Project Number: 900807

Project Start: Jan. 1, 2008 **Project Duration (in years): 2**

Please indicate what type of project is being proposed (mark only one).

☐	☒	☐	☐	☐
Feasibility/Scoping [Less than 100 days effort]	**Development**[1]	**Research**	**Infrastructure**[1]	**Education**

☐	☐
Time Series	**Institute Initiative**

Project Manager[2]: Brett Hobson

Principal Investigator: Brett Hobson

Lead Scientist: Jim Barry

Lead Engineer:

Project Title: Benthic Imaging AUV

[1] Development and infrastructure projects must complete the risk matrix (see item #5 at the end of the proposal form).
[2] Not all projects will require all four titles to be filled in. Please indicate individuals only for those titles that are appropriate for your project.

1) ABSTRACT (new projects only)

2) PROPOSAL

a) Continuing Projects

Current status of project and results to date:

Most of the work for the Benthic Imaging AUV (BIAUV) was scheduled for the fall of '08, however we have still made good progress. This project is to develop the capability to capture high quality images of the seafloor from MBARI's Dorado-class AUVs. To do this we need to develop:

1. A lighting system that is bright enough for high resolution color imaging from 3m altitude, yet reduce backscatter.
2. A camera system capable of rapidly capturing and processing high resolution images.
3. A data system that can embed the relevant metadata inside each image so they can be easily retrieved and manipulated from mass storage.
4. An image processing capability that can easily assemble adjacent images in spatial mosaics.

We are focused on tasks 1 and 2 during 2008. During 2009 we will continue to refine tasks 1 and 2 as well as address task 3 and 4.

The greatest challenges of this effort are:

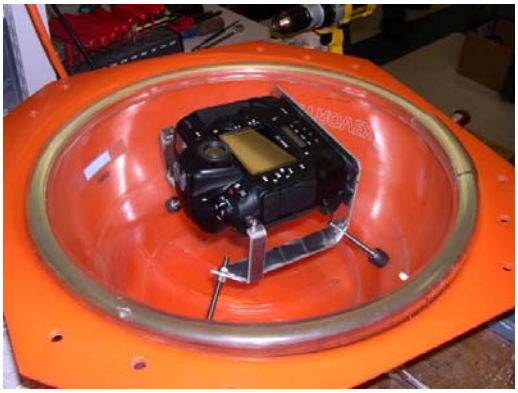
1. Safe AUV flights close enough to the seafloor for high quality imaging.
2. Provide enough light and to capture and store overlapping images (every 1.5 seconds). This is required to create image mosaics at the AUV's lowest speed.

Operational experience during the AUV Docking project provides confidence that the first challenge is tenable; therefore we were focused on the second challenge during in the first half of '08. We also designed the mechanical, electrical and software systems and are now preparing for our engineering review. We will move forward with camera and strobe integration next, followed by sea-testing in the fall.

What we have completed so far:

1. Drafted a set of Functional Requirements for the camera and lighting.

2. Prior to the project start, we selected and purchased a 12 MP Nikon SLR that met the Functional Requirements. We were asked to make this purchase using 2007 funds. We mounted the camera in a 17" sphere with a ground and polished port for testing.



3.

Figure 1: Nikon SLR mounted in 17" polished sphere

4. Selected a commercial Xenon strobe capable of 1m-sec strobe pulses every 1.5 seconds. Tested and repackaged the strobes into 6km housings.
5. Performed a 3m range test comparison between the Nikon SLR and a 5MP Prosilica machine vision camera (Benthic Rover's) mounted in a flat-port housing. The greater resolution of the Nikon and chromatic distortion from the flat port confirmed we needed a >10MP camera and dome port optics.

