Boat #4

UD SOLAR SPLASH TECHNICAL REPORT 2025

April 28, 2025

Faculty Advisors: David Perkins, Rydge Mulford

Members: Kaitlin Niebauer, Michael Wolf, Ellie Opalek, Brian Piper, Sydney Guerin, Jack Mueller, Cory Howley, Jack Erick, Nick Yeoman, Lucas Cosentino, Courtney Provost, Erin Fox, Rachel Guinee, Brennan Geiger, Molly Eure, Elliot Stasek, Lucy Westbrook, Brock Smith

2024 University of Dayton Solar Splash Technical Report

I. Executive Summary

UDSS placed 6th overall in the 2024 Solar Splash competition, with the main performance weakness being the boat's low maximum speed as a result of the design's small propeller. In addition, the team faced issues during the competition with unwanted motor shutoff, insecure charge controller wiring connections, and the propeller becoming disengaged from the shaft.. Based on these results, designing a custom outboard and propeller, improving steering design and driver positioning, repairing damage to the boat, and improving electronics system diagnostic capabilities were identified as main priorities for improvement.

The 2024 design achieved a maximum speed of 5.8 mph, significantly below the top performing sprint speed achieved by the University of Puerto Rico at Mayaguez, 24.9 mph (Appendix F). Therefore, designing an outboard and propeller capable of achieving speeds necessary to win the competition was the primary design focus. The outboard was designed to withstand the force generated by the propeller at 12 m/s with a 1:1 gear ratio at the bevel gears. The team investigated the use of a toroidal propeller to increase efficiency and thrust in the competition.

The 2024 design included a tiller-based steering system, with the driver positioned in the starboard aft deck corner. The driver's legs were positioned in the bilge beneath solar panels mounted 19 inches above the deck. This position made slalom steering difficult, driving for long periods uncomfortable, and egress difficult (though within Solar Splash regulations of five seconds). Therefore, the 2025 design moved the driver's position towards the bow, with steering controlled by a cable-based system. The team also focused on repairing water damage to the flotation foam and plywood of the hull, achieving a higher build quality and decreasing overall weight. This entailed removing all of the foam from the hull and replacing only the necessary foam.Multiple solar charge controllers, unevenly distributed among panels, potentially causing charging and discharging imbalances. These charge controllers were replaced with a single Victron Energy MPPT 150/35 charge controller that is capable of charging the system at 36 volts, and offering more advanced data monitoring capabilities. In addition, the team addressed unintended motor shutoff encountered during the 2024 competition by adjusting the peak motor speed within motor controller tuning. The team made no changes to battery and coolant system designs.

On-water testing will be conducted at Eastwood Metropark in Dayton, Ohio to determine hull drag, motor power consumption, and optimum propeller dimensions. The design improvements are expected to significantly improve competition performance in the 2025 Solar Splash competition.

II. Table of Contents

III. Overall Project Objectives

The University of Dayton Solar Splash team's goals for the 2024-2025 academic year are detailed in ***Table 1***.

Table 1: UDSS 2025 project objectives

System	Goal
Solar	Redesign the solar panel setup to be more space-efficient.
Electrical	Organize electronics wiring to be more space efficient on the hull.
Power Electronics	Address unwanted motor controller automatic shutoff by tuning motor controller software.
Hull Design	Repair water damage to hull wood to maintain structural integrity.
	Remove excess floatation foam to decrease hull weight.
	Reposition the driver's seat from the starboard aft to be amidships towards the bow, in conjunction with the redesigned steering system to create a more ergonomic driving experience.
Drivetrain & Steering	Design and build a new outboard to replace the previously used Johnson Marine 4R76M outboard.
	Design and build a steering joint and steering cables to replace tiller-based steering.
	Replace coolant system motor with one of lower power that meets the required performance specifications, while conserving power and space.
Data Acquisition and Communications	Implement a diagnostics system to monitor the motor, motor controller, solar panels, and battery performance characteristics.

IV. Solar System Design

A. Solar Panels

1) **Current Design**: The 2023-2024 solar system design was composed of 5 panels in a 720W system (***Table 2***), secured to the boat using aluminum frames. All solar panels except the Renogy RNG-100D-SS (A) were donated to the team by a university research lab. These panels have a low power density, and took up the majority of the available deck space (***Figure 1***). As a result, panels were mounted on hinging aluminum frames to allow access to the electronics below. The panels left very little room for the driver, making boarding and egress difficult.

Table 2: UDSS 2024 and 2025 solar panel characteristics

	2024				2025
Specification	**Renogy RNG-100D-SS**	**Renogy RNG-100D**	**QSolar QSF**	**SANYO HIP-200BA3**	**Panasonic EVPV360PK**
Qty	1	1	2	1	2
Dimensions (in)	20.75 x 41.75	21.25 x 47	32.75 x 52.25	34.25 x 52	69.1 x 40.94
Pmax (W)	100	100	160	200	360
Weight (lb)	14.3	21.0	30.9	30.9	43.0
Efficiency (%)	21	15.47	16.96	16.96	19.72
Vmp (V)	17.9	18.9	55.8	55.8	33.9
Imp (A)	5.72	5.29	3.59	3.59	10.62
Voc (V)	21.6	22.5	68.7	68.7	40.6
Isc (A)	6.24	5.75	3.83	3.83	11.26
Weight/Area (lb/in^2)	0.0165	0.0210	0.0180	0.0180	0.0302
Watts/Area (W/in^2)	0.115	0.100	0.094	0.094	0.202

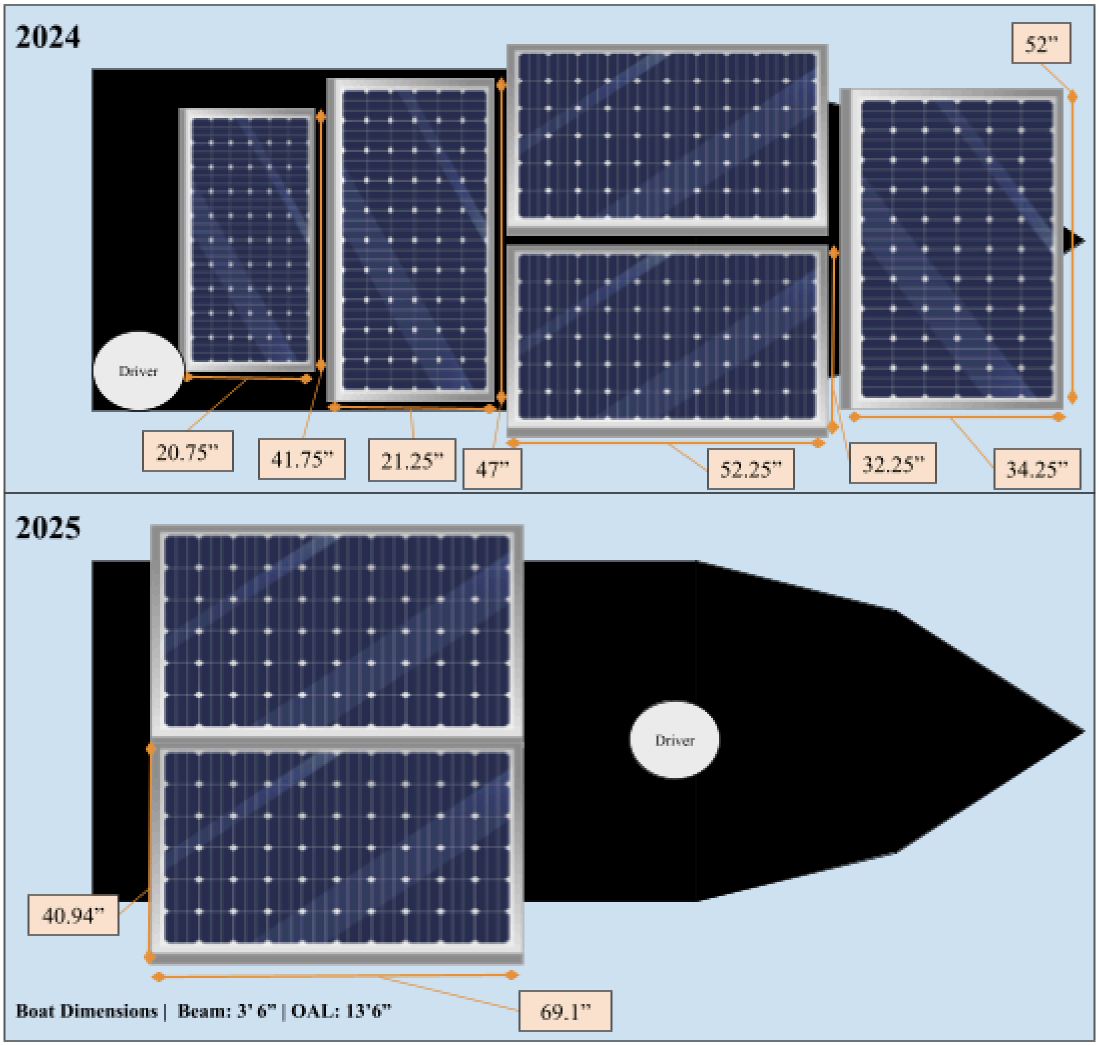


Figure 1: Solar panel layout for the 2024 and 2025 UDSS boat

2) **Analysis of Design Concepts**: The solar panel setup was redesigned by University of Dayton students for MEE-461 (See Appendix G). The design was projected to cost $961.16 for solar panels, framing, and wiring. The design implementation cost 794.13. Two Panasonic EVPV 360W solar panels are wired in series, and are positioned behind the driver (***Figure 1***).
3) ***Design Testing and Evaluation:*** The team performed functionality testing on the Panasonic EVPV 360W panels by measuring voltage in direct sunlight. During future on-water testing, energy generated by solar panels in varying sunlight conditions will be measured, and compared to product specifications (***Figure 2***).

