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Keith Raybould
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Dear Keith,

I appreciated the invitation to participate in your MOOS program reviews and I hope you found the effort was it fruitful. You have a very ambitious and challenging project on your plate and are fortunate to have the technical and institutional support that MBARI so uniquely offers.

A brief summary of my specific thoughts is attached. Also, an invoice covering expenses and stipend is appended. I will be interested in following your progress and would like to stay in touch.

Respectfully,

Hugh

Hugh Milburn
Oceanographic Engineer

Enclosures (2)

Review comments by Hugh Milburn

MOOS SYSTEM CONCEPT DESIGN REVIEW

I recognize the outside reviewers were not called on to review the "System Concept", but some interesting points were made. First, the concept of putting significant power on the seafloor from a surface mooring has tantalized ocean engineers for years, and the recent DEOS and NEPTUNE discussions have heightened the issue. Strong 'science drivers' for benthic studies was shown, but it is difficult to justify this project for upper water column work. The expense could not be justified compared to other options (multiple moorings, profilers, drifters, gliders, etc). Along with that, it was made clear that any AUV docking should be done at or near the bottom, unlike the drawings for 1A and 2A were shown with an AUV high in the water column. The AUV docking and charging challenges defined by Jim Bellingham must be given high priority, as without this capability there will be little justification for this project beyond seafloor seismometery.

Recognition of the importance of data management at this stage of the project shows the value gained from previous efforts and a level of commitment that is commendable. As we have learned, it is important to recognize the potential legacy value of unique and difficult to obtain measurements, and they need to be more than just archived. They also need to be accurate and accessible. There are too many cases that failed to follow this path, and I applaud your effort here. However, it is important to recognize that developing software protocols and standards that will gain acceptance beyond the organization is a daunting task in this community.

MOOS MOORING RISER CONCEPT DESIGN REVIEW

The basic design presented with a large float below the surface buoy reminds me of many similar systems that have been sketched, a few that have been built, and none that have worked. We have to ask ourselves "why do we want to do that?" It seems in most cases to be an attempt to artificially bring the seafloor closer to the surface (with a stiff subsurface float) to somehow simplify the surface buoy mooring. In this case it is apparently to compensate for a very heavy and non-extensible cable.

The results of Mark G's modeling effort show some odd characteristics with the tension as noted in the discussions and that should be resolved. However, I would still be concerned about the possible dynamic interaction of the surface buoy and the subsurface float in high seas. A theoretical sea may not show the extreme conditions that will be encountered and uncertainties in model parameters may yield somewhat unrealistic results. Consequently, regardless of the final design, prototype moorings should be heavily instrumented to validate model results. Load cells should be located below the buoy, above the anchor and at other spots in the mooring where there are concentrated masses or changes in line compliance characteristics. Simple inclinometers must be used with caution in the upper part of the mooring where wind wave driven motion will induce large accelerations, but can be useful deeper. Pressure sensors can also be used to define

the shape of the mooring. A motion-sensing package on the buoy can show the range of motions and attitude. Also, high frequency sampling during deployment might be instructive for observing anchor launch transients. As discussed, strumming will be a factor, but is difficult to measure, as any significant instrument may act as a node that will affect the local strumming amplitude. Although it is not simple to fully characterize the mooring performance, I encourage you to give this a good shot. Any engineering data gathered will be invaluable for model comparison and logical design evolution.

The concise and definitive presentation given by Ed Mellinger on power options was very impressive. With a little creativity it appears that a 100-watt source seems possible, but larger buoys should be considered. The extra area for FV panels, wind generators and batteries would make a more workable platform and give some desirable extra capacity.

The mooring EO cable design is a brute force approach. It would certainly carry the power but is it optimized for mooring a small surface buoy? I would say not. The WHOI coiled cable hose connection may add sufficient compliance and possibly the relatively benign weather of the primary sites will not cause undue stress, but I would be concerned about the "tail wagging the dog". The large virtual mass of the cable and the small displacement of the proposed buoy do not match up well. I would recommend contracting Henri Beateaux to give this more study. Additionally, a custom cable designed with variable density, fishbite protection, strength, stiffness, torque resistance, and long life could be specified, and possibly one of the cable manufactures would respond with something quite different than we have seen before.

I would not recommend using the RV PT.SUR as a baseline for deployment of these moorings. Although Mike Kelly is clearly capable of coming up with a workable deployment scheme, it is a very small vessel and will put unwarranted constraints on the system design. There are many vessels available for contract, and although not as handy, that approach would open the door for what I see as a logical step – using a larger buoy. This would be true irrespective of the basic design, as the amount of copper required for power transmission will mandate a relatively large mooring line.

Your 'staged development' plan that recognizes future upgrades and allows testing of subsystems before any major deployment requirements puts you in an enviable position. However, the timing of this review leaves me in question of the stated aims of the review. The design is well along and the prototype deployment schedule leaves little room for any major redirection.

In summary I recommend the following: 1) revisit the drawing board, 2) test, test, and test in anyway possible to determine potential points of failure, 3) don't give up if at first you are not successful, as this is a project that must be successful, and 4) be cost conscious in your designs to make it possible for this technology to be exported to less well endowed organizations.