Project Number: [Enter number here]

Project Start: Jan. 1,	**2016**[1]	**Project Duration (in years):**	**5** [1]

Please indicate if proposal includes requests for any of the following (mark all that apply).

Ship Time	ROV	AUV	Wave Glider	Mini ROV
x		x		

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

Feasibility/Scoping [Less than 100 days effort]	Development[2]	Research	Infrastructure[2]	Education	Time Series	Institute Initiative
	x					

Project Manager[3]:	Brett Hobson
Principal Investigator:	Ken Smith
Lead Scientist:	Ken Smith, Charlie Paull
Lead Engineer:	Rob McEwen

Park-n-Fly AUV for long-term surveys in extreme environments

[1] This date and number should remain the same for the duration of the project. If your project start date for 2017 is not January 1, please indicate the start date in the first cell of the milestone chart. Format for duration example: "Year 2 of 5".
[2] Development and infrastructure projects must complete the risk matrix (see item #5 at the end of the proposal form).
[3] 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.

a) Continuing Projects

Current status of project and results to date

This is a follow-on proposal from the feasibility study that is ongoing through 2016. The core science rationale is unchanged and supports the Integrated Time Series and Pelagic Benthic Coupling and the Carbon Cycle projects while the engineering challenge is aimed at advancing a persistent presence in the deep ocean by developing AUVs capable of 12-month deployments. We have broadened the science application of this effort to investigate the geologic evolution of mud volcanoes and the biogeochemical processes that occur within these methane rich ecosystems, as well as advancing the studies of this and surrounding environments of the upper slope of the Beaufort Sea.

This is a 5-year project to:

- **Develop the capability for a persistent presence in the deep ocean**
- **Conduct seasonal, seafloor imaging and bioacoustics surveys at Station-M. Without a ship.**
- **Conduct seasonal, seafloor mapping with sidescan and multi-beam sonars to investigate the geologic evolution of mud volcanoes in the Arctic. Without a ship. For one year. Under the ice**.

Approach:

- **Stretch our routine AUV operation from a continuous run over 17 hours to ~four 3-hours missions spaced over one year**
- **Park the AUV between missions and put it to sleep**
- **An independent controller wakes the AUV up, runs the checklist, starts the mission and monitors for problems. If the AUV cannot get back to the dock, just sink to the seafloor and wait for help**
- **Optionally enable event response by allowing a remote or local trigger the deployments remotely or locally for event response**

We are ½ way through an initial feasibility study and we've identified 5 risk areas: (1) Robust Docking, (2) Hibernation, (3) Long-term effects of immersion, (4) AUV reliability and (5) Schedule risk. For each of these issues we've designed a risk-mitigation strategy that will be reviewed at the Concept Design Review in December 2016.

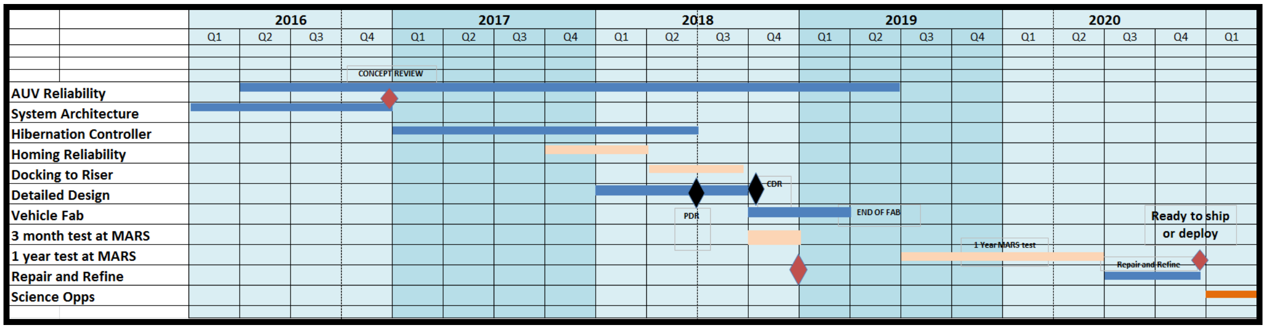

Figure 1: Project Schedule

The program is broken into the following major tasks scheduled as shown in Figure 1 above.