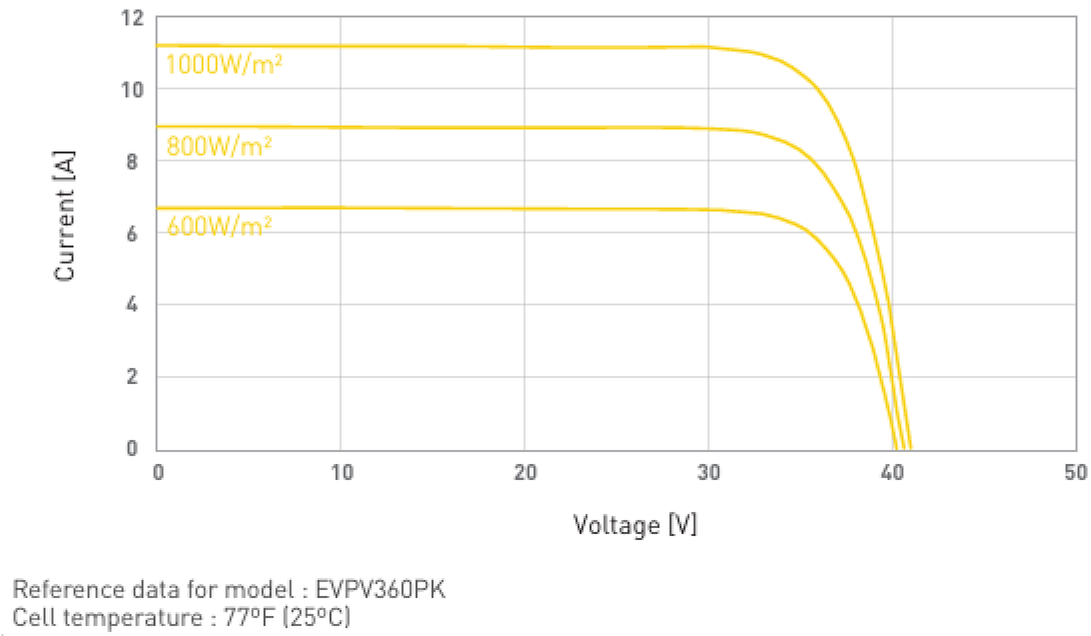


Figure 2: Panasonic EVPV 360W voltage and current dependency on irradiance [1]

B. Battery Bank

1) ***Current Design:*** The propulsion battery bank is composed of three UPS Battery Center TLV12500F11 12V 50 Ah batteries. The supplementary battery system is 12V Mighty Max Battery ML18-12 battery. Battery placement and wiring is shown in ***Figure 3***. In future years, the team may investigate battery systems with a higher discharge rate and capacity to avoid lags in the battery power output and greater endurance, but no design changes were made to the system based on prior success. Battery system data sheets are shown in Appendix A.
2) ***Analysis of Design Concepts:*** N/A
3) ***Design Testing and Evaluation:*** N/A

V. Electrical System

A. *Electrical System Block Diagram*

1) ***Current Design:*** The detailed circuit diagram for the team's boat is shown in ***Figure 3.*** The craft's main battery bank powers the propulsion, control, and coolant systems. A secondary circuit with a separate battery powers the onboard bilge pump. Five onboard solar panels with a total output of 720W offer charging capabilities to extend overall runtime in sunny conditions.

   Four SunSaver MPPT-15L charge controllers are used to convert the AC power generated by the panels to DC power for charging the main battery bank. While the design has many strengths, the four charge controllers used are unevenly distributed among the three propulsion system batteries, and 5 solar panels, which may negatively affect charging rate distribution.

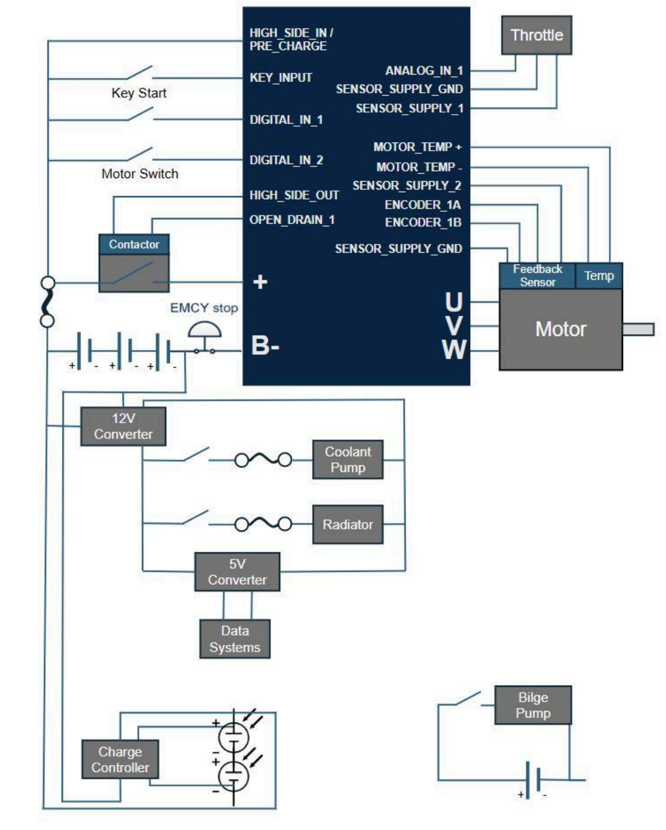


Figure 3: Electronics diagram

2) ***Analysis of Design Concepts**:* The prior design's charge controllers are replaced with a single SmartSolar MPPT 150I35 charge controller (***Table 3***). The single charge controller will prevent present and future issues with balancing distribution between batteries and panels, even if future teams modify the amount further. Consolidation of the charge controllers into one will also simplify troubleshooting any future charge controller errors. The updated charge controller also provides battery voltage, panel wattage flexibility, and built-in data acquisition capabilities (addressed in [IX. Data Acquisition and Communications]()).

Table 3: SmartSolar MPPT 150/35 and SunSaver MPPT-15L technical specifications [2], [3]

Competition Year		**2024**	**2025**
Charge Controller		**SunSaver MPPT-15L**	**SmartSolar MPPT 150/35**
Maximum Output Current		15 A	35 A
Cost		~$300	$184.45
Nominal Battery Voltage		12, 24 V	12, 24, 36, 48 V
Nominal PV Power	**12**	260 W	500 W
	24	520 W	1000 W
	36	N/A	1500 W
	48	N/A	2000 W
$I_{max, sc}$		Not Listed	40 A
$V_{PV, max, oc}$		60 V	150 V
Peak Efficiency		97.5 %	98 %
Data Communication		Modbus and SNMP over EMC Protocol	VE.Direct and Bluetooth via VictronConnect App
Dimensions		16.9 x 6.4 x 7.3 cm	130 x 186 x 70 mm
Weight		0.6kg	1.3kg

3) **Design Testing and Evaluation**: N/A

VI. Power Electronics System

1) ***Current Design:*** The craft uses an Inmotion Technologies ACS GEN7 motor controller [4] and a DHX P20 brushless motor [5] for propulsion (***Figure 4***). The motor controller translates throttle commands from the skipper, and monitors an extensive list of motor parameters, including speed and temperature. The 2024 system did not display any diagnostic feedback to the skipper, however, any error codes were saved onboard the controller for post-run analysis. After implementation of the propulsion circuitry, the motor controller was tuned to ensure precise control of the motor's speed, position, and direction, in collaboration with an Inmotion Technologies representative. Despite tuning efforts, the team encountered persistent, unwanted motor controller auto shutoff in testing, and were not able to address the source prior to the 2024 competition.

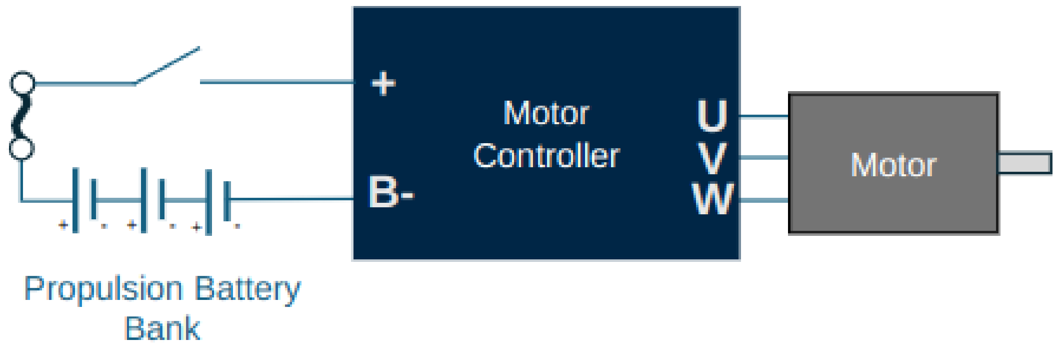


Figure 4: Motor and motor controller design

2) ***Analysis of Design Concepts:*** The team worked with InMotion representatives to recreate motor shutoff error. From the error recreation, the peak motor speed was raised from 4500 RPM to 6500 RPM.
3) ***Design Testing and Evaluation:*** The team validated the effectiveness of the motor controller changes during testing.

