



Battery Pack Development Proposal

**Revision A0
12/27/2022**

Prepared for the Monterey Bay Aquarium Research Institute

1. Introduction

The Monterey Bay Aquarium Research Institute (“MBARI”) is a non-profit oceanographic research center focused on advancing marine science and engineering to understand the changing ocean. MBARI was founded by David Packard in 1987, on the core principle of science, engineering, and marine operations working together in equal partnership to develop innovative marine technology.

This proposal describes the effort required to design, develop, and test a custom high voltage battery pack, and to deliver this pack to MBARI for deployment as part of a Wave Energy Extraction Device. The Wave Energy Extraction Device will be used as the source of power to charge the batteries within this pack. Due to the nature of ocean waves being the power source, the electrical power produced is very pulsative with no constant value. Ultimately, the power generated by the waves will be used to supply energy to scientific instrumentation aboard the buoy, as well as charging an Autonomous Underwater Vehicle in the future.

2. Background

Stafl Systems has been developing and delivering Battery Management Systems, Power Electronics and Custom Batteries since its inception in 2010. Our technology is used in a variety of applications including electric aviation, electric cars, industrial mining equipment, marine vessels, and stationary energy storage.

Specifically, we have deep expertise with the following as it pertains to Lithium-Ion Batteries and Battery Management Systems (BMS):

- High energy density and power density lithium-ion cells
- Experience with all major BMS ICs on the market (TI, Linear Technology, Analog, Maxim, etc.)
- Various communication interfaces
 - CAN bus
 - RS485 / Modbus
 - RS232
 - Ethernet
 - Discrete contacts
- Extremely low power budgets (<50 μ A in sleep)
- Battery State of Charge (SOC) / State of Health (SOH) algorithms
- PCB design (schematic, layout) and prototyping
- Low voltage (<60 V) and high voltage (1000 V) systems
- Sophisticated cell performance and safety testing
- Battery system safety and fault protections
- Battery designs that prevent thermal runaway propagation
- Battery designs for rugged environments and applications

3. System Specifications

The MBARI battery pack is a 336 V DC battery used to store and provide the electrical energy required for scientific instrumentation aboard the buoy. Besides cells, the pack will include contactors, pre-charge relay/contactor and resistor, BMS, external interface harnessing, and other components necessary for a safe and functional power source. The BMS will be powered by an auxiliary 12/24V rail generated by a DC-DC converter that is not part of the battery pack.

Below is a summary of the battery pack specifications known at this time:

- Nominal voltage: 336 V
- Cell chemistry: Lithium Titanate
- Number of cells: 144
- Pack configuration: 144S1P
- Coulomb capacity: 35 Ah
- Energy: 12 kWh
- Maximum voltage: 393 V
- Minimum voltage: 336 V
- Maximum charge rate: 35 A
- Maximum discharge rate: 35 A continuous
- Communication interface: CANbus

Stafl Systems will design and build the core battery pack with a basic enclosure for voltage touch safety, but it will not be sealed against water or dust (IP20 rating). MBARI will design and build the exterior enclosure in a manner sufficient to protect the battery from the elements it will be exposed to.

4. Proposed Project Structure

A phased approach is proposed to support the development of the MBARI battery pack:

- 1. Phase 1 – Requirements Analysis, System-Level Design, and Cell Identification**
Generate requirements/specifications, identify candidate cells and high-level pack concept.
- 2. Phase 2 – Design, Test, and Pack Component Delivery**
Characterize the cells for BMS and models. Perform the detailed design work. Develop and test firmware for the specific application requirements. Build and test the generated design.

5. Scope of Work

The following tasks will be performed by Stafl Systems during this project:

Phase 1: Requirements Analysis, System-Level Design, and Cell Identification

1. Generate a requirements document for approval by MBARI
2. Identify candidate cells and perform initial tests
3. Define pack modeling approach
4. Define communication interface
5. Develop initial pack module CAD concept
6. Highlight any major design trade-offs

Phase 2: Design, Test, and Pack Component Delivery

1. Cell test and characterization
2. Module design, including voltage and temperature sensing strategy, communication harnesses
3. Module build
4. Current collector plate attachment design
5. PDU and busbar development, component placement, build and test
6. System-level connections and harnessing
7. Embedded software model development and implementation
8. BMS application development
9. Pack build
10. Pack-level test and verification of performance

The project scope does not include:

- Travel or on-site support
- Sealing enclosure design or build
- Installation into the buoy system
- Third-party certification or external lab testing

Additional scope may be added by mutual agreement between MBARI and Stafl Systems.

