



5/6/2019

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ESP Engineering Exploration and Concept Generation Proposal

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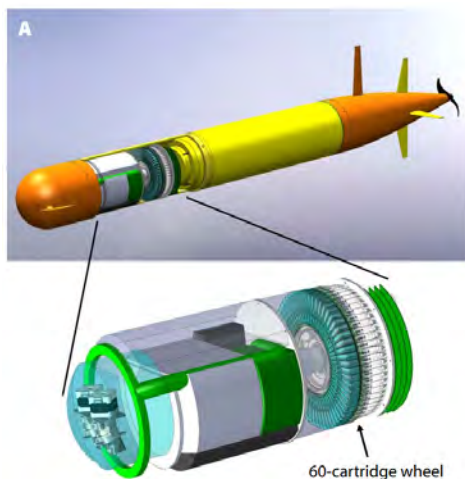
Rev 1.0



Project

The Monterey Bay Aquarium Research Institute (“MBARI”) has developed an Environmental Sample Processor (“ESP”), an autonomous instrument for collecting and preparing sea or fresh water samples for a variety of analyses both on board and when returned to a lab. The ESP is a modular cartridge-based system, with cartridges that can either be used to archive a sample or to prepare and pass samples to separate onboard analysis modules. A sample can be processed for archiving or different analyses using specific reagents stored within each individual cartridge. The cartridges are reusable, and are disassembled and cleaned (e.g., with 10% HCl) between deployments. The ESP holds 60 cartridges so it can process up to 60 samples without surfacing when used in an autonomous undersea vessel. Deployments could last days or even weeks. When packaged for hand carrying, the ESP is envisioned to be used in as part of a smaller system (“the Tackle Box”) for water monitoring in fresh water streams, for example.

MBARI is working on its third generation system (Gen 3) and has already developed a functional prototype of the design. It is evaluating third-party engineering design support to potentially reduce the cost of its reusable cartridges, facilitate their use (e.g., ease of assembly, ease of cleaning), and ideally improve the system’s robustness. MBARI has invited Function Engineering, Inc. (“Function”) to submit a proposal for an initial investigation phase for determine opportunities and generate initial concepts for meeting these objectives.



Rendering of 60-Cartridge ESP from *Oceanography*, Vol. 30, No. 4

Preliminary Requirements and Considerations

MBARI has shared information in a preliminary phone conversation, at an in-person meeting on April 25 at its facilities, and in supporting emails. The in-person meeting was the primary information used to inform this proposal. Function received and reviewed a background article published by *Oceanography* in 2017, and a costed Bill of Materials (BOM) for the current prototype system.



Scope

Function will provide mechanical engineering services in support of an investigation of design opportunities relative to MBARI's goals for the Gen 3 ESP. Function will assist in coordinating with MBARI's internal team regarding marine science, operations, mechanical engineering, electrical engineering, software/firmware, interface development, prototyping, and verification testing. MBARI or its partners will be responsible for the science of the system, electrical engineering, software/firmware, manufacturing, and testing, as well as mechanical engineering of any opportunity that emerges, beyond the scope outlined. This initial phase of proposed work will not result in functional prototypes. Function would be happy to propose its support for further development of any promising solutions if MBARI would like further support.

We do not anticipate requiring third-party fabrication for this initial scope of work. However, Function may make preliminary inquiries to certain vendors regarding specific parts without disclosing the design details, MBARI as the client, or purpose of the effort. Function will support identification of suppliers and vendors for components and custom part fabrication, where appropriate. For purposes of this scope of work, component suppliers and third-party part fabricators are vendors, not agents or subcontractors, of Function.

Agency compliance testing and lead times for approvals are not included in this proposal. It is assumed that MBARI will be responsible for final regulatory agency submittal. Function will work with MBARI for the mechanical portion of the agency requirements, if any.

Development Phases

Phase 1: Engineering Investigation and Concept Generation

Phase 1 will focus on generating potential solutions for the key mechanical requirements and goals for the cartridge, with the understanding that some concepts may have repercussions for the overall ESP.

Deep Dive and Creation of Brainstorming Tools. Function will review the presentations MBARI shared along with our notes and draft a preliminary mechanical requirements summary with specification, considerations, and key information for guiding design. We will delve further into the details of the sampling and processing steps to build our understanding. During this review, we will use email or brief, informal web meetings to clarify key issues with MBARI's team. We will draft brainstorming guidelines to support our internal brainstorming on various aspects of the cartridge. Brainstorming will be conducted with different groups within Function and will vary between open-ended ideas for sampling and processing to narrower focused issues (e.g., mechanisms, materials, or manufacturing processes).

Preliminary Brainstorming and Concepting.

Function will use problem decomposition, brainstorming, and analysis to generate and evaluate concepts for product architecture and key design features. Using the existing MBARI CAD, we will perform a basic fluid flow analysis to help understand bubble behavior. Brainstorming will be done at different levels with different teams within Function. Some brainstorming will be "blue sky," addressing the overall cartridge - what could it be if you have only these inputs, outputs, and interface? We will also review the existing cartridge and brainstorm ways of improving upon it or eliminating issues that MBARI has encountered (or anticipates).

Concepts at this stage are typically crude engineering sketches and/or crude concept CAD (not design, just used for illustration). We organize the concepts into a Powerpoint document for review with MBARI. Each concept presented has a brief description in bullets and some preliminary comments about its plusses and minuses.