VII. Hull Design

1) ***Current Design:*** Flats River Skiff 14 (FRS-14) “stitch and glue” build plans [6], sponsored by Salt Boatworks (***Figure 5***), were used to construct a hull that minimized drag through planing, could achieve a top speed of over 25 MPH, and had a wide beam that would allow for effective cornering during the slalom event. Construction of the hull began in Spring 2024, and concluded in Fall 2024. A mixture of 2-pound and 5-pound density foam was used due to material availability. After completing the original build, the team opened up several of the bulkheads for driver seating, battery storage, and bilge seating. In addition, framing was added on the flooring to attach panel standoffs, charger controllers, driver seat, motor control unit, and control panel.

While the hull was functional in the 2024 competition, the design had several drawbacks. Lack of team experience in stitch and glue build and composite manufacturing lead to uneven and nonsymmetric surfaces on the hull. In addition, the boat contained more foam than was required to prevent the boat from taking on water, and was extremely heavy. Both of these were predicted to negatively impact speed and efficiency. Finally, improper epoxy sealing techniques allowed water damage to the plywood to occur.

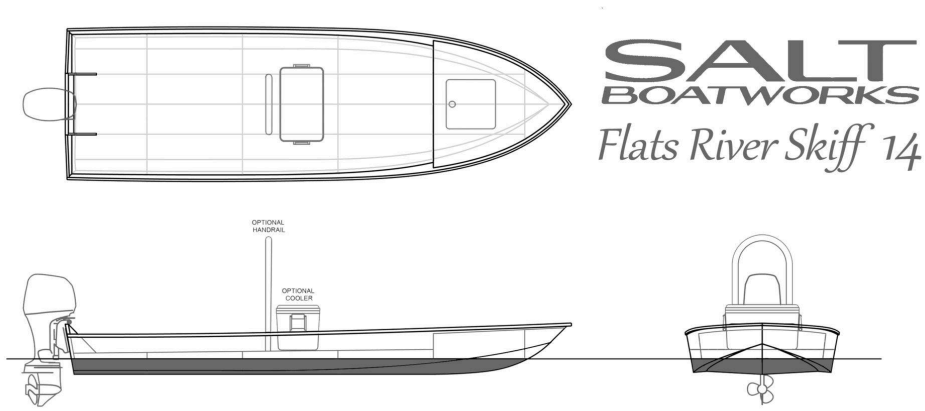


Figure 5: Salt Boatworks FRS-14 overall layout, shown on the Salt Boatwork website [7]

2) ***Analysis of Design Concepts:*** In order to address excess foam and water damage concerns, all foam was removed from the boat, and 2 lb density expanding polyurethane foam repoured in all bulkheads except in two central exterior compartments (***Figure 6***). Foam-containing bulkheads were chosen based on required mass of foam (see Appendix B) and required deck sturdiness based on mass distribution. Water-damaged wood was removed, and reinforced with new wood, then fiber glassed and epoxied. A new plywood deck was installed , fiberglassed, and sanded. In addition, driver placement was moved towards the boat bow to allow for more even weight distribution. The team kept the two wells used in the 2024 competition, but switched which ones were being used for battery storage and as a foot well for the 2025 competition (***Figure 6***).

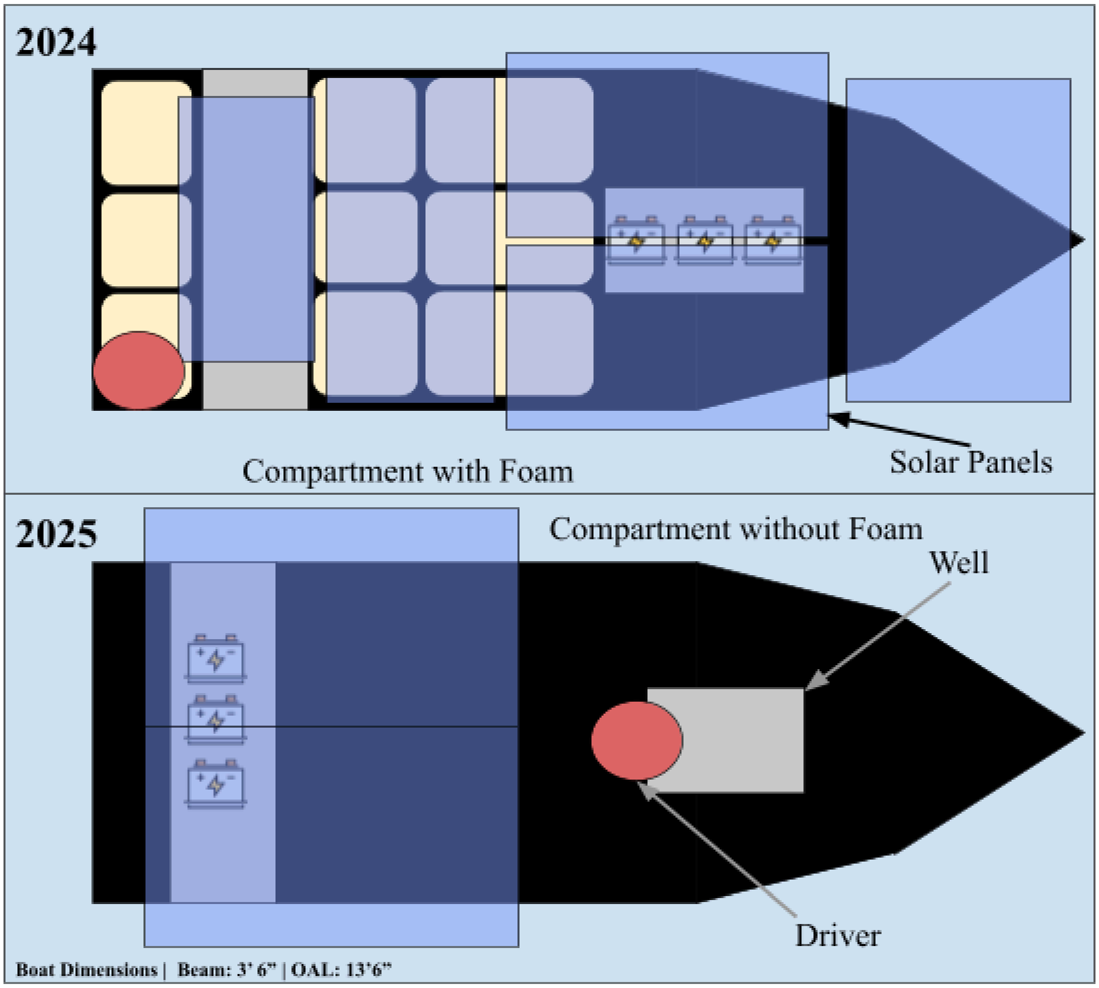


Figure 6: Hull foam and deck 2024 and 2025 designs

3) ***Design Testing and Evaluation:*** Hull modifications removed an estimated 50 lbs from the hull, allowing for decreased drag and greater ease of transportation. Hull drag and weight calculations may be found in Appendix B. Flotation Calculations. During on-water testing, drag will be experimentally determined using methods outlined in section D. Propeller.

VIII. Drivetrain and Steering

A. Drivetrain

1) ***Current Design:*** The 2024 drive train was created from an adapted Johnson Marine 4R76M. This outboard motor from 1976 originally came with a two-piston, two-stroke internal combustion engine that was rated for 4 horsepower. The team removed all combustion engine parts from the outboard, to allow for the integration of a *DHX* Peregrine P20 Motor (***Table 4***). This motor can provide a peak output of 25 horsepower and 30 ft*lb of torque, and is controlled with an *inmotion* ACS48M55 Gen 7. The P20's nominal RPM of 4400 matches the wide-open throttle range of the original Johnson outboard engine. The outboard had a 25:12 gear ratio into the propeller, giving an output speed of 2200 RPM [8], [9].

Table 4: Peregrine P20 motor characteristics

Speed (RPM)	Nominal	4400
	Peak	6500
Torque (N-m)	Nominal	25
	Peak	40
Power (kW)	Nominal	11.5
	Peak	18.4
Current (A)	Nominal	250
	Peak	425
Efficiency	Peak	95

2) ***Analysis of Design Concepts:*** The custom-designed outboard (***Figure 7, Table 5***) was CNC manufactured by the team. The team machined the shaft down to a stock size for the spline, but did not have the capabilities to match the spline to the kit we purchased, so the shaft was sent to Dayton Gear to cut the spline and complete the prop shaft.