6. Deliverables

The following deliverables will be generated and provided to MBARI as part of this project:

Phase 1: Requirements Analysis, System-Level Design, and Cell Identification

- Requirements document for approval by MBARI
- Cell selection comparison and recommendation
- Estimated space claim based on cell selection recommendation and cell configuration

Phase 2: Design, Test, and Pack Component Delivery

- 3D Model (Step file) of battery pack design
- Drawings indicating module mounting points
- Manual describing the operation of the BMS within the pack
- CAN protocol and DBC file
- Report documenting the performance of the pack design as tested at Stafl Systems
- Modules, PCBAs, harnesses, busbars, contactors, pre-charge resistor, current sense element, for assembling a single pack (exclusive of mounting/securing hardware, external communication/power connectors)

7. Assumptions

The following assumptions are made regarding the project for the purposes of this proposal:

- The basic goals and requirements of the project have been accurately conveyed in the pack requirements specification and meetings to date.
- MBARI will provide the sealed enclosure of the battery pack that is appropriate for a seawater environment.
- MBARI has sufficient internal electrical engineering and software development capability to interface with and answer relevant technical questions.
- MBARI will make its equipment, facilities, and team available for necessary testing and integration of the delivered design where relevant.
- No certification testing, abuse testing, or formal standards testing of the pack will be done. Testing at external labs, if required, will be quoted separately.
- The cells chosen for the project can be electrically connected without laser welding, for example, by bolting interconnect to the cells.
- Durations assume cells for comparison and testing are readily available without long lead times or supply chain issues.
- Cells will be procured by Stafl Systems.
- No thermal management design is required for this battery pack.

If one or more of these assumptions prove out to be incorrect, or if MBARI chooses to modify the project while underway, there may be a budget and/or timeline impact. In that case, Stafl Systems will communicate any projected changes to MBARI in an Engineering Change Order (ECO). Placeholder then may accept the ECO or withdraw the change request.

8. Estimated Project Phase Duration

The following durations are estimated for each phase of the project:

- Phase 1:
 - Requirements Analysis and Concept Design: 4 weeks
- Phase 2:
 - Design, Test and Pack Delivery: 28 weeks

Although reasonable efforts will be made to ensure compliance with the proposed timeline, a development project like this may be impacted by several factors, which may affect the achievable timeline. Situations or factors that may have a timeline impact will be communicated to MBARI.

9. Project Budget

This project is quoted as a Fixed Bid for the described scope of work:

Project Budget	
Systems Engineering	\$ 25,000.00
Electrical Engineering	\$ 10,000.00
Mechanical Engineering	\$ 220,000.00
Software Engineering	\$ 80,000.00
Engineering Technician	\$ 10,000.00
Project Management	\$ 15,000.00
Materials	\$ 40,000.00
Testing	\$ 30,000.00
Total	\$ 430,000.00

Phase 1	\$ 43,000.00
Phase 2	\$ 387,000.00
Total	\$ 430,000.00

All amounts are in USD.

For project requests outside of the scope of this proposal, the time spent on the project will be billed at our Standard Hourly Rates, as shown in Appendix A.

Travel and other incidentals will be billed at cost + 10%.

9.1. Payment Terms

To start the project, please submit a Purchase Order (PO) for the Phase 1 amount (\$43,000) as a single line item.

To start this project, an initial payment of 50% of the Phase 1 effort, or \$21,500, is required.

Upon completion of the Phase 1 activity, an invoice for the remaining 50% of Phase 1 will be generated. To continue with Phase 2 activity, please submit a PO for the full Phase 2 amount (\$387,000). A deposit of 50% of this amount will be due at the beginning of Phase 2 (\$193,500).

Upon delivery of all Phase 2 deliverables as outlined in Section 6 above, the remaining 50% of the Phase 2 amount will be due (\$193,500).

10. Shipping

The customer will be responsible for all shipping charges of deliverables from the Stafl Systems facility to a location of their choice.

11. Changes to Scope

If MBARI would like to change a requirement of the project, add additional capability or features, or otherwise change scope, Stafl Systems will generate an Engineering Change Order (ECO) describing the requested change as well as the budgetary, timeline and performance impact of the requested change. MBARI may accept the ECO or withdraw the change request.

12. Cancellation

If MBARI wishes to cancel the project while it is underway, written notice must be given to Stafl Systems. An invoice for any unbilled work will be generated within 5 business days. The customer shall pay this final invoice within 15 days of receipt. Any deposit or pre-payment amounts will not be refunded.