1. **AUV reliability**: The success of this effort relies on AUV reliability and many of the procedures, components, and systems developed here will be migrated back to the other DMO AUVs to hopefully improve their reliability as well. An analysis of past failures and estimates of MBTF will be used as a baseline to capture future events/issues that reduce vehicle reliability. can be used for ongoing AUV operations. This is a long-term effort that will run for most of the project.
2. **System Architecture**: We are striving to design the simplest system that can achieve the science goals. A concept design review will be held at the end of 2016.
3. **Hibernation controller development:** This is the keystone component that we hope will allow minimal changes to the core AUV but provide a method to power up, initiate automated built-in-tests and ultimately be responsible for initiating a mission and scuttling the vehicle if it cannot get back to the dock. Because it must be always be alive, its power efficiency is important.
4. **Homing reliability analysis**: Once a mission is initiated, the vehicle must get back to the relative security of the dock and homing system reliability is paramount. One of our first tasks will be to asses this reliability by running over 100 homing missions during 2017. MBARI does own a homing sensor purchased in 2006 for the previous docking work that could be used for this task. However, if we are to build on the statistic results of the homing trials, we should not switch sensors after investing in the testing. It is very likely the new system is much better than the original unit.
5. **Docking to riser:** If we can reliably home to a cable, we will move on and develop the mechanical latch that holds the AUV to the dock and deploys and stowes a pair of whiskers that guide the cable into the latch. To confirm the AUV has successfully latched to the cable, a video feed to shore is required as well as data telemetry to/from the AUV. We will design and build a surface buoy fitted with radios, batteries, solar panels and a subsurface camera with a light and a non-contact telemetry device like Sonardyne's BlueCom optical system (~$45k). We build a similar buoy with radio telemetry for data and video for the Power Buoy project and the design and many of the components remain.
6. **AUV detailed design-PDR-CDR**: If we can demonstrate reliable docking we will be ready to perform the detailed design of a dedicated AUV and at this point decide how many vehicles are needed.
7. **3-month deployment at MARS**: While the new vehicles are being designed and build the prototype system will be deployed for a 3-month series of missions at MARS.
8. **1 year deployment at MARS:** After the new vehicle(s) are built and tested, a 1-year extended deployment will be run at the MARS observatory and/or at Station M.

9. **Repair and refine:** Following the 1-year test, we will repair and refine the design and AUV and consider moving forward with science deployments. If serious problems remain another series of development and testing will be required.
10. **Science Operations:** If all the previous steps are successful, we could begin science operatons in early 2021.

We are fortunate to have the previous docking effort, a strong fleet of Dorado vehicles and components, strong industrial partnerships with companies such as Sonardyne and the MARS node available to address most of the high-risk elements of this proposed effort. If we cannot demonstrate a path to success, the project could be ended, scaled back. We believe that a thorough at-sea testing plan can mitigate much of the risk with this effort. The science payoff is high and this project aligns well with the Persistent Presence theme of the MBARI Technical Roadmap.

Significant changes from previous project proposal

At the inception of this effort we were focused exclusively on time-series operations at Station M. We have now broadened the target application set to include high risk/high reward science deployments in places like under the ice in the Beaufort Sea for Dr. Paull and hydrothermal vent sites.

Publications based on the results of this project only

No publications for this project yet.

b) New and Continuing Projects: Plans for 2017

Engineering/technology development

1.Homing (1560 hours)

1.1 AUV nose – Hobson (25), Cazenave (575), Thomas (40) ET (100), MT (100), Mshop (100) - Design and build the guts of a new nose for the Iceberg AUV that holds a new, titanium 6G Sonardyne iUSBL and use 6km rated syntactic foam. This requires about 2.8 cubic feet of foam, which is what the iceberg nose had so we'll use the cost of those parts.

1.1.2– Whiskers - Cazenave (90) - Fixed whiskers need to be designed and mounted along with a wear plate to resist the impact of the mock-dock.

1.1.3 Camera – Hobson (10), Cazenave (50) - We need to document the accuracy so a stand-alone MBARI SeaStar camera system will be integrated into the nose.

1.1.4 Homing code – McEwen (160) – The old AUV docking code needs to be refined for the case of pure pursuit. Missions are required that start and loop quickly around to get the most docking approaches as possible. The target is 25 cycles/day.

1.2 Homing Mooring – Hobson (25), Cazenave (100) MT (50), ET (100), Mshop (90) – A Paragon-deployable anchor with a subsurface float that holds a transponder and a vertical fiberglass rod. The AUV will home towards the transponder and get close enough for the whiskers to align the vertical pole to the center of the whiskers to be counted as a successful "dock". The AUV will not stop, so the pole will tilt and slide out the bottom of the whisker catcher. Refer to Figure 2 below.