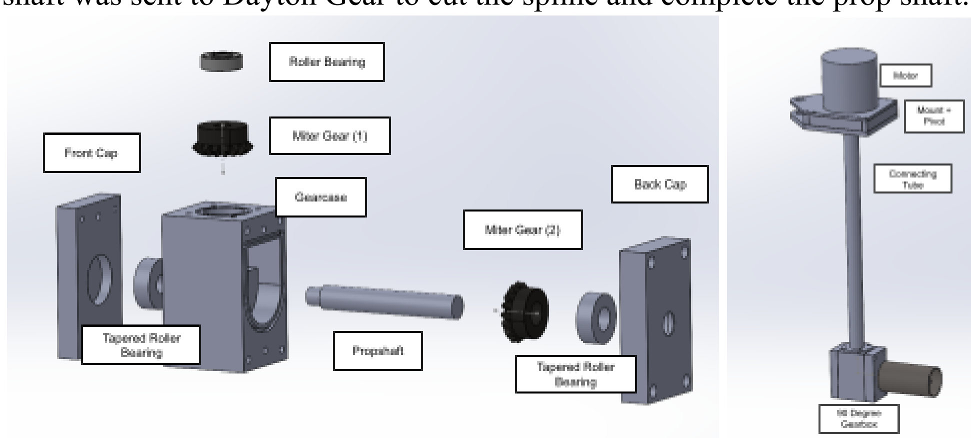


Figure 7: Custom outboard design CAD

The aluminum gearbox contains 2 KHK-SM3-16 gears and was machined in two sections connected by screws and locating pins (***Figure** 7*). The O-ring and oil seal in the gearbox ensure it is water tight. The prop plate holds the oil seal and back bearing, while the back plate holds the other bearing that transmits the thrust from the prop to the rest of the boat. The outboard design is modular, which will allow for future design modifications as needed. The 1:1 gear ratio under the water makes designing change gears outside of the water significantly easier should the team decide that is necessary in future years.

Table 5: 2024 and 2025 Outboard Characteristics

	2024	**2025**
	Johnson Marine 4R76M	**UDSS Designed Outboard**
Material	Steel	CNC Aluminum
Gear Ratio	25:12	1:1
Maximum Rotational Speed	3120	6500
Modularity	Limited to standard service disassembly	Fully modular to allow for partial development in future years

3) ***Design Testing and Evaluation:*** N/A

B. Coolant System

1) ***Current Design:*** In this design, shown in ***Figure 8***, coolant is transferred from the reservoir into the pump, then pushed through the motor, radiator, and then finally back into the reservoir. This system runs the electric pump and radiator concurrently off of one switch. The design of this system was heavily influenced by the suggestions of DHX representatives, who recommended a JEGS 555-60346 transmission cooler, and a coolant flow rate between 15.5 and 26 L/min. The recommended JEGS transmission cooler assembly was selected for the radiator and fan cooler. The Wasserman 4WDP5-55-12V pump has a flow rate of 18.9 L/min and is designed to be used in RVs and other systems with limited power.

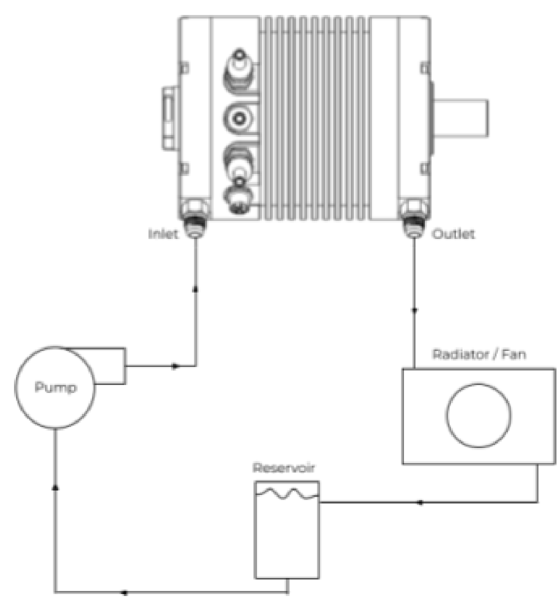


Figure 8: Coolant System layout

2) ***Analysis of Design Concepts:*** N/A
3) ***Design Testing and Evaluation:*** N/A

C. Steering

1) ***Current Design:*** The 2024 steering system used the integrated tiller from the outboard's original setup. The tiller was modified to stand at a slightly higher angle to avoid the radiator. Due to time constraints and concerns about commonly encountered failures in cable-controlled systems, the team did not pursue a more technical steering system for the 2024 competition.

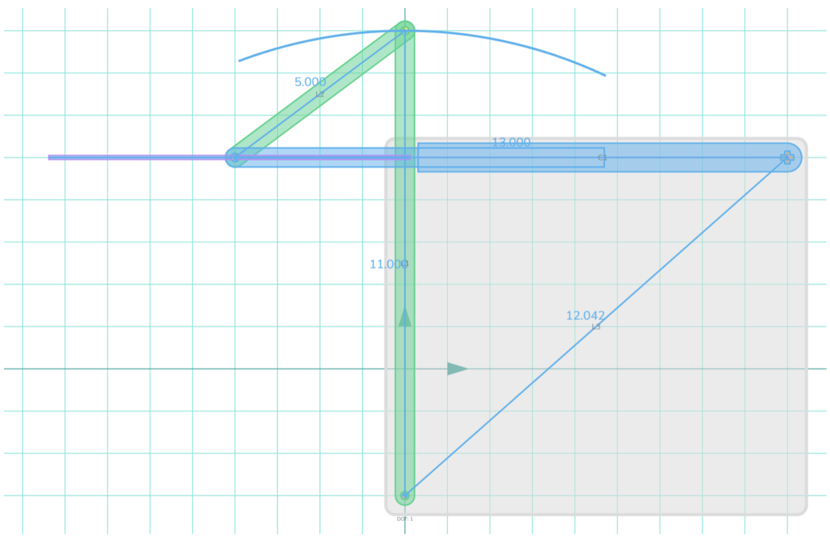


Figure 9: Cable-based steering system dimensions

2) ***Analysis of Design Concepts:*** With the driver's position being moved towards the bow by the hull team (see [VII. Hull Design](#)), the team implemented a new cable-based steering system. Using a steering wheel for the control point, the VEVOR Boat Steering System was used to translate steering wheel motion into outboard movement. The cable steering system uses a cog to push/pull the cable, allowing the outboard 35 degrees of rotation from center in either direction (***Figure 9***).
3) ***Design Testing and Evaluation:*** N/A

D. Propeller

1) ***Current Design:*** The team used the original 7.5x6LH propeller from the converted Johnson 4R76M outboard. The propeller was undersized for the converted drivetrain motor and was operated at high rotational speed, leading to low propeller efficiency and suboptimal thrust generated.

2) ***Analysis of Design Concepts:*** The new design features a new toroidal propeller, designed and tested by the team, as well as commercially available propellers from *Turning Point* (***Table 6***). The selection of *Turning Point* for the propellers allows the team to reuse the same propellers with multiple different hubs and their associated drive splines, using the *MasterGuard* #11 hub kit, which will provide dependable driving of the propeller up to 75 horsepower (***Figure 10***).

Figure 10: Turning point MasterGuard #11 hub kit

These hubs allow us to easily attach the in-house designed toroidal propellers, which are able to achieve greater efficiency and thrust while lowering cavitation compared to conventional propellers [10]. The characterization of toroidal propellers requires the use of additional dimensions, described in ***Figure 11***, including vertical angle (α) and lateral angle (φ).

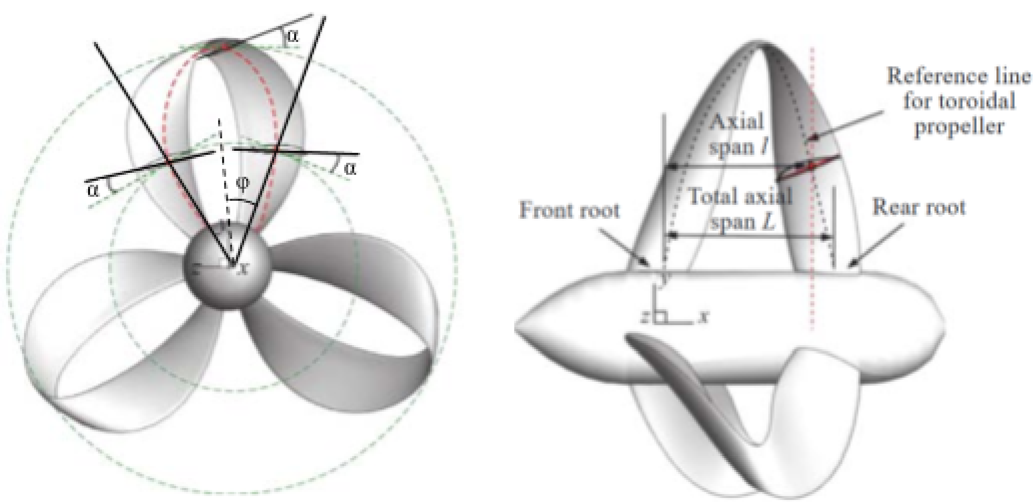


Figure 11: Common dimensions used in toroidal propeller design, modified from [10]

Python code was used to generate 3D points for desired propellers, using equations from [10].

Table 6: Commercial and designed propeller characteristics

Propeller	Hustler 2130 1110	Hustler 2130 1510	Sprint Toroidal Propeller	Endurance Toroidal Propeller
Diameter	10.875 in	10.13 in	TBD	TBD
Pitch	11 in	15 in	55 deg	48.5 deg
Hub Diameter	3.25 in	3.25 in	55 mm	55 mm
Axial Span (L)	2.75 in	3.35 in	0.33D	0.13D

Commercial propeller analysis will be performed using Matlab OpenProp [11] to determine power number, thrust number, and efficiency of commercial propellers for use in on-water testing.