13. Warranty

All material delivered to MBARI as part of this project will be supported with a Prototype Warranty, which covers workmanship defects for a period of 90 days after leaving the Stafl Systems facility. If the customer believes a unit is faulty within this period, please request an RMA from Stafl Systems, which will inspect the unit upon arrival to its facility. Stafl Systems will either repair or replace the defective unit. Shipping to Stafl Systems is paid for by the customer, and if the Warranty is determined to apply, Stafl Systems will pay for shipping back to the customer.

14. Intellectual Property

This project is quoted as a custom battery pack, meaning that Stafl Systems will exclusively make this battery pack available to MBARI upon full and timely payment. Stafl Systems may not provide, sell, or demonstrate this design to other customers without written permission of MBARI.

The BMS, battery module and pack design itself will leverage 12 years of Stafl Systems' BMS and battery reference designs, proprietary circuit elements and other intellectual property. As such ownership of the design and intellectual property itself resides with Stafl Systems.

15. Marketing Rights

Stafl Systems requests the right to associate itself with MBARI. This includes adding MBARI to our client list, linking MBARI marketing materials on our websites and social media platforms, and displaying images and videos of the MBARI products on the Stafl Systems website. Proposed new material that will be published that refers to MBARI or this project will be submitted to MBARI for approval prior to publication, which shall not be unreasonably withheld.



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16. Conclusion

The project proposed here will enable the development of battery pack for Monterey Bay Aquarium Research Institute's Wave Energy Extraction Device.

I look forward to the opportunity to work with MBARI to help build the next generation of energy storage to supply power for ocean research and exploration!

Sincerely,

A handwritten signature in black ink, appearing to read "Erik Stafl", is written over a light gray horizontal line.

Erik Stafl

President
Stafl Systems, LLC

17. Acceptance

This proposal is formally accepted by Monterey Bay Aquarium Research Institute:

By: _____

Name: _____

Title: _____

Date: _____

Appendix A – 2023 Hourly Rates

Our standard hourly rates for each resource are shown below:

Position	Rate
Principal Engineer	\$ 450.00
Sr. Staff Electrical Engineer	\$ 375.00
Sr. Staff Mechanical Engineer	\$ 375.00
Sr. Staff Software Engineer	\$ 375.00
Sr. Staff Systems Engineer	\$ 375.00
Sr. Staff Industrial Designer	\$ 375.00
Sr. Staff Engineering Technician	\$ 285.00
Staff Electrical Engineer	\$ 320.00
Staff Mechanical Engineer	\$ 320.00
Staff Software Engineer	\$ 320.00
Staff Systems Engineer	\$ 320.00
Staff Industrial Designer	\$ 320.00
Staff Engineering Technician	\$ 225.00
Senior Electrical Engineer	\$ 290.00
Senior Mechanical Engineer	\$ 290.00
Senior Software Engineer	\$ 290.00
Senior Systems Engineer	\$ 290.00
Senior Industrial Designer	\$ 290.00
Senior Supply Chain Specialist	\$ 290.00
Electrical Engineer	\$ 240.00
Mechanical Engineer	\$ 240.00
Software Engineer	\$ 240.00
Systems Engineer	\$ 240.00
Industrial Designer	\$ 240.00
Supply Chain Specialist	\$ 225.00
Test Engineer	\$ 225.00
Project Coordinator	\$ 190.00
Senior Engineering Technician	\$ 185.00
CNC Machinist	\$ 175.00
SMT Operator	\$ 175.00
Engineering Technician	\$ 165.00
Operations Technician	\$ 135.00

Utilization of Stafl Systems equipment will be billed at the following rates:

Equipment Name	Billable Rate
Motor Dynamometer	\$ 250.00
IPG 1000W Laser Welder	\$ 200.00
5-axis CNC	\$ 175.00
Vibration Test Cell	\$ 150.00
1000V 60kW Bidirectional Power Supply	\$ 100.00
32 cu.ft. Environmental Chamber	\$ 60.00
60V Pack Test System	\$ 50.00
Cell Test System	\$ 50.00
3D FDM Printer	Per Job
3D SLA Printer	Per Job
MJF 3D Printer	Per Job
4000W Laser Cutter	Per Job
SMT Assembly Equipment	Per Job

Allocation of space in the Stafl Systems facility will be billed at \$4.00 / sqft per month.