration)	TBD	30
h) Instrument object to data system interface (ISI coordination)	Rich Henthorn	10
Implementation subtotal		190
5) Test and rework		
a) Test with Canyon Dynamics data (if appropriate)	Project team	50
b) Feed results of test back into design & prepare for next iteration	Project team	50
Implementation subtotal		100
Total IAG time		440
Total SE time		20

b) Design reviews

- Preliminary Design review.
- Test plan review

c) Preliminary test plan

- Test plan for 2001 MOOS field experiment: Canyon Dynamics.

d) High risk items

e) Specific deliverables

Milestone 1: Design Document.
Milestone 2: Preliminary Design review.
Milestone 3: Test plan for 2001 MOOS field experiment: Canyon Dynamics.
Milestone 4: Test plan review
Milestone 5: System implementation, iterative release #1
Milestone 6: Test and rework

f) Dependancies

g) Project team

Francisco Chavez: Advise on user requirements for operational system.
Mike McCann: Project manager, coordination of design and development activities, implementation of data processing, catalog, and visualization components.
Rich Schramm: Design and implementation of instrument object interface.
Dan Wilkin: Design and implementation of data access.
Gerry Hatcher: Design and implementation of data access, especially GIS related data
IAG Hire #1: Implementation of data file translators
IAG Hire #2: Application program support
Reiko Michisaki: Assist with implementing the operational data management system – defining system requirements and prototyping.
Brian Schlining: Assist with design of object interface and adapter. Assist with implementing the operational data management system – defining system requirements, architecture, and prototyping.
Duane Edgington: Coordinate with Instrument Software Infrastructure development.
Richard Henthorn
Mike Matthews: Strategic planning and advice on system design

3. Budget 2001

Outside consulting for systems administration and other services ($1000)
Solaris server for production MOOS data server ($20,000)
200+ GB RAID array for MOOS data server ($20,000)
Travel to other institutions, e.g. Rutgers for LEO-15 ($6,000)
Miscellaneous software (Matlab licenses, Java development libraries, ODBC libraries, etc.) ($10,000)

Appendix F: Canyon Dynamics Experiment

Project Manager: Gene Massion

Benthic MOOS Implementation Strategy

1. Introduction

The Benthic MOOS group has described three use scenarios, Canyon Dynamics (CD), Carbon Cycling (CC) and MOVES (MOOS Observations of Vents and Seismology; the Monterey Canyon development phase of the RIDGE MOOS effort), as examples of how the MOOS capabilities might be used to support MBARI science. The goal of this document is to describe a MOOS implementation strategy which identifies the critical MOOS capabilities required to support the use scenarios along with a schedule that allows equipment and processes to be deployed and tested early in the program. These initial deployments support the science described in the use scenarios and will provide engineering data that can only be acquired from field experience early enough in the project cycle to refine the designs resulting in a more robust MOOS capability. The systems required to support the range of experiments described in the use scenarios span a range of capabilities. Simple systems can be built primarily with commercial off the shelf (COTS) equipment e.g., Sentinel ADCP and InterOcean S4 current meter. For the purposes of this document we include currently operational MBARI assets under the COTS label e.g., short period and broadband seismometers with the LP1 data logger. We can take advantage of this COTS equipment to test new and/or risky elements of the design without the requirement to have a full MOOS implementation in place. The proposed strategy plans for the advanced capabilities envisioned for MOOS and required for more sophisticated MOOS experiments to be integrated with or replace the initial COTS equipment with minimal redesign effort.

The generic benthic elements currently being discussed in the Benthic MOOS group consist of a network of nodes of instruments at remote sites that we are calling remote instrument nodes (RINs) in bi-directional communication with and eventually deriving power from the MOOS mooring. The current concept includes a benthic interconnect node (BIN) which serves as a hub for multiple RINs and the mooring. An AUV docking station is key to several of the long range benthic MOOS missions but is not required for the initial missions described here and is not discussed in this document. High priority technologies which should be developed early in the MOOS project to support the planned science include a ROV cable laying capability, a networking capability between multiple benthic RINs and the MOOS mooring, the SideArm processor board, a network time protocol that allows data acquired at all nodes to be synchronized in time and a modest rate real time data telemetry capability. Key engineering design issues we would like to address early include 1) the development of a RIN that must support a wide range of instruments and deployment scenarios, 2) the design of RINs and BINs that can be easily deployed from various platforms and interconnected/serviced by MBARI ROVs and 3) the equipment, tools, techniques and processes that must be developed to support ROV cable laying. Critical to this last issue is selection and testing of the cable that will be used.