We will schedule weekly reviews with MBARI to solicit feedback on initial concept directions and areas to focus for additional exploration and/or refinement.

Additional Brainstorming, Preliminary Component/Materials/Process Research, Concept Refinement and Tradeoffs.

Based on feedback from the mid-phase meeting, Function will flesh out preferred concepts in more detail. We will continue to brainstorm on areas that are needed. We will do preliminary analysis and/or concept, material, or manufacturing process



research to help inform trade-offs among concepts or concept refinement. Function will develop concept layouts of select directions or design features, where appropriate. We may also develop crude physical mock-ups of design options, if doing so will facilitate communication.

Function will prepare a final concept presentation to capture the concepts, reasoning, any preliminary analyses, identified trade-offs, etc.

Function will meet with MBARI in Moss Landing to go over the results from this phase, at which time MBARI and Function together will select the preferred direction(s) for continuing development, if any.

Tasks

- / Kick-Off and Deep Dive (receive current cartridge design and go over it in detail with MBARI, understand the ESP in further detail including operational considerations and testing that is done, review manufacturing strategy to date, understand disassembly and cleaning of the cartridges as well as how they are prepped for a voyage, etc.)
- / Preliminary Mechanical Requirements Summary Development
- / Fluid Flow Animation (Solidworks)
- / Brainstorming Guidelines Development
- / Initial Review with MBARI (review requirements summary, brainstorming guidelines, and animation)
 - / Ensure Function understanding of what the system is doing and what has been explored
 - / Agree upon guidelines for brainstorming
- / Brainstorming & Concept Development, focusing on the following challenges (independently and in combination, where needed):
 - / Blue Sky brainstorming of overall product architecture and approach for sampling and processing sample
 - / Specific brainstorming on mechanisms for fluid flows, bubble handling, lysate distributions, valving, etc.
 - / Problem decomposition and enumeration of high level architecture/design choices
 - / Compile state tables for current cartridges, understand requirements, synthesize alternatives
 - / Materials, manufacturing process, and components
 - / Special considerations (pressures, temperatures, etc.).
- / Weekly Reviews with MBARI
- / Preliminary Component, Materials, and Process Investigations
- / Preliminary Analysis, where needed
- / Further Brainstorming and Concept Refinement
- / Development of Key Trade-Offs
- / Preliminary Concept Layouts and/or Mock-Ups, where useful for communicating options
- / Concept Report Generation
- / Review with MBARI

Deliverables

- / Preliminary Requirements Summary Document (precursor of a specification for design)
- / Brainstorming Guidelines
- / Fluid Flow Visualization (in Solidworks FloXpress)
- / Weekly Concept Report (Powerpoint with sketched or rough CAD concepts and/or preliminary analysis)
- / Final Concept Report (Powerpoint including concepts, preliminary analyses, trade-offs, preliminary component/material/process research)
- / Crude CAD concept layouts and/or mock-ups, if valuable for communicating intent



Estimated Budget and Schedule

Phase	Description	Est. Labor	Est. Expense	Duration	Notes
1	Engineering Investigation and Concept Generation	\$45k	\$500	~4 wks	

Terms

- / The project start date will be scheduled upon receipt of the signed proposal, which will form the basis for the Statement of Work (Exhibit A) under a Master Services Agreement mutually agreed upon between Function and MBARI.
- / The engineering program is assumed to be contracted on a time and materials basis. Labor and expense fees included in this proposal are estimates and are provided for budgeting purposes only.
- / If adjustments are necessary due to changes in project direction, schedule, or scope of work, Function will submit a written explanation of cost and time impact before implementing the changes. At the end of each phase, the budget and schedule will be reviewed and approved prior to the beginning of the subsequent phase.
- / Out-of-pocket expenses will be billed at cost plus 10% for administrative charges. Invoices will be submitted for payment every two weeks. Terms of payment are net 30 days from the date of invoice. All delinquent accounts will be subject to a 1.5% per month interest charge (18% per annum). Accounts with delinquencies may be subject to project suspension or termination.
- / Sales tax is not included in the estimates above but is applicable to prototyping and other expenses.
- / Limitation of Liability. THE ONLY WARRANTIES APPLICABLE TO THE SERVICES TO BE PROVIDED BY FUNCTION ENGINEERING ARE SET FORTH IN THIS PROPOSAL. FUNCTION EXPRESSLY DISCLAIMS ANY OTHER WARRANTIES OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. FUNCTION'S LIABILITY ARISING OUT OF THIS PROPOSAL SHALL BE LIMITED TO THE COMPENSATION PAID TO FUNCTION PURSUANT TO THIS PROPOSAL, AND IN NO EVENT SHALL FUNCTION BE LIABLE IN ANY AMOUNT FOR ANY CONSEQUENTIAL, INCIDENTAL, INDIRECT OR SPECIAL DAMAGES, HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY.
- / The design and any patentable intellectual property that may result from the work described in this proposal will be assigned to MBARI or its designee upon payment for services rendered. However, (because we are engineers and not lawyers) Function will not be conducting patent searches or otherwise determining whether the work is covered by existing proprietary rights or is patentable.

Agreed to:

Monterey Bay Aquarium Research Institute

Signature

Name

Title

Date