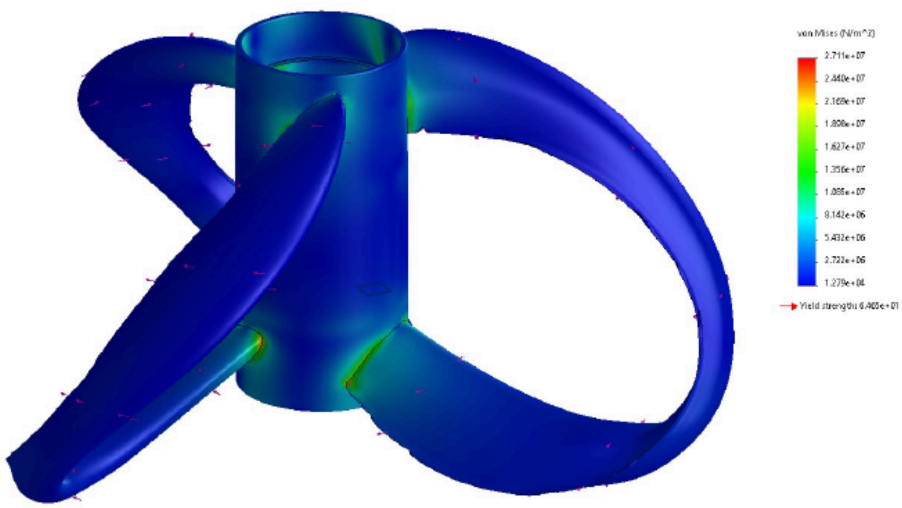


Figure 12: FEA static torque analysis stress results for 10" diameter sprint propeller

SolidWorks finite element analysis (FEA) was used to evaluate the suitability of ABS and PETG for toroidal propeller 3D printing at 40 N-m of applied torque (***Figure 12***). FEA results consistently predicted propeller permanent deformation under maximum torque loading. Due to the variability in material properties of FDM printing [12] propeller strength will be validated using destructive torque tests.

3) ***Design Testing and Evaluation:*** Propellers will be verified to withstand torque up to 40 N-m (peak motor torque) within the elastic deformation region, to ensure they do not break or deform during use (***Figure 13***).

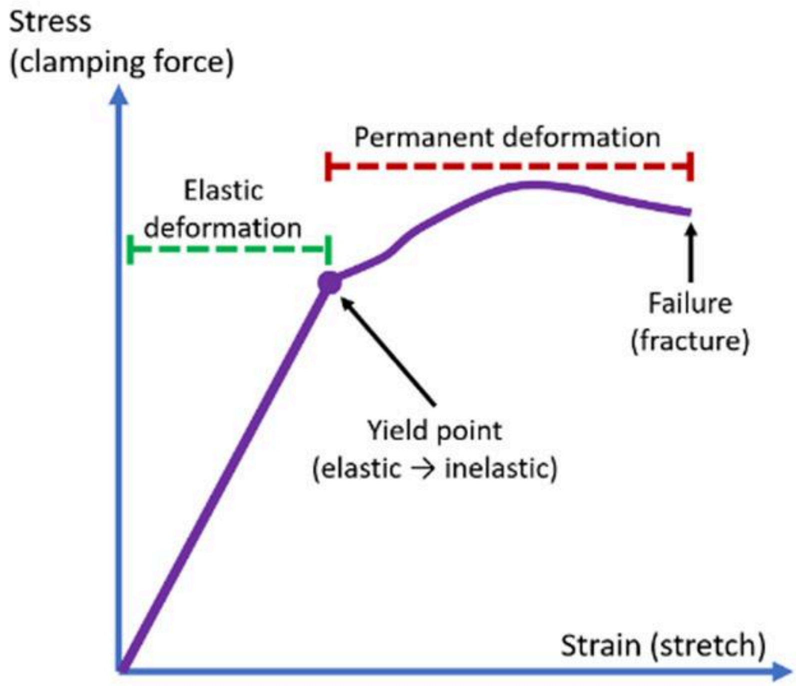


Figure 13: Labelled example of torque-to-failure destructive test results to be performed on 3D printed toroidal propellers [13].

Propeller performance will be quantified through power number (N_P), torque number (N_Q), thrust number (N_τ), and efficiency (η) (***Table** 7*). Propeller torque (Q), power delivered (P), and motor rotational speed (n) are measured directly by the motor controller (Appendix H) and reported through the data acquisition system (IX. Data Acquisition), allowing for direct calculation of N_P, N_Q, and J.

Table 7: Propeller performance characteristics

Parameter	Equation	Description
Power Number	$N_p = \frac{P}{n^3 D_i^5 \rho}$	Ratio of power produced to fluid density, impeller speed and size.
Torque Number	$N_Q = \frac{Q}{n^2 D_i^4 \rho}$	Ratio of torque produced to fluid density, impeller speed and size.
Thrust Number	$N_\tau = \frac{\tau}{n^2 D_i^4 \rho}$	Ratio of thrust produced to fluid density, impeller speed and size.
Efficiency (%)	$\eta = \frac{N_T\, J}{2\,\pi\, N_T}$	Ratio of thrust horsepower to delivered horsepower.
Advance Coefficient	$J = \frac{v}{n\, D_i}$	Distance a propeller travels over the distance the propeller rotates.

Propeller thrust generated is not captured in the data acquisition system, and will therefore be calculated for toroidal propellers using hull drag. At constant speed, the thrust delivered by the propeller is equal to the form and friction resistance of the hull:

$$T = N_{\tau} n^2 D_a^2 \rho = \frac{1}{2} \rho v^2 A C_d$$

Thrust coefficients for commercial marine propellers will be estimated using Matlab OpenProp, and will be used to determine the drag coefficient (C_d) at varying speeds. Toroidal propeller N_{τ} will be calculated by operating the hull at the same range of speeds, and using the previously determined C_d to calculate N_{τ}.

IX. Data Acquisition and Communications

Motor parameters (Appendix H) are monitored through the ACS GEN7 motor controller, and passed to Raspberry Pi 1, running Raspberry Pi OS. Battery and solar array qualities are monitored (Appendix H) through the Victron Smart Solar charge controller, and data passed to Raspberry Pi 2, running Venus OS. Both Raspberry Pi's are powered by the primary propulsion system batteries, and communicate with UDSS members on shore through a Remuar Wifi HaLow ethernet bridge, which broadcasts a WiFi signal to a bridge and router onshore (***Figure 14***).

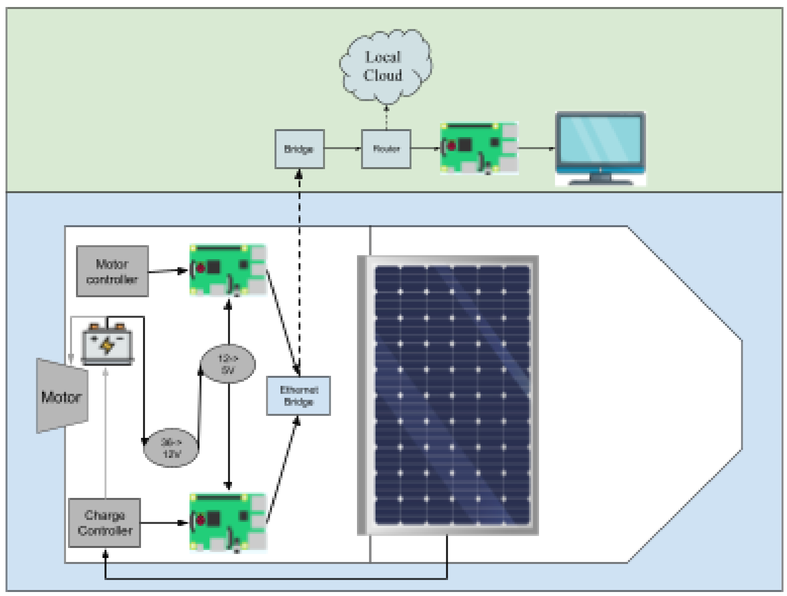


Figure 14: UDSS data acquisition systems

Data processing is performed on Raspberry Pi 3, and displayed to a primary monitor onshore, though any UDSS member connected to the WiFi may view the data in the local cloud. The skipper and UDSS data monitoring team communicate through Cobra 50WXST radios as needed.

X. Project Management

UDSS is divided into hull, motor, electronics, and business subteams, with an associated student lead (see Appendix D. Team Roster) facilitating subteam meetings and delegating action items. The team president oversees all subteams, communicates with Solar Splash and the university, and facilitates full-team meetings. The treasurer leads budgeting, coordinates all purchases, and applies for university funding. The team holds biweekly full-team and weekly subteam meetings.

Fund availability has historically been a large hurdle faced by the team. The team has had limited success with monetary sponsorships from companies, but consistently receives funding targeted towards student clubs from University of Dayton organizations. The team received funding from the Student-Innovative-Creative-Hands-on Project (SICHOP) grant, offered by the Ohio Space Grant Consortium (OSGC). The team's largest source of funding is the UD School of Engineering (SoE) fund match program for eligible donations to engineering competition clubs (***Figure 15***). UDSS received fund matching from the SICHOP grant, Kokosing Sponsorship, and funding from the 2023-2024 school year. For the 2024-2025 school year, the team's had $13,533.57 in rollover funding and sponsorships.