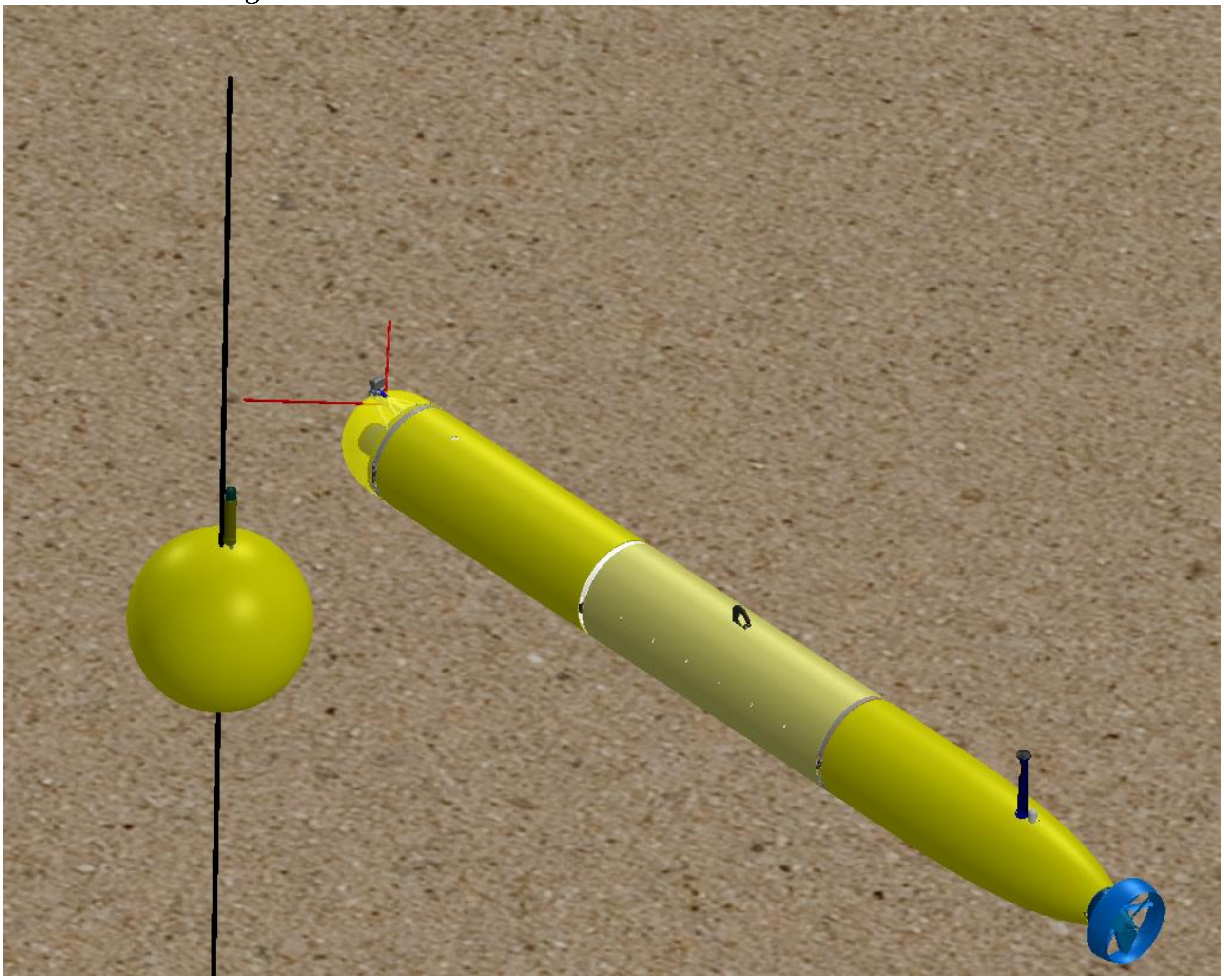

Figure 2: Mock Dock

1.4.1 Active cable latch – Erickson (350) – During the second half of the year we will design a prototype active latch and test it in the test tank to determine the effect of different buoyancy states (neutrual to 5 lbs negative) as well as docking and undocking.

