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ESP Engineering Iterative Design & Prototyping Proposal

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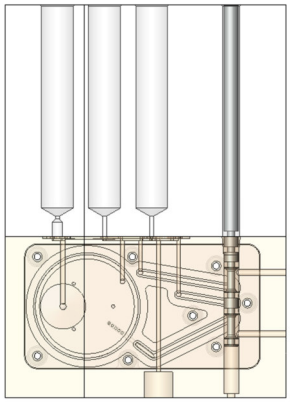
Rev 1.0

Project

The Monterey Bay Aquarium Research Institute (“MBARI”) has developed an Environmental Sample Processor (“ESP”) for collecting and preparing sea or fresh water samples for storage and analysis. The ESP holds 60 cartridges so it can process up to 60 samples without surfacing when used in an autonomous undersea vessel. MBARI previously engaged Function Engineering, Inc., (“Function”) for an engineering exploration and concept generation phase to explore concepts for improving the design of its reusable cartridges, ideally reducing cost, facilitating their use (e.g., ease of assembly, ease of cleaning), and improving the system’s function/robustness. MBARI has invited Function to submit a proposal for designing and developing prototypes so that the concepts that emerged in Phase 1 can be evaluated.



Early Concept CAD Illustration from Phase 1

Scope

Function will provide mechanical engineering services to design and develop (1)independent breadboard prototypes of individual features to test out concepts from Phase 1, followed by (2) an integrated prototype capable of being tested in a modified version of MBARI’s benchtop fixture. 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, and ESP 3 benchtop testing, as well as mechanical engineering beyond the cartridge scope outlined. Phase 2 of work will result in initial integrated prototypes of the cartridge. Function anticipates that further refinements will be required based on testing. Phase 3 will include those refinements and conclude with a pre-production model. Function would be happy to propose additional production support following this phase, if MBARI would like further support.

Function will support identification and selection 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, employees, or subcontractors, of Function. Function will coordinate with MBARI regarding the release of information needed for part fabrication.

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 2: Prototype Design & Development – Independent Breadboards & Integrated "Alpha"

Function will design physical breadboard prototypes for evaluation and testing.

Individual Breadboards of Key Features. The first step will be to design and prototype individual features of the cartridge based on concepts that emerged from Phase 1. These designs will be done as independent breadboard prototypes so that we can test the individual concepts before creating an integrated design. This proposal anticipates breadboarding features for evaluating areas such as:

- Puck port locations during tilt/roll
- Additional sealing/gaskets/o-rings
- Check valves
- Magnets

These quick and simple breadboards will include the minimum features required to mechanically demonstrate the selected concepts. Function will supplement the prototype design with engineering analysis, where appropriate.
Function will oversee the fabrication of breadboard parts based on rapid prototyping methods or machining. We will order off-the-shelf components, as needed, or components may be provided by MBARI. Because the focus of the breadboards is demonstrating mechanical concepts, we will prepare minimal prototype documentation for parts to be fabricated from 3D CAD files. After receiving the fabricated parts, Function will assemble and debug the breadboards. We will test and evaluate these initial independent breadboard prototypes at our lab(s) in Function's offices.

Integrated "Alpha" Prototype. With the information gained from the independent breadboards and MBARI's feedback, Function will design an integrated prototype of the cartridge. The prototype will be appropriate for testing in a modified version of MBARI's benchtop fixture. The Alpha prototypes will be based on interfaces to the system provided by MBARI and will be functional. Function will model parts with feature details in CAD; propose parts breakup, manufacturing processes, and materials; and perform engineering analyses for areas of concern. An interim check model will be fabricated (via rapid prototyping methods) as an early verification of the modeling.
The Alpha prototypes may lack mass production features that are not easily prototyped, as is appropriate to this phase of development.