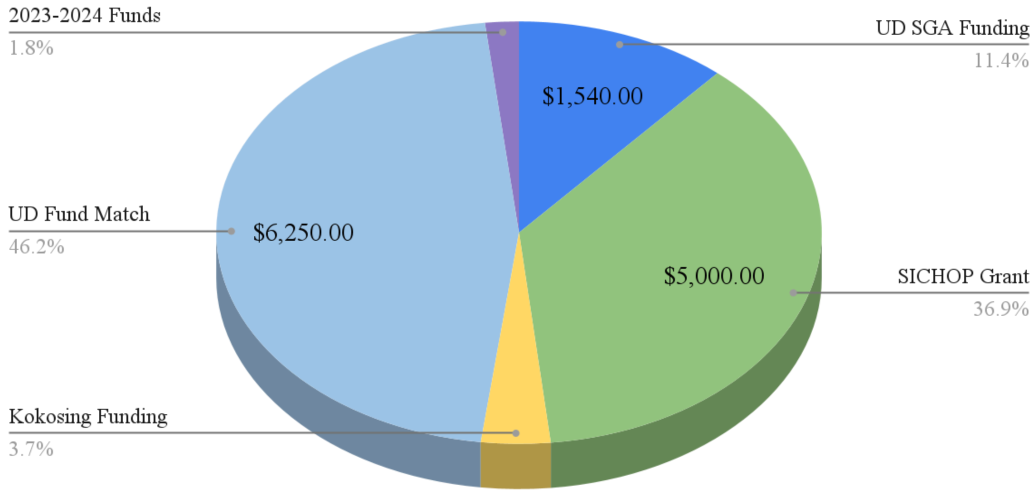


Figure 15: 2024-2025 academic year fundraising amounts and sources

The team anticipated a budget of $7,748.15 for the 2024-2025 school year, and were remarkably close, at an actual total of $7,458.03, despite overspending in the hull and data acquisition categories, and underspending in the drivetrain & steering (***Figure 16***).

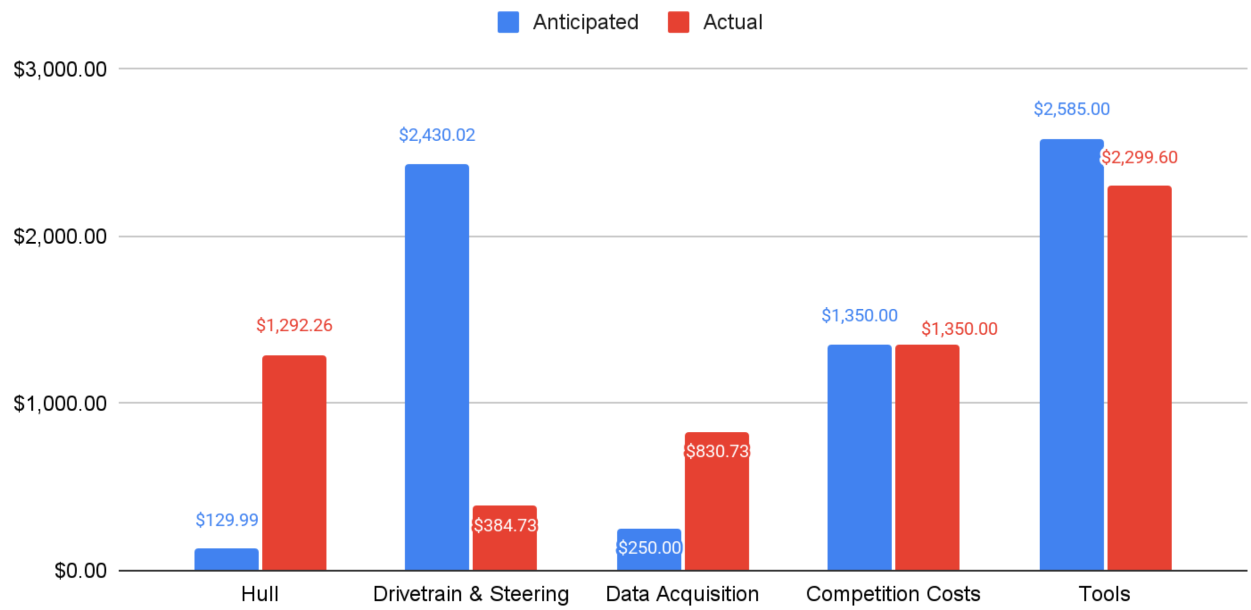


Figure 16: Predicted and actual budget for the 2024-2025 academic year

Project management was identified as a top priority for the team, to allow for adequate time for testing (***Figure 17***). This year, the team met most of their timeline objectives. Specifically, the design timelines were maintained with manufacturing and testing falling short this year. These manufacturing and testing delays come as a result of a multitude of causes, however the most common cause was the delayed arrival of funding this spring. Another major hurdle for the team was a three week period where no progress was made on hull repairs. This came from team members being off for spring break and two weeks of poor weather which delayed the completion of hull repairs, and as a result delayed implementation of other systems onto the hull in addition to delaying the testing schedule.

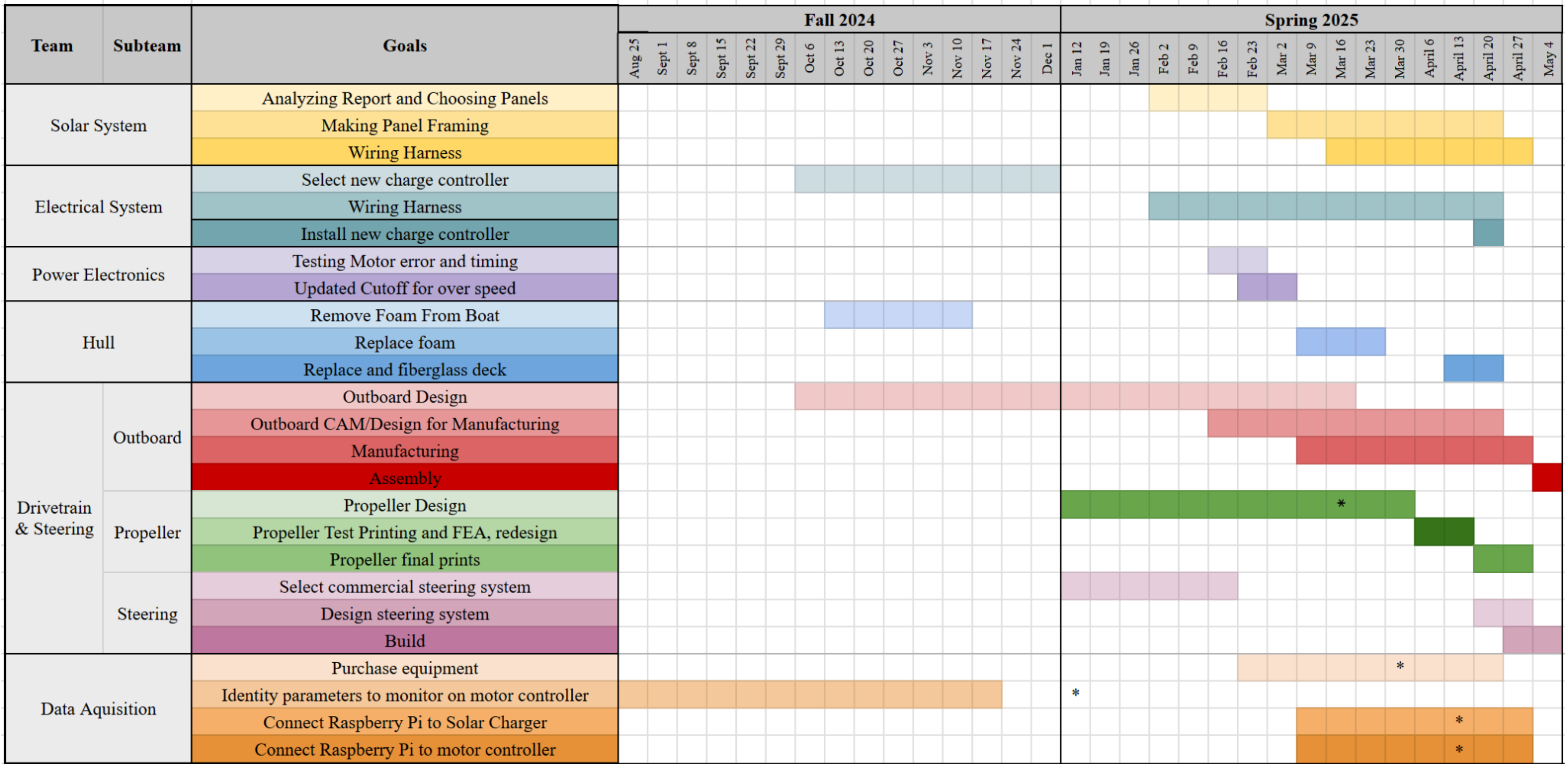


Figure 17: Project timeline gantt chart

XI. Conclusion and Recommendations

In the future, the team plans to design and build a new carbon-fiber hull, improve data acquisition, continue to develop better propellers, and add change gears to offer gearing changes to better suit each propeller. Failure points at competition and at future testing will also be addressed. The team hopes to improve upon sub-team organization and time management, and increase planning time for projects. In addition, the team struggled somewhat with new member retention, especially underclassmen who lacked experience in design work and were hesitant to engage as a result. In future years, the team hopes to incorporate teaching younger members through collaborative projects and meetings to address this issue. Finally, progress during the Fall semester was hindered due to a lack of available funding, which the team hopes to avoid in future years, and has budgeted to achieve next year. Teamwork and collaboration enabled much of the successes the team has had this year. The addition of a data acquisition system, new panels and chargers, a custom outboard, and multiple propellers are major technical successes that will positive impact the team's performance throughout this competition and into the future. An evaluation of individual team goals is detailed in ***Table 8***.

