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Battery Pack Development Proposal

Revision A1
01/16/2025

Prepared for the Monterey Bay Aquarium Research Institute &
University of Washington Applied Physics Laboratory

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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 µA 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: TBD (LFP, NMC or LTO)
- 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 repurpose its BAT1411 pack as 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. The BAT1411 base specification can be found in Appendix B.

4. Proposed Project Structure

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

1. **Phase 1 – Requirements Analysis, System-Level Design, and Cell Identification**
   Generate requirements/specifications, preliminary system design and verification of BAT1411 use case.

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. Define communication interface
3. Specify required changes to BAT1411
4. Highlight any major design trade-offs

Phase 2: Design, Test, and Pack Component Delivery

1. PDU and busbar development, component placement, build and test
2. System-level connections and harnessing
3. Embedded software model development and implementation
4. BMS application development
5. Pack build
6. 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
- 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 shell design
- Drawings indicating module mounting points
- Manual describing the operation
- CAN protocol and DBC file
- 4 Completed packs with customized PDU

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.
- 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: 16 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. At the conclusion of Phase 1, the final schedule for Phase 2 will be determined.

9. Project Budget

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

Project Budget	
Systems Engineering	$73,000.00
Electrical Engineering	$26,000.00
Mechanical Engineering	$74,500.00
Software Engineering	$55,000.00
Project Management	$20,000.00
Materials	$189,000.00
Testing	$25,000.00
Total	**$462,500.00**

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 Schedule

Estimated Date	Milestone	Payment
2024-01-31	Downpayment / Project Scheduled	$200,000.00
2025-03-31	Project Kickoff	$0.00
2025-05-02	MS1: Requirements Approval	$50,000.00
2025-05-05	MS2: Phase 2 Kickoff	$50,000.00
2025-07-14	MS3: Pack Build Complete	$100,000.00
2025-08-25	MS4: Final Delivery to MBARI	$62,500.00
	Total	**$462,500.00**

9.2. Payment Terms

To start this project, please submit a Purchase Order (PO) for $462,500.00. Payment terms for each invoice are NET15, except for the downpayment invoice, which is due on receipt.

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,

Erik Stafl

President
Stafl Systems, LLC

17. Acceptance

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

By: _____

Name: _____

Title: _____

Date: _____

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Appendix A – 2025 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 Suppl	$ 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.

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Appendix B – BAT1411 Base Specification

BAT1411 11 kWh High Voltage Battery Pack

Description

The Stafl Systems BAT1411 is an 11 kWh battery pack built for versatility and ease of integration. Using Stafl Systems BMS technology, the pack provides safety and reliability, while maintaining the flexibility to use the pack as a standalone system or as a module in a larger assembly. Connection is possible in parallel or series (up to 2S) with up to 16 packs in a single array. This architecture provides a safe and convenient option for building larger systems while reducing integration effort.

The pack features a built-in power distribution unit, which eliminates the need for external contactors, fuses, pre-charge circuits and other components that are often needed in a high-voltage system. Liquid cooling allows for high charge and discharge rates. This, along with high-performance NMC cells with Silicon Anode technology, enables greater performance without compromising cycle life.

The BAT1411 battery pack is Stafl Fleet ready. This optional system quickly connects with Stafl Fleet, providing real-time data about the battery pack anywhere in the world, with the ability to monitor performance and quickly identify and address issues to reduce system downtime.

Features

- 11.6 kWh Lithium-Ion Battery Pack
- 365 V Nominal Voltage
- 89 kg Pack Mass
- 131 Wh/kg
- Integrated Stafl Systems BMS Technology
  - State of Charge (SOC)
  - State of Health (SOH)
  - Safe Operating Envelope (SOE)
  - Cell Temperatures / Voltages
  - CAN Bus Communication
  - Pre-charge Circuit
  - Sophisticated Fault Management System
  - Advanced Fault Monitoring
  - Low Quiescent Current
- LED Indicators
- Connection in Parallel or Series (up to 2S)
  - Up to 16 Packs per Array
- Liquid Cooling
- Built-In Power Distribution Unit
  - Eliminates need for external contactors, fuses, pre-charge circuits and other necessary components
- IP67 Enclosure
- Stafl Fleet Ready
  - Enables telematics and monitoring
- Made in USA

Applications

- Marine
- Aviation
- Off-Highway

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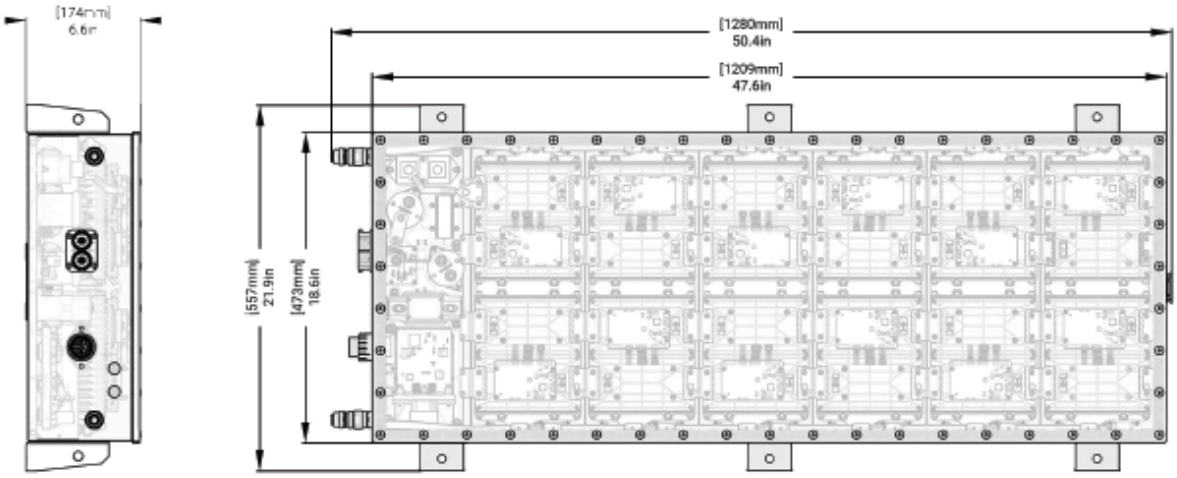
Mechanical Drawing



Specifications

Parameter	*Conditions*	*Min*	*Typical*	*Max*	*Units*
General					
Cell Chemistry			Lithium Ion NMC w/ Silicon Anode		
Pack Energy	32 A Discharge (1C Rate) / 23 °C		11.6		kWh
Pack Voltage		288	365	418	V
Pack Capacity	32 A Discharge (1C Rate) / 23 °C		32		Ah
Power					
Continuous Charge Power				23.2	kW
Continuous Discharge Power				58.0	kW
Peak Charge Power	10 seconds / 23 °C			58.0	kW
Peak Discharge Power	10 seconds / 23 °C			116.0	kW
Mechanical and Environmental					
Pack Mass			89		kg
Gravimetric Power Density			1200		W/kg
Gravimetric Energy Density	1C Rate / 23 °C		131		Wh/kg
Operating Temperature	Charge	10		45	°C
	Discharge	-20		60	°C
Other					
System Isolation Voltage Rating	HV (Battery) to Accessory	1000			V
Accessory Power Input		9	12 / 24	32	V
Accessory Power Current	Depends on State	20		500	mA