2.0 Reliability and long-term survivability (1950 hours)

2.1 AUV Software

2.1.1 QNX code – Henthorn (100), Headley (50) - Add hooks and behaviors for the hibernation controller to interact with the main vehicle computer and flight code.

2.1.2 Automate pre-dive check lists – Henthorn (200) – This task is being addressed in the AUV Infrastructure project, but we provide time here for docking specific tasks.

2.2 AUV Hardware

2.2.1 I/O – Jensen (50), McGill (40) – The existing main vehicle computer stack doesn't have the necessary hardware input/output channels to support heartbeats and communication to and from the hibernation controller.

2.3 Hibernation Controller

2.3.1 Hardware – McGill (100) – Use requirements for the hibernation controller derived in 2016 to select and purchase the appropriate hardware.
2.3.2 Carrier – Jensen (50), McGill (200), ET (50) – A carrier PCB needs to be designed with all of the appropriate I/O, power switching, filtering and the board needs to be fabricated and tested.
2.3.3 Testing – Kieft (150), Jensen (50), McGill (200), ET (75) – extensive testing of the stand-alone system and with an AUV MVC.
2.3.4 Embedded Software – Kieft (150), Henthorn (100) – The custom PIC (or alternate) needs to be written and tested.
2.4 Foam and Corrosion – Hobson (20), Cazenave (20) – A second set of long-term immersion tests should be conducted at Station M with syntactic foam from a second vendor (CRP). Follow-on corrosion related work will also be needed.
2.5 Dorado Reliability
2.5.1 Past failures – Hobson (50) – Work with Hans and his team to identify the 10 most common reliability problems and devise a documentation procedure that is easy for the Dorado team to maintain.
2.5.2 Future failures – Kieft (20), Headley (50), Henthorn (50), Kemp (20), Raanan (20) - Work with AUV reliability expert Mario Brito at Southampton to adopt his failure tracking framework. Develop new procedures like mission simulation, and software behaviors to increase reliability.
2.5.3 BITs – Kieft (20), Henthorn (50), Kemp (20), Raanan (20) – Develop Built-in-Tests (BIT) that can run on Dorado.

3.0 Vehicle Operations (315 hours)

3.1 Deploy Mock Dock – Hobson (20), Jensen (20), Cazenave (20) – Deploy the Mock-Dock mooring from the Paragon at a location within Freewave radio range of the Copula (~2-3 miles)
3.2 Homing Tests – Hobson (60), McEwen (85), Henthorn (40) – Conduct six days of Tow-out operations with the iUSBL equipped Iceberg AUV using the Paragon. McEwen runs the missions from shore via the Freewave. The operations are spread over 2 months.
3.3 Test Tank docking – Hobson (10), McEwen (30), Henthorn (10) – Deploy the Mock Dock in the tank and try to latch to the cable between the float and the anchor.

4.0 Project Management (765 hours)

4.1 Overhead for meetings – Hobson (50), Kieft, Jensen, Cazenave, Headley, McGill, McEwen, Henthorn, Kemp, Thomas all have 25 hours, which is roughly bi-monthly meetings
4.2 Contingency to respond to unplanned issues – Kieft (50), Hobson (30), Jensen (25), Cazenave (100), Thomas (100), Kemp (40)
4.3 Project Management and Reporting – Hobson (150)

Field programs (detail ship requirements/deployments/diver requirements)

Deployment of the test mooring and AUV for nearshore testing will all be performed from the R/V Paragon. We request 20 days of ship time aboard the Paragon during 2017.

Specific deliverables

In 2017 we will deliver:

1. Dorado nose module containing a iUSBL and the syntactic foam to float the instrument and fixed whisker cable catcher and a stand-alone recording camera.
2. Mock-dock mooring
3. Prototype hibernation controller
4. Deploy a second set of syntactic samples for long term, high pressure test.
5. Dorado Reliability log sheet
6. Automated Dorado checklists
7. Homing test results from ~100 homing runs
8. Test results from tank test cable latch tests

Milestones (see personnel classification list)

[Click here to enter text]