Table 8: Evaluation of 2025 project objectives

System	Objective	Evaluation of Objective
Solar	Redesign the solar panel array to be more space-efficient.	The array was made much more efficient through a reduction in components.
Electrical	Organize electronics wiring to be more space-efficient on the hull.	Organization and wire management was successfully improved, additions to circuit were implemented seamlessly, without impacting the overall circuit.
Power Electronics	Address unwanted motor controller automatic shutoff by tuning motor controller software.	Motor controller shutoff issue addressed. Though it may have been addressed through 1:1 gearing on custom outboard and larger propeller diameter, the team gained knowledge useful for addressing future issues.
Hull Design	Repair water damage to hull wood to maintain structural integrity.	Damaged wood was successfully removed and the team gained knowledge about proper epoxy application.
	Remove excess floatation foam to decrease hull weight.	Foam removed and replaced with correct weight foam and limited the overall weight, though the boat is still quite heavy compared to other teams.
	Reposition the driver's seat from the starboard aft to be amidships towards the bow.	Steering design was improved to allow for height adjustments for the steering wheel and seat.
Drivetrain & Steering	Design and build a new outboard to replace the previously used Johnson Marine 4R76M engine outboard.	Designed outboard meets needs and design goals, and is a significant improvement from prior Johnson outboard. However, the design finished several weeks later than intended.
	Design and build a steering joint and steering wires to replace tiller-based steering.	The steering wheel should greatly improve boat control, with the added speed of the new outboard.
Data Acquisition and Communications	Implement a diagnostics system to monitor the motor, motor controller, solar panels, and battery performance characteristics.	Remote data acquisition is a significant advance from previous years, but the team has done little work so far to enable automatic data processing.

References

[1] "ds_evpv370pk_360pk.pdf." Accessed: Apr. 28, 2025. [Online]. Available: https://ftp.panasonic.com/solar/datasheet/ds_evpv370pk_360pk.pdf

[2] "MPPT solar charger manual." Accessed: Apr. 28, 2025. [Online]. Available: https://www.victronenergy.com/media/pg/Manual_SmartSolar_MPPT_150-35__150-45/en/index-en.html

[3] "SunSaver MPPT," Morningstar Corporation. Accessed: Apr. 28, 2025. [Online]. Available: https://www.morningstarcorp.com/products/sunsaver-mppt/

[4] "ACS Inverters." Accessed: Apr. 28, 2025. [Online]. Available: https://evs-inmotion.com/en/acs-gen7-inverters

[5] "MOTORS," DHXmachines. Accessed: Apr. 28, 2025. [Online]. Available: https://www.dhxelectricmachines.com/motors

[6] Salt Boatworks, *How to Stitch and Glue a Boat - How to Build a Boat Part 3*, (Aug. 01, 2018). Accessed: Apr. 28, 2025. [Online Video]. Available: https://www.youtube.com/watch?app=desktop&v=KtKtXfVrzNs

[7] "Flats River Skiff 14 - Micro skiff Plans," Salt Boatworks. Accessed: Apr. 28, 2025. [Online]. Available: https://saltboatworks.com/product/flats-river-skiff-14/

[8] "1976 Johnson 4HP 7603 Outboard Service Manual." Accessed: Apr. 28, 2025. [Online]. Available: https://watercraftmanuals.com/outboard/johnson/johnson-7603.htm

[9] "GEARCASE-STANDARD DRIVE - 1976 Outboard 4 4R76M | Crowley Marine." Accessed: Apr. 28, 2025. [Online]. Available: https://www.crowleymarine.com/johnson/oem-parts/outboard/1976/4r76m/gearcase-standard-drive

[10] Y. Liyu, W. Chao, S. Cong, and G. Chunyu, "Mathematical expression method for geometric shape of toroidal propeller," 2024.

[11] L. K. P. D'Epagnier, H.-L. Chung, M. J. Stanway, and R. W. Kimball, "An Open Source Parametric Propeller Design Tool," in *OCEANS 2007*, Sep. 2007, pp. 1–8. doi: 10.1109/OCEANS.2007.4449400.

[12] K. S. Patel, D. B. Shah, S. J. Joshi, F. K. Aldawood, and M. Kchaou, "Effect of process parameters on the mechanical performance of FDM printed carbon fiber reinforced PETG," *J. Mater. Res. Technol.*, vol. 30, pp. 8006–8018, May 2024, doi: 10.1016/j.jmrt.2024.05.184.

[13] "Force Testing | Stable Micro Systems." Accessed: Apr. 28, 2025. [Online]. Available: https://www.stablemicrosystems.com/force-testing.html

XII. Appendix

Appendix A. Battery Documentation

Three *UPS* TLV12500F11 12V batteries for propulsion, and one *Mighty Max Battery* ML18-12 12V battery for the supplemental battery circuit. The safety data sheets for both are appended below.

1) UPS TLV12500F11 Safety Data Sheet

SAFETY DATA SHEET

Section 1 – Identification

Product Identifier: Non-Spillable Batteries Technical Name(s): Sealed Lead-Acid Batteries (SLA), Valve Regulated Lead-Acid Batteries (VRLA), Absorbed Glass Mat Batteries (AGM), Sealed Lead Calcium Batteries, Sealed Maintenance Free Lead-Acid Batteries
Manufacturer: UPS Battery Center Ltd., 147 Limestone Cr., Toronto ON M3J 2R1 Canada
Company phone number: 1-416-848-7755 **Emergency telephone (24hr) - INFOTRAC - 1-800-535-5053 (Domestic), 1-352-323-3500 (International)**
Product Use: Electric Storage Battery
Prepared by: UPS Battery Center Ltd. (416 848-7755)
Prepared date: April 10, 2021 (Not valid after April 9, 2024)
Trademarks: UPS BATTERY CENTER.COM This SDS applies only to products bearing these trademarks.

Section 2 – Hazards Identification

2.1 Overview

This product is a battery with the GHS Label: Valve Regulated Lead Acid Battery, Non-Spillable.

Under normal conditions, this product is sealed and does not leak or vent gasses or hazardous substances. There is no contact with the internal components of the battery or the chemical hazards under normal product use and handling. In the absence of an accident or incident, the classifications below are not likely to apply. Nevertheless, this Safety Data Sheet (SDS) contains valuable information critical to the safe handling and proper use of this product. This SDS should be retained and made available to employees and other users of this product.

The information in the classifications below in Section 2.2 and Section 2.3 apply to contact with discharged sulfuric battery electrolyte, which could occur during an accident or incident. This could occur under severe over- charge conditions where there may be venting of sulfuric acid gas and could also occur when hazards are presented during reclamation (recycling).

2.2 Classification of substance

Hazard	Category	Hazard Statements
Health Hazards		

Acute Toxicity – Oral	Category 4	H302 Harmful if swallowed
Acute Toxicity - Inhalation	Category 4	H332 Harmful if inhaled
Skin Corrosion / Irritation	Category 1A	H314 Causes severe skin burns and eye damage
Reproductive Toxicity	Category 1A	H360Df May damage the unborn child. Suspected of damaging fertility
Specific Target Organ Toxicity (Repeated Exposure)	Category 1	H372 Causes damage to organs (respiratory system) through prolonged or repeated exposure
Specific Target Organ Toxicity (Repeated Exposure)	Category 2	H373 May cause damage to organs through prolonged or repeated exposure
Serious Eye Damage / Eye Irritation	Category 1	H318 Causes serious eye damage
Specific Target Organ Toxicity (Single Exposure)	Category 3	H335 May cause respiratory irritation
Specific Target Organ Toxicity (Single Exposure)	Category 1	H370 Causes damage to organs (respiratory system)
Environmental Hazards		
Hazardous to the Aquatic Environment - Acute	Category 1	H400 Very toxic to aquatic life
Hazardous to the Aquatic Environment - Chronic	Category 1	H401 Very toxic to aquatic life with long lasting effects
Physical Hazards – not classified		

Signal Word: DANGER

Label elements

Placards are only required for transportation of spent or damaged batteries destined for reclamation (recycling).

2.3 Canada

Classification of substance

D1A	Class D - Poisonous and Infectious Material, Division 1: Materials causing immediate and serious toxic effects, Subdivision A: Very toxic material
D2A	Class D- Poisonous and Infectious Material, Division 2: Materials causing other toxic effects, Subdivision A: Very toxic material
E	Class E – Corrosive Material

Label elements

Signal Word: DANGER

Other hazards

In Canada, sealed lead-acid batteries are considered as hazardous according to the Workplace Hazardous Materials Information System (WHMIS).