Tasks

Independent Breadboard Prototype Design/Fab/Assembly/Debug/Test

- Material Selection and Verification
- Engineering Analysis
- Magnetic Simulation, if appropriate
- Breadboard CAD Layouts
- Breadboard Part Design
- Engineering Review with MBARI
- Breadboard Prototypes Release
- Breadboard Procurement
- Assembly and Debug
- Function In-House Testing
- Breadboard Review with MBARI

Integrated “Alpha” Prototype Design/Fab/Assembly/Debug/Test

- Specification Review
- Test Plan Creation
- Material Selection
- Engineering Analysis (FEA, tolerance, etc.)
- Alpha Layout
- Alpha Part Design
- Check Model Release and Fabrication (SLA, FDM, or other rapid process)
- Check Model Review
- Alpha Prototype Documentation (Parts List, BOM, CTF Part Drawings)
- Alpha Engineering Review
- Alpha Prototype Release and Fabrication
- Assembly and Debug (in-house at Function)
- Testing Support (at MBARI)
- Final Prototype Review with MBARI

Deliverables

- Individual Breadboard Prototype CAD Databases
- Breadboard Prototypes
- Breadboard Test Results & Findings Summary Report (as PDF from PPT)
- Integrated Prototype CAD Database & Documentation (Alpha)
- Alpha Prototypes
- Alpha Prototype Review
- Alpha Testing Support
- Weekly Communication Report
- End of Phase Report

Phase 3: Detailed Design: Beta Prototype & Production-Ready Database

Assuming Phase 2 results demonstrate/validate the design direction and MBARI elects to continue the program, Phase 3 involves detailing the design in two iterations: detailed "Beta" prototype design to a production-ready database.

Detailed "Beta" Design and Prototyping. Function will use the evaluation of the Alpha prototypes to refine the CAD database and documentation for fabrication of refined Beta prototypes. The Beta prototypes are intended to be close to the final product and will include final mass production features where possible. During this phase we will work closely with MBARI's manufacturing team to incorporate manufacturing recommendations.

Function will coordinate fabrication and support the assembly and debug of the Beta units. We will support the selection of prototype vendor and coordinate its services for the Beta build. We will provide basic testing and debug to ensure the prototypes reflect design intent, and we support the testing of the Beta units at MBARI. A number of the Beta units will be for testing purposes at MBARI.

Production Design & Tool Release. Assuming the Beta Units provide MBARI with confidence in the design direction to continue, Function will work closely with MBARI's selected manufacturing team to incorporate manufacturing recommendations. After evaluating the Beta units, we will make refinements to the CAD files and drawings for production tooling, update CTF drawings, and prepare the database for tooling release.

Tasks

Detailed Beta Design and Prototyping

- Design Refinement
- Detailed Beta Layout
- Detailed Beta Part Design
- DFM and Engineering Analysis
- Check Models Release and Fabrication (SLA, FDM, or other rapid process)
- Check Models Review
- Beta Documentation
  - Parts List and BOM
  - CTF Drawings
- Engineering Review
- Beta Prototype Release and Fabrication
- Beta Prototypes Assembly and Debug
- Design Intent Debug & Basic Testing
- Prototype Review with MBARI
- Support for MBARI Testing
- Preliminary Tool Quotation Release

Production Design and Tool Release

- Design Refinement
- Engineering Analysis (FEA, Tolerance Analyses)
- Updated 3D Database
- Updated 2D Documentation
- Manufacturing Review and Approval
- Production Documentation
  - Final Parts List and BOM
  - CTF Part Drawings
  - Component Specifications
- Tooling Release

Deliverables

- Beta CAD Database and Documentation, Check Model, Beta Test Plan
- Beta Units (Quantity TBD)
- Tooling Release Database and Documentation, Final Parts List

Estimated Budget and Schedule

Phase	Description	Est. Labor	Est. Expense	Duration	Notes
2	Prototype Design & Development				
	Independent Breadboard Prototype Design/Fab/Assy/Test	$60k	$9k	~3-4 wks	Total labor is estimated at 2 FTE x ~ 7 weeks labor
	Integrated Alpha Prototype Design/Fab/Assy/Test Support	$40k	$6k	~3-4 wks	
	Phase 2 Estimated Total	$100k	$15k	~ 7 wks	
3	Detailed Design & Production-Ready Database				
	Detailed Beta Design and Prototype	$65k	$9k	~3-4 wks	Total labor is estimated at 2 FTE x ~ 7 weeks labor
	Production Design and Tool Release	$35k	$1k	~3-4 wks	
	Phase 3 Estimated Total	$100k	$10k	~ 7 wks	
	Proposal Estimated Total	$200k	$25k	~14 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 Birch, James Digitally signed by Birch, James DN: cn=Birch, James, o, ou, email=jbirch@mbari.org, c=US Date: 2020.01.29 16:22:29 -08'00'

Name _____

Title Director, SURF Center

Date January 29, 2020