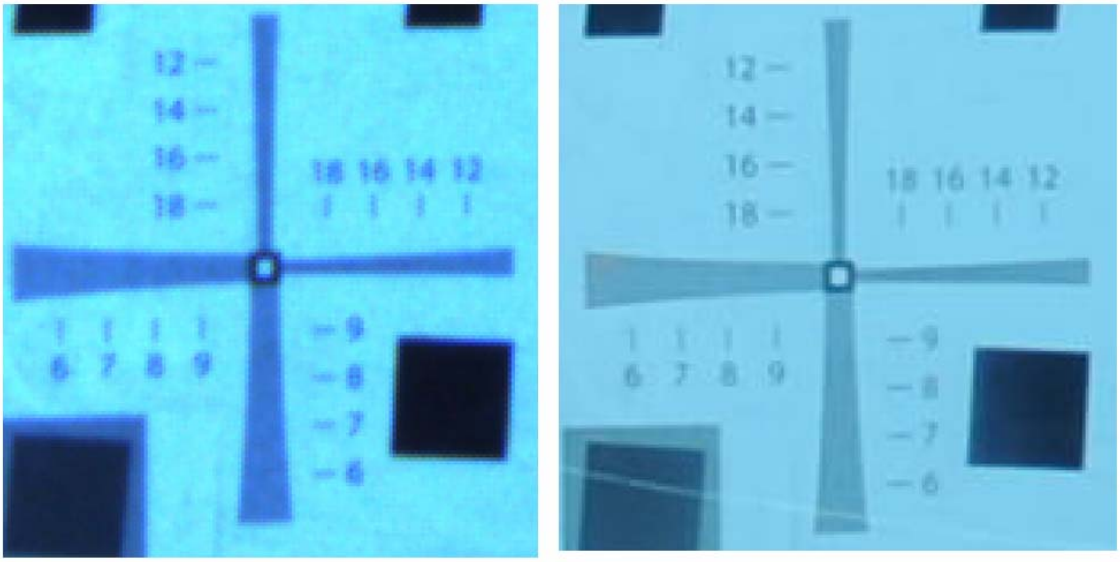


Figure 2: Portion of test image from a 5MP camera behind flat port on left, 12 MP behind dome on right. Chromatic distortion in the left image is from the flat port. Less pixilation on the right image is a function of the higher resolution and the gradation of black to gray in the box may be a result of higher dynamic range.

6. Designed the AUV mechanical layout and identified and ordered long-lead items.

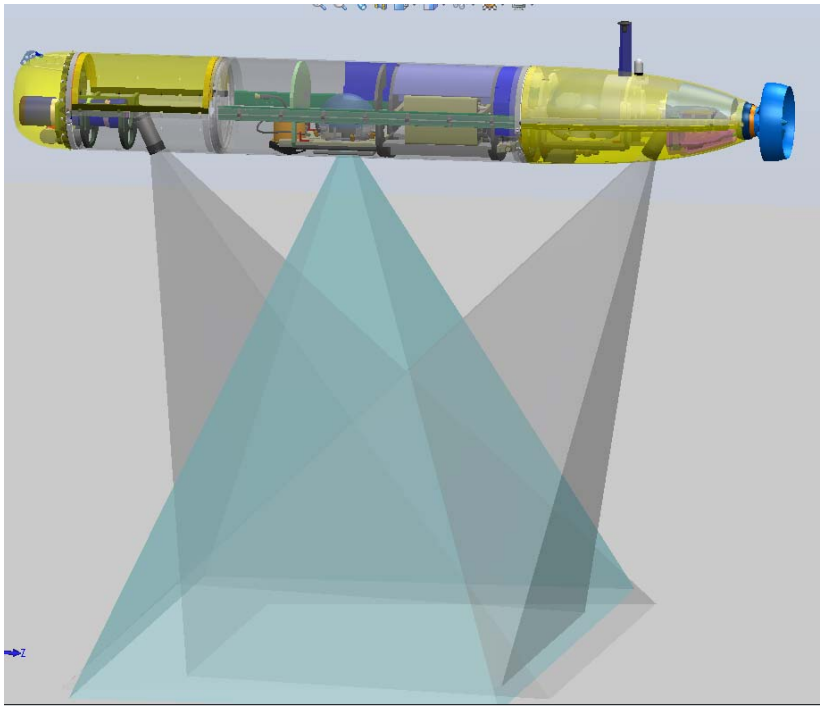


Figure 3: Benthic Imaging AUV mechanical layout.

7. Developed an AUV software driver for the Nikon and worked out an electrical and software layout to power and control the camera.
8. Refined the AUV control software developed under AUV Docking for use in this project and connducted mission simulations.

Conclusions from 2008 work thus far:

1. Even with a narrow field of view (50 deg), a dome port is required
2. We can resolve ~1mm at 3mm range with a camera with >10 MP resolution across a 3m wide field of view.
3. A Nikon SLR will work for this application, though autonomous operation of this consumer camera in the AUV has proved challenging. In addition, the Nikon SLR will require a very large housing (9.25" ID) that will be very expensive for 4 or 6 km depth rating.
4. The polished glass ball is ideal for camera evaluation and lens selection, but imperfections in the glass and the relatively large size are not ideal.
5. Autonomous control of a Prosilica machine vision camera has been developed under the Benthic Rover project though the Rover camera and housing cannot be used for this effort. Therefore we are planning to evaluate and probably switch to a larger and higher resolution (11 MP) version of the Rover camera later this month. This will allow this project to join forces and leverage work going on in other imaging projects within the institute. We expect the Smith lab to adopt this

camera for their tripod camera and hope any new camera efforts can use one of the many camera modules built by Prosilica.

What we expect to complete by the end of 2008:

1. Integrate the Prosilica camera into a 13" diameter polished glass sphere housing.
2. Build up the AUV with the Prosilica camera, two strobes, USBL navigation sonar and an obstacle avoidance sonar.
3. Field test AUV and collect high resolution images of the seafloor.
4. Demonstrate controlled low-altitude flight and overlapping still images.

Significant changes from previous project proposal

1. Added a second strobe for more even illumination
2. We plan to investigating range-gating techniques to minimize backscatter

Publications based on the results of this project only

No publications yet

b) <u>New and Continuing Projects: Plans for 2009</u>

Engineering/technology development

During 2009 we propose to further refine the camera and lighting system demonstrated in '08 as well as streamline the data handling and then focus on missions for science.