We have selected two experiments as examples of how the MOOS development can be staged to accomplish the goals stated above. The first experiment addresses the questions raised in the CD use scenario that must be answered in order to plan a comprehensive CD experiment. In addition, instrument testing for the CC and MOVES experiments can be accomplished in this deployment. This experiment has the particular advantage of providing a way to gain valuable experience with deploying and interconnecting RINs, to a BIN early in the project cycle at a site that is within a half hour of the Moss Landing entrance buoy while acquiring a unique scientific data set. The system proposed for the second experiment integrates the more advanced MOOS capabilities described above with the equipment developed in the first experiment to support the MOVES project. This system approaches the kind of comprehensive, multidisciplinary experiment described in the MOOS workshop and subsequent documents and also provides a better site for early engineering tests of the MOOS mooring.

2. Overview

The following is a high level description of the suggested implementation plan, details of these steps will be provided later in this document. The first step, already in process, is to define the functional requirements and then develop the system requirements document. The next step is the MOOS system engineering where the high level system architecture will be defined. We have made some assumptions about what this architecture will look like in order to add detail to help make this document effective. We expect that this document may only serve as a starting point for discussions of possible implementation strategies and will go through several iterations as the MOOS details are defined. As a result of these two steps, we would expect to have enough information to start designing the generic MOOS RIN and BIN. The next step will deploy two or three RINS with one BIN to develop the ROV cable laying and interconnection capability as well as evaluating the RIN and BIN design, in actual field conditions to acquire the initial CD data set. The instruments planned for this deployment all provide internal data logging and power. Ventana would visit the easily accessible BIN site on a 2 - 3 month basis to upload data from the RINs. Batteries packs would also have to be refurbished but on a less frequent basis. We believe that this deployment can be achieved with COTS instrumentation, network electronics and software allowing the majority of the MOOS engineering resources to be applied to developing the advanced systems required to support a fully functional MOOS.

3. Details

RIN Development:

Our initial concept for this part of the system is an anchor that serves as a foundation for a easily configurable framework designed to support equipment identified in the MOOS benthic instrumentation list. A single generic design should support the majority of benthic instruments from this list. However, we expect that minor modification of this basic design will be required for future MOOS experiments. For example, we would expect to design all benthic MOOS components to be trawl resistant which also implies some degree of minimum hydrodynamic influence on instrumentation however, a RIN for the high energy conditions desired in the CD experiment will require a heavier anchor than most other scenarios. The RIN will include a pressure housing designed to support the RIN controller subsystem defined by the MOOS system design document (the existence of a RIN controller similar to a Tiburon data concentrator is one of the assumptions we have made about the system architecture). COTS electronics can be used to communicate between the RINs and the benthic node in the first deployment. The terminal server currently used in the Ventana telemetry system is one example of the kind of COTS electronics that will meet the requirements for this initial deployment. As the more sophisticated MOOS RIN controller electronics and software become available, we can repopulate the RIN pressure housing with the new subsystem.

Benthic Node Development:

Our initial concept for this part of the system is a rugged framework designed to support a panel for ROV mateable connectors, an electronics housing and the required structure. It may be useful to design this node to also support instruments. In the first deployment, the minimum requirement for this node is to provide a data connection between Ventana and the RINs. However, it would be closer to the MOOS concept if the BIN could provide power to the RINs. However, the impact of adding this capability needs to be examined in detail and is beyond the scope of this document. Ideally, we would be able to design the BIN so that when power can be provided to the RINs, the power source e.g., a benthic elevator of Deep Sea Power & Light batteries, can simply plug into the pre-assigned power connector on the BIN. Carrying this concept one step further, when a MOOS Mooring with data telemetry is ready along with the required BIN controller (another assumption about the final system architecture) the initial BIN electronics housing can be replaced with the new subsystem and the mooring plugged into a pre-assigned connector. The final step would be to replace or supplement the pallet of batteries with power generated on the MOOS mooring.

ROV Cable laying process and equipment development:
A vendor for the types of cable packs suitable for ROV deployment has been identified. However, the exact cable that should be used is highly dependent on the MOOS functional and system requirements and is the critical decision that must be made before this capability can be developed. We have money and resources in this year's MOOS/COMB budget to procure test packs, build a cable laying specific tool sled and run some test dives to develop our ROV cable laying capability. It makes sense to use the BIN node and RIN sites identified in the CD use scenario as the end points for the initial cable laying tests so the first successful cable deployments can be used to support the experiment.

Canyon Dynamics/Cable Laying deployment:

For the first deployment, we are suggesting a wide ledge on the wall of the canyon that is less than 1/2 hour off the Moss Landing entrance buoy, relatively protected from fishing and within 3 km of 2 sites identified for the Canyon Dynamics RINs. The instruments deployed will include ADCP, current meter, CTD, pressure gauge, transmissometer, seismometer, hydrophone, and other sensors as they become ready for testing (particularly chemical sensors such as ISUS). All the instruments have data storage sufficient for a 2 - 3 month deployment. The instruments also have internal power sufficient for approximately 6 months and up to 1 year in some cases. This deployment requires a Ventana dive on the benthic node every 2 - 3 months where Ventana would plug into the benthic node and upload the data from each of the instruments at the RINs. This would be accomplished by running the instrument vendors standard software from a computer on the Pt. Lobos communicating with the remote instruments through the standard

Ventana telemetry system (possibly the existing spare Ethernet link), the benthic node and the ROV laid cable. Every 6 months (or so) Ventana would be scheduled to refurbish the battery packs (unless we implement a power source at the BIN as described above). With the exception of the mechanical anchors and structural elements which will be designed to support the overall MOOS requirements, all this can be accomplished with COTS instruments, electronics and software.

