

Project Number: 900403

Project Start: Jan. 1, 2007

Project Duration (in years): 1

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

☐☒☐☐☐☐

Feasibility/Scoping
[Less than 100 days effort]

Development¹

Research

Infrastructure¹

Education

**Time
Series**

Project Manager/PI: Alana Sherman/John Ryan

Project Title: AUV Gulper Applications

¹

Development and infrastructure projects must complete the risk matrix (see item #5 at the end of the proposal form).

1) ABSTRACT (new projects only)

The *Gulper* water sampling system for the *Dorado* AUV is being developed this year and will be completed by the end of 2006. The science users who participated in the planning and definition of requirements are eager to apply *Gulper* for research in the Monterey Bay region. These researchers include John Ryan, Chris Scholin, Joe Jones / Bob Vrijenhoek, Steve Haddock and Francisco Chavez. Routine deployment of *Gulper* in regional research will require further software development to achieve adaptive sampling, i.e. water sample triggering based on real-time information coming from sensors already operational on the AUV. The purpose of this new project proposal is to develop and test adaptive control behaviors. As the MT recommended at the abstract phase, this project is limited to adaptive control software development and testing; the AUV operations team will integrate adaptive control software developed by this project and will lead development and testing of prescribed grid sampling with *Gulper*. Applying *Gulper* in regional research efforts will be a progressive step in reducing dependence upon ship operations through advancing the technology of autonomous vehicles. In addition to software development, this proposal requests *Zephyr* time to test behaviors. Researchers, individually and collaboratively, are requesting *Zephyr*+AUV/*Gulper* time in their 2007 research project proposals. These fall into two categories: monitoring (in parallel with the AUV CTD project) and process studies (red tide and harmful algal bloom studies, larval ecology studies).

2) PROPOSAL

a) The problem addressed (new projects only)

Statement of the problem

The AUV *Gulper* is a unique MBARI asset that adds value to the extensive suite of contextual data currently being collected on the AUV *Dorado*. This tool will enable science applications that require an actual water sample for analysis. The *Gulper* system is scheduled to be complete at the end of 2006. This proposal requests a year of development to deploy and test the system, and to write new sampling behaviors for the upper-water-column vehicle. We propose development of adaptive behavior control software for three phenomena: plumes, fronts and layers. Software engineering time is the primary requirement, with each behavior requiring 2 weeks of SE and 2 days of at-sea testing. We also request some mechanical technician time to develop tools to operate and dispense the samplers routinely.

Why it is important

The spectrum of measurements being made from the MBARI AUV *Dorado* is outstanding, and the science enabled by these measurements is thus broad and multidisciplinary. However, important science remains inaccessible by underway instrument readings alone. Many important research applications require a sample

of water for analysis; for example plankton and larval ecology, Harmful Algal Bloom (HAB) detection and mapping, sediment transport / carbon flux, primary productivity incubations. AUV onboard intelligence provides a unique opportunity to strategically acquire water samples when and where they can provide the most valuable information, and to place lab analysis of these samples within the interpretive context provided by the multidisciplinary mapping of the upper-water-column AUV.

Present state of art/understanding

The Gulper water sampler has been designed, built and tested. This sampler meets the functional requirements specified from use cases of multiple researchers at MBARI. To make this well designed hardware an effective resource, unique in the oceanographic community, control software is needed. There is currently no software designed to trigger water sample acquisition based on AUV sensor readings that identify important oceanographic phenomena encountered during AUV surveys.

How it relates/contributes to MBARI's mission and strategic plan

Water sample acquisition from the AUV via the *Gulper* system will benefit multiple science labs at MBARI (Chavez, Haddock, Ryan, Scholin, Vrijenhoek). This critical phase of development, application of the complete system during 2007, represents a significant step towards reducing dependence of ocean research on ship operations. It also represents a forward looking, community leading capability for AUVs in coastal ocean observing systems.

b) Approach to the problem (new and continuing projects)

Status of project

We expect the 10-sampler mid-body system to be built and initial engineering tests complete by the end of 2006.

Results to date

1. For target research applications, tests were conducted to evaluate potential effects on analysis results of sample intake (shear, unbiased sampling of volume), and sample hold (time and variable conditions on the AUV during which water constituents may change prior to analysis). These results were summarized in last year's proposal and supported the effective application of *Gulper* for diverse research efforts of multiple labs.
2. Validation studies of single *Gulper* sampler compared the salinity of the *Gulper* sample to Niskin samples and the ROV CTD. Results confirmed the *Gulper* held water from the sample location without contamination from leakage.
3. We tested shape memory actuators for triggering the *gulper* in the lab and ROV. The actuators repeatedly fired at depth, and were cycle-tested successfully.

Publications (from the last 5 years)

N/A

Plans for 2007

Engineering/technology development

In 2007 we plan to:

1. Develop tools to make the Gulper systems easier for science and operations to work with.
2. Develop and test software for adaptive sampling, with software design review
3. Fix any problems that occur after routine AUV deployment
4. Write system documentation and engineering publication describing the Gulper system

Field programs

The field efforts specifically requested under this project are for the purpose of testing control system behaviors. We propose development of adaptive behavior control software for three phenomena: plumes, fronts and layers. Each behavior will require 2 days of at-sea testing on Zephyr.