2017 Project Start Date: 01/01/2017	**Milestone 1**	**Milestone 2**	**Milestone 3**	**Milestone 4**	**Milestone 5**	**Total Resources**[4] for each resource category for all milestones listed here
Milestone Date	**1**	**2**	**3**	**4**		
Milestone Description	**AUV Docking**	**Reliability**	**Testing**	**Project Mgt.**		
EE	**0**	**690**	**20**	**75**		**785**
SE	**160**	**965**	**165**	**150**		**1440**
ME	**820**	**90**	**110**	**355**		**1375**
EE Tech	**200**	**125**	**20**	**0**		**345**
ME Tech	**150**	**0**	**0**	**0**		**150**
Res Engr	**0**	**40**	**0**	**60**		**100**
Res Sp	**0**	**40**	**0**	**0**		**40**

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

AUV Sup	**40**	**0**	**0**	**125**		**165**
Machine Shop	**190**	**0**	**0**	**0**		**190**

Budget justification

1. We request funds to purchase a Sonardyne inverted Ultra Short Baseline (iUSBL) acoustic homing sensor. $80,000
2. Syntactic foam for the AUV nose section to float the iUSBL. $10,000
3. SeaStar II camera system. $5000
4. Misc. parts to fabricate the whisker line capture system and integrate the camera. $1,200
5. Misc. electronic components to develop the hibernation controller. $900

Project team

Brett Hobson – PI/PM – 450 hours
Mathieu Kemp – RE – 100 hours
Ben Raanan – RS – 40 hours
Paul McGill – EE – 565 hours
Scott Jensen – EE – 220 hours
Rich Henthorn – SE – 575 hours
Brian Kieft – SE – 415 hours
Rob McEwen – SE – 300 hours
Kent Headley – SE – 150 hours
Francois Cazenave – ME 575 hours
Jon Erickson – ME – 350 hours
Hans Thomas – AUV Support – 165 hours

Project lab and office space requirements
In addition to any changes to current space usage, please also include anticipated office and lab needs for students, postdocs, collaborators, etc.

We request a bench and some storage space in Bldg. G to build sub-assemblies and store components.

Data storage requirements (see Todd Ruston for assistance)

500 GB of video and AUV log files

Data availability outside project team, uniqueness

We plan to share the video and project results in general.

R/V *Paragon* Requests
If the project team will be requesting time for the R/V Paragon, please specify the operators in the group and provide estimates of their availability to operate the vessel.

Brett Hobson, Brian Kieft and one of the AUV operators are captains and will handle all of the vessel operations for this effort.

Export Regulation
Does the project team anticipate any foreign collaborations or international travel? If so, please identify collaborators by name, institution, and country.

No plans to export.

Does the project team plan or anticipate export controlled purchases, shipments, or transfers of items (e.g., research instruments, proprietary data, hand-carried tools or samples) outside the U.S. temporarily or permanently? If yes, please identify country or countries and indicate whether these items will remain under MBARI control while abroad or controlled by others. Will the items be exported to more than one country? Please include foreign collaborator information as described above.

No plans

Monterey Bay National Marine Sanctuary (MBNMS)

General Permit
Projects teams need to indicate if any work will be performed that is either: (1) currently authorized under our general permit; or (2) will require that we obtain authorization. The current permit can be viewed at http://mww.mbari.org/pco/permits/mbnms-2015-002_feb2015.pdf. Please see Mandy Allen for questions.

Is a permit with MBNMS required for your work?

Yes, we plan to temporarily dischange an AUV offshore MBARI, which appears to be covered by the existing permit.

SESAs ([General map]())
*Projects will need to indicate whether or not work will be conducted within one of the Monterey Bay National Marine Sanctuary's Ecologically Significant Areas (SESAs). An interactive map can be found on the Sanctuary's SIMoN webpages at http://sanctuarysimon.org/maps/sesa/. (*Note: It may take a moment for the page to load, so please be patient. Also, if prompted for a login, hit "Cancel" and then you will be able to access page.*) To determine if your work will occur in a SESA, specific coordinates can be entered using the locator function (click on the red "target" button in the toolbar at the top of the map). If your work will be conducted in one of these areas, please indicate which area, by number.*

None

Authorizations/Permits from other Agencies or Organizations
Is the project team aware of any other permits or authorizations that will be necessary to perform the proposed work? If so, please list below along with status of authorizations (obtained, pending, need to apply, etc.). Please see Mandy Allen if you have questions.

None

Active Acoustics
We are compiling information on active acoustic use at MBARI. If the project involves using active acoustic instrumentation, please describe plans.

We plan to operate the USBL tracking system, a variant of which is what is used aboard the ships to track the AUVs and is included in the existing list of equipment.

Risk matrix (development and infrastructure projects only)

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