Tasks for 2009 include:

1. Complete Prosilica software support and AUV integration. We hope to secure additional time in late '08 to finish this software task but list it here if we are unsuccessful at lobbying for additional Software Engineering in '08.
   160 hours, Kent Headley
2. Have a custom housing and dome optics designed and built for the 11 MP Prosilica camera with a fixed focal length lens.
3. Integrate the new camera housing into the AUV.
   50 hours for Jon Erickson
4. Migrate the AUV electrical interface to the new camera housing.
   40 hours for Alana Sherman
5. Add two lasers to the AUV for target scaling.
   20 hours for Jon Ericson and 20 hours for Alana Sherman
6. Refine the low-altitude AUV control and imaging navigation.
   80 hours for Rob McEwen

7. Integrate a Benthos acoustic modem and develop remote-tracking navigation like that used on the mapping AUV. This will remove the requirement for seafloor transponders during transects. Parallel track mosaics will still require seafloor transponders.
   80 hours Rob McEwen, 40 hours Alana Sherman, 20 hours Jon Erickson
8. Operate the BIAUV during 3 engineering dives.
   75 hours Brett Hobson, 75 hours Rob McEwen, 48 hours Kent Headley, 40 hours for Alana Sherman
9. Operate the BIAUV during 4 science dives.
   75 hours for Brett Hobson, 75 hours for Rob McEwen
10. Adapt existing data-handling software to offload images and refine the AUV navigation data.
    320 hours, Mike McCann or Brian Schlining
11. Develop and automated image conversion process to convert the Bayer format images to JPEG and thumbnails.
    192 hours, John Graybeal and Kevin Gomes
12. Align the CenSeam format to imbed AUV metadata into the images.
    64 hours, John Graybeal.
13. Tank test investigation of Range-Gating using Rover's low-light monochrome camera and a prototype LED array. We expect to need some technique of backscatter reduction to image in areas with suspended particulate, e.g. near canyon axis and water <80m.
    80 hours, Brett Hobson and 80 hours for Alana Sherman.
14. Management and reviews:
    80 hours for Brett Hobson and 50 hours for Kent Headley
15. Publications:
    64 hours for Brett Hobson and 64 hours for 64 hours for Kent Headley

Field programs (detail ship requirements/deployments)

We plan to conduct three engineering dives and four science missions in 2009.

Specific deliverables

1. Benthic images covering Dr. Barry's benthic survey along Smooth Ridge.
2. An image mosaic to support the Marine Protected Area (MPA) project.
3. An image mosaic of a yet to be determined target, perhaps a whale fall

Milestones

1. AUV operational with camera, lasers and USBL navigation - March
2. AUV operational with remote navigation - June
3. First Science mission - July
4. Second Science mission - September
5. Third science mission - October

Budget justification

1. Camera housing from Insite Pacific = $9500.
2. Scaling Lasers = $8300
3. Benthos Acoustic Modem = $6000
4. Upgrade AUV components = $4800
5. Mass storage for images (500GB) = $7500
6. Acoustic Transponder with float and release = $8500
7. Prototype LED panels = $2000

Project team

Brett Hobson: principle investigator and project manager
Jim Barry: Lead Scientist
Rob McEwan: Controls engineer
Alana Sherman: Electrical engineer
Kent Headley: Software engineer
Rich Henthorn: Software engineer
Johnny Ferreira: Mechanical Tech
Hans Thomas: AUV systems engineer
Steve Rock and Charlie Paull: MPA project Collaborators
Lonny Lundsten: Image mosaic creater

Project lab space

We currently share space with the DMO AUV group, and the high-bay. We request additional lab space or permanent vehicle storage space outside of the AUV lab.

Data availability outside project team, uniqueness

All data generated with the BIAUV will be stored on MBARI's internal servers which will be managed and backed up by IS. Interested parties will have access to all data that is generated. Publications of results in refereed, international journals will proceed in a timely manner.

Risk matrix (development and infrastructure projects only)

	Technical Risk	Organizational Risk	Tech Transfer Risk	Labor Estimate Risk
High				X
Medium	X		X	

Low		X		

3) MILESTONES (new and continuing projects)

	Milestone 1	Milestone 2	Milestone 3	Milestone 4	Milestone 5	
Milestone Date	**March 09**	**June 09**	**July 09**	**September 09**	**October 09**	**Total Resources[3]** for each resource category for all milestones listed here
Milestone Description	AUV operational with camera, lasers and USBL navigation	AUV operational with remote navigation	First Science mission	Second Science mission	Third science mission	
EE	**60**	**40**	**40**	**40**	**40**	**220**
SE	**376**	**235**	**130**	**64**	**35**	**840**
ME	**125**	**65**	**54**	**100**	**120**	**464**
Support Engineering	**100**	**120**	**50**	**25**	**25**	**320**
EE Tech	**20**	**20**				**40**
SE Tech						
ME Tech	**40**	**40**				**80**
Machine Shop	**40**	**40**				**80**

[3] This number should be the same number you entered on the resource requests for this particular resource.