2007 field programs associated with this project fall into two categories (Table 1):

Category 1: Researchers seeking to apply Gulper in ongoing AUV monitoring

In this category, the normal requests for Zephyr+AUV that are part of the AUV CTD project monitoring will cover *Gulper* deployment. The software needed for triggering Gulper will be developed by the Gulper Applications Project (adaptive sampling) and the AUV Operations team (prescribed grid sampling). The AUV CTD project will be leveraged to acquire water samples at the time series stations (C1, M1, M2) concurrently with Pt. Lobos cruises to evaluate replacement of existing ship based methods. AUV CTD monitoring along the shelf time series sections will be leveraged by Ryan, Haddock and Silver to sample plankton in patches, layers, frontal zones, and the hypothesized red tide incubator of northern Monterey Bay (phytoplankton enumeration in collaboration with MBARI adjunct Mary Silver).

Category 2: Researchers seeking to apply Gulper in targeted process studies

In this category, additional requests for Zephyr+AUV/Gulper will be made by researchers involved in the process studies (see proposals for projects 900613/Scholin, 200104/Vrijenhoek, and 900533/Ryan). These process studies are focused on planned deployments of the ESP in 2007: two deployments during spring and one deployment during fall. Research goals of these field programs relate to larval ecology, harmful algal bloom ecology, and red tide ecology, and they will apply prescribed and adaptive behaviors.

2007 Proposal Process – Internal-Only Projects
Submission Deadlines: Phase I – August 22nd, Phase II – September 28th

Researchers	Research goal	Number of AUV/ Gulper days	Project #
Chavez, Pennington	Compare water sample analysis results from Gulper with Pt. Lobos cruise data	12	900300
Ryan, Haddock, Silver	Define seasonal evolution of phytoplankton in the red tide incubator and in frontal zones, examine bioluminescent species	12	900300
Scholin, Preston, Greenfield	Extend probe-based microbiology around ESP mooring deployments	8	900613
Jones, Vrijenhoek	Study larval ecology, especially related to invasive green crab	2	900718
Ryan, Silver	Examine variability in dinoflagellate populations in the northern bay during the peak season for red tide development (August-October)	8	900533

Data (availability outside project team, uniqueness)

Dorado science data reduction is well developed and integrated with the data and metadata management of SSDS. Time-stamping of Gulper samples by the AUV main vehicle computer will permit easy integration of water sample analysis results with the contextual science data from *Dorado*. Each lab will manage, analyze and interpret their own water samples for their unique research goals.

Significant changes from previous project proposal (continuing projects only)

N/A

c) Specific deliverables (new and continuing projects)

1. Tools for handling and dispensing samplers
2. AUV behaviors to adaptively sample
3. Engineering publication on system

d) Project team (new and continuing projects)

Alana Sherman: project manager, electrical/system engineering

John Ryan: lead scientist

Larry Bird: mechanical technician, design of tools and shore-side interfaces.

Tom O'Reilly: software engineer, write and test AUV behaviors

Hans Thomas: AUV Operations lead, integration and testing of control software

e) Project lab space (new and continuing projects)

None needed

3)BUDGET JUSTIFICATION (new and continuing projects)

Personnel:

Alana Sherman, project manager, is requesting a total of 35 days (EE) for project management and publication preparation (engineering publication to describe the system). John Ryan, project scientist, is requesting 10 days to participate in the Gulper meetings, control behavior definition (using existing AUV data) and at-sea testing. We request 35 days of Tom O'Reilly's time (SE): 10 days per behavior x 3 behaviors + 5 days to work with Alana on publication preparation. We request 25 days of Larry Bird's time (ME Tech) for hardware development that will facilitate transition of the system to Marine Operations and use of the sampler system by researchers, and for publication preparation. The work breakdown for Larry is 60% developing tools for handling samples, 40% building spares, maintenance of the original system. Lastly, we request 8 days of machine shop time for fabrication (breakdown: 75% new tools 25% spares).

Other:

- Development Software: \$1000
- Equipment: \$8000 (replacement parts, spares, extra samplers)
- General supplies: \$5000 (raw materials for tools)
- Tools: \$1000
- Travel: \$5000, for domestic travel to a conference for two people, with an additional \$1000 for conference fees.

4) MILESTONES (new and continuing projects)

	Milestone 1	Milestone 2	Milestone 3	Total Resources ² for each resource category for all milestones listed here	
Milestone Date	First Quarter	Second Quarter	3 rd 4 th Quarters		
Milestone Description	Tools for samplers 1 behavior written and tested on AUV	2 remaining behaviors written and tested on AUV	Routine use of Gulper, Engineering Publication		
EE	10 days	10	10	30	
SE	10	20	5	35	
ME					
Support Engineering					
EE Tech					
SE Tech					
ME Tech	20		5	25	
Machine Shop	8			8	

² This number should be the same number you entered on the resource requests for this particular resource.

5) RISK MATRIX (development and infrastructure projects only)

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