MOVES/Advanced MOOS Capabilities deployment:

The goal for this deployment is to integrate the advanced capabilities envisioned for the MOOS such as the SideArm processor, Software Infrastructure and the MOOS Mooring. The key MOOS capabilities required for this phase are 1) provide a SideArm upgrade to the LP1 in order to provide real time telemetry and reasonable batch data upload (from the instrument) rates 2) provide a time synchronization capability between the various instruments connected to the BIN and 3) provide a real time telemetry capability using the MOOS mooring. We propose to build a second RIN and BIN for this deployment that builds on the lessons learned from the previous deployment. This is also a logical deployment to add the remote power capability to if it was not implemented already. Both of these nodes could implement the first generation MOOS electronics and software with the capabilities described above. The BIN would provide for a connection to the MOOS mooring to provide real time telemetry. The total data generated by the proposed seismic experiment is large on a per day basis (~200 Mbytes/day) but is only about 23 kbaud and may be well within the capabilities of COTS radio modems e.g., the Free Wave modems currently used on the AUVs.

Carbon Cycling

The instrumentation for the CC and CD scenarios are similar (COTS such as the Hydroscat 2 and the S4) and the geography of the initial CD deployments are within the area identified as providing useful scientific value for the CC scenario, at least initially.

4. Risk Mitigation

The primary risk that this plan addresses is that comprehensive testing of certain MOOS elements can only be gained from actual deployments and if this testing is not accomplished early, major redesign of a large part of the system may be required late in the project cycle. We believe that by deploying the systems proposed in this plan we will be mitigating a major element of risk while simultaneously accomplishing the incremental development of MOOS based science and technology.

Without proper upfront system engineering, finishing a design of the mechanical elements before the electrical design is complete, can lead to significant redesign efforts when the final details of the electrical system are defined. We believe that this risk is clearly mitigated by the currently defined MOOS plan for deriving functional requirements, system design requirements and budgeting for a proper system engineering effort. This effort will be finished before starting the detailed design efforts proposed in this plan. Furthermore, the design of the RIN and BIN will be driven by the instrumentation, ROV mateable connectors and other complexities allowing us to leave a generous allowance for the infrastructure electronics without driving up the size, complexity or cost of the RIN or BIN.

The risk that will be most difficult to mitigate is protecting the deployed subsystems from trawling. This issue should be addressed early in the project and the risks and possible mitigating measures understood to the greatest extent possible. For example, if a 5 km cable pack costs $25,000 to purchase and deploy and we expect to incur damage to cable runs in vulnerable areas we may decide to either budget for replacement cable packs and cable laying deployments, or not budget for this expense and simply let an experiment die if the cables are damaged.

	Cost	Quantity	Subtotal	Total	Ship Days	
					Pt. Lobos	Western Flyer
1 MR System Engineering						
2 Experiment Plan						
3 Instrument Selection						
4 Engineering Test Plan						
5 Requirements Review						
6 Familiarization						
7 Concept Test						
Instrument Rental	$1,500	1		$1,500		
Telemetry Hardware	$4,500	1				
8 RIN/BIN Design				$0		
Prototype Materials	$2,500	1		$2,500		
9 PDR				$0		
10 CDR				$0		
11 Fabrication				$0		
RIN/BIN	$69,000	3		$207,000		
Anchor/Structure	$3,000	1	$3,000			
Electronics Housing	$12,000	1	$12,000			
Connector Panel						
Wet mateable E/O connectors	$25,000	1	$25,000			
Wet mateable electrical connectors	$3,500	6	$21,000			
Cabling	$7,500	1	$7,500			
Instrument Mounts	$500	1	$500			
2nd and 3rd BIN E/O connector	$25,000	2		$50,000		
Cable lay Tool Sled						
Prototype Materials	$1,500	1		$1,500		
Ventana Tool sled	$1,500	1		$1,500		
Cable lay mechanical	$2,000	1		$2,000		
Cable lay monitoring equipment	$2,500	1		$2,500		
Cable lay tests					4	
Cable Packs (subcontract + 15% inflation)	$49,275	1.15		$56,666		
12 Integration and Test				$0		
13 Installation				$0		
Rigging Equipment	$4,500	1		$4,500		
RIN/BIN Installation						3
Cable Lay					2	
14 Test Execution				$0		
Data upload dives					2	
15 Engineering publication				$0		
Travel to present paper	$2,500	1		$2,500		
TOTALS				$332,166	8	3