2.4 Precautionary Statements

Prevention	Do not handle until all safety precautions have been read and understood
	Obtain special instructions before use
	Use personal protective equipment as required
	Wash face, hands and any exposed skin thoroughly after handling

	Do not breathe dust/fume/gas/mist/vapors/spray
	Use only outdoors or in a properly ventilated area
	Do not eat, drink or smoke when using this product
	Avoid release into the environment
	Keep out of reach of children
	Do not attempt to remove cover
	Avoid heat, sparks and open flame while charging batteries
	Avoid contact with internal acid
	Always be aware of the risk of fire, explosion or burns
	Do not solder a battery directly
	Keep away from fire or open flame
	Do not disassemble or modify the battery
	Do not short circuit the positive and negative terminals with any other metals
Response	Immediately call a poison center or doctor/physician
	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center or doctor/physician
	IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower. Wash contaminated clothing before reuse
	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a poison center or doctor/physician if you feel unwell
	IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell. Rinse mouth. Do not induce vomiting
Storage	Store locked up
Disposal	Dispose of contents/container to an approved waste disposal plant in accordance with applicable regulations

2.5 OSHA Regulatory Status

This product is considered hazardous by the OSHA HCS (Hazard Communication Standard), WHMIS (Work- place Hazardous Materials Information System), IOSH (Institution of Occupational Safety and Health), ISO (International Organization for Standardization) and by EU Directive (67/548/EEC) and a SDS is required for this product considering that when used as recommended or intended, or under ordinary conditions, it may present a health and safety exposure or other hazard.

Section 3 – Composition / Information on Ingredients

Under normal use and handling there is no contact with internal components of battery. Under normal use and handling batteries do not emit regulated or hazardous substances. After contact with terminals, wash hands before eating, drinking, smoking, applying cosmetics or handling contact lenses. If battery is damaged all listed precautions should be taken to prevent exposure.

Components	Chemical Abstract Service (CAS) Number	Enzyme Commission Number (ECN)	% Weight	OSHA Regulatory Status
Lead (Pb)	7439-92-1	231-100-4	about 50%	Hazardous
Lead Dioxide (PbO2)	1309-60-0	215-174-5	about 10%	Hazardous
Lead Sulfate (PbSO4)	7446-14-2	231-198-9	about 10%	Hazardous
Calcium (Ca)	7440-70-2	231-179-5	about 0.05%	Hazardous
Sulfuric Acid (H2SO4)	7664-93-9	231-639-5	about 20%	Hazardous
Fiberglass Separator	65997-17-3	266-046-0	about 5%	Hazardous
Acrylonitrile Butadiene Styrene Case	9003-56-9	618-371-8	about 5%	Non- Hazardous
Tin (Sn)	7440-31-5	231-141-8	0 - 0.25%	Non- Hazardous
Arsenic (As)	7440-38-2	231-148-6	about 0.2%	Hazardous

Ingredients reflect components of a finished product

Section 4 – First Aid Measures

Non-spillable batteries are sealed and do not leak or vent gasses under normal conditions. Venting of sulfuric acid gas and hydrogen can occur under severe overcharge conditions. During lead reclaim operations, or if battery is ruptured or damaged, exposure to sulfuric acid electrolyte and lead can occur.

Eye Contact: Sulfuric acid electrolyte. Immediately flush with water for 20 minutes, lifting the upper and lower lids. Get immediate medical attention.

Skin Contact: Sulfuric acid electrolyte. Immediately flush with water for 20 minutes. Remove contaminated clothing and launder before reuse. Get medical attention if irritation persists, if area is large or if blisters form.

Inhalation: Sulfuric acid fumes. If irritation develops, remove victim to fresh air and get medical attention. Give CPR (Cardiopulmonary Resuscitation) if breathing has stopped.

Ingestion: Sulfuric acid electrolyte. Do not induce vomiting. Do not give anything by mouth to an unconscious or convulsing person. Flush out mouth with water. Give water or milk to drink followed by milk of magnesia or vegetable oil. Get immediate medical attention.

Lead (Pb): The toxic effects of Lead are accumulative and slow to appear. If symptoms appear see your physician.

After any contact with internal components of the battery, wash hands before eating, drinking, smoking, applying cosmetics or handling contact lenses.

Section 5 – Fire Fighting Measures

5.1 Flammable Properties

Sealed batteries can emit Hydrogen, vaporized sulfuric acid or highly toxic arsine gas in a fire.
Sealed batteries can emit Hydrogen while being over-charged. (Float Voltage in excess of 2.40 Volts Per Cell at 25º C / 77º F).

5.2 Extinguishing Media

Provided that batteries are not part of an electrical circuit, use any media appropriate for surrounding fire (including water, dry chemical, foam, CO2, Halon).

If batteries are part of an electrical circuit, isolate them from power source at the circuit breaker before using water to extinguish fire. If this cannot be done immediately, then water must not be used as an extinguishing media.

5.3 Protection of Firefighters

Ventilate the area well. National Institute for Occupational Safety & Health (NIOSH) approved Self-Contained Breathing Apparatus (SCBA) and full fire-fighting turn out gear is recommended.

Unusual Fire and Explosion Hazards: Keep lighted cigarettes, sparks and flames away. Explosion can result from improper charging and ignition of resulting gases. Explosion can result if charged in gas tight container. Hydrogen can burn with almost an invisible flame of low thermal radia. People have unknowingly walked into hydrogen flames. Hydrogen is easily ignited.

Section 6 – Accidental Release Measures

Steps to be taken if battery vents hydrogen or sulfuric acid gas: Sealed batteries can emit Hydrogen while being over-charged. (Float Voltage in excess of 2.40 Volts Per Cell at 25º C / 77º F). Keep well ventilated and away from flame, spark or heat. If concentrations of sulfuric acid mist are known to exceed Permissible Exposure Limit (PEL), use NIOSH or Mine Safety and Health Administration (MSHA) approved respiratoryprotection.

Steps to be taken if battery is broken: Avoid contact with sulfuric acid electrolyte. Each non-spillable battery contains only enough sulfuric acid to saturate fiberglass separators, so a large spill is not likely to occur. If leak occurs, dilute with water, neutralize with sodium bicarbonate (baking soda), sodium carbon (soda ash) or calcium oxide (lime) until fizzing stops. Hydrogen gas may be given off during neutralization, provide adequate ventilation. The pH should be neutral at 6-8. When neutralized the spill is non-hazardous and can be flushed down the sewer. Do not allow un-neutralized acid to enter the sewage system. Broken battery contains lead and should be treated as hazardous waste. Place broken battery in a heavy gauge plastic bag or other non-metallic container and follow disposal procedure as per Section 13 below.

Section 7 – Handling and Storage

Store indoors in a cool, dry, well-ventilated area away from combustibles and activities that may create flame, spark or heat. Do not store in sealed, unventilated areas. Do not use organic solvents on the batteries. Do not allow metallic tools to short across terminals, as spark may occur. Do not wear metallic jewelry when working on small batteries as dangerous short circuit and severe burns may occur. There is risk of electric shock from strings of series-connected batteries even when not hooked up to charger. Sealed batteries can emit Hydrogen while being over-charged. Do not allow float voltage to exceed 2.40 Volts Per Cell at 25º C / 77º F. Do not remove vent covers.

Section 8 – Exposure Controls & Personal Protection

8.1 Engineering Controls

Charge in areas with adequate ventilation. General dilution ventilation is acceptable.

8.2 Personal protective equipment (PPE)

a) Under normal conditions no protection is required.
b) If battery is ruptured follow precautions in Section 6 and use the following protective equipment:

8.2.1 Eye/face Protection:

Safety glasses or goggles recommended to handle battery if case is damaged.

8.2.2 Skin Protection:

Use acid-resistant gloves to handle battery if case is damaged. An acid-resistant apron is also recommended for large clean-up operations.

8.2.3 Respiratory Protection:

When concentrations of sulfuric acid mist are known to exceed PEL, use NIOSH or MSHA approved respiratory protection.

8.2.4 General Hygiene Conditions:

After any contact with internal components of the battery, wash hands before eating, drinking, smoking, applying cosmetics or handling contact lenses. Discard lead contaminated clothing in a manner that limits further exposure. After contact with terminals, wash hands before eating, drinking, smoking, applying cosmetics or handling contact lenses.

8.3 Exposure Guidelines & Limits

Under normal conditions there is no risk of exposure other than to lead (Pb) through contact with the terminals. If case is damaged, or during reclaim operations, the following table should be observed.

Components	CAS Number	ACGIH* TLV	OSHA PEL	NIOSH REL	NIOSH IDLH	Quebec PEV	Ontario OEL
Lead (Pb)	7439-92-1	0.05 mg/m³	0.05 mg/m³	0.05 mg/m³	100 mg/m³	0.05 mg/m³	0.05 mg/m³
Lead Dioxide (PbO2)	1309-60-0	0.05 mg/m³	0.05 mg/m³	0.1 mg/m³	100 mg/m³	0.05 mg/m³	0.05 mg/m³
Lead Sulfate (PBSO4)	7446-14-2	0.05 mg/m³	0.05 mg/m³	0.1 mg/m³	100 mg/m³	0.05 mg/m³	0.05 mg/m³
Calcium Ca)	7440-70-2	None Listed	None Listed	None Listed	None Listed	None Listed	None Listed
Sulfuric Acid (H2SO4)	7664-93-9	0.2 mg/m³	1 mg/m³	1 mg/m³	15 mg/m³	1 mg/m³	0.2 mg/m³
Fiberglass Separator	Not Listed	None Listed	15 mg/m³	5 mg/m³	None Listed	None Listed	None Listed
Acrylonitrile Butadiene Styrene	9003-56-9	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Tin (Sn)	7440-31-5	2 mg/m³	2 mg/m³	2 mg/m³	100 mg/m³	2 mg/m³	2 mg/m³
Arsenic (As)	7440-38-2	0.01 mg/m³	0.01 mg/m³	5 mg/m³	3 ppm	0.1 mg/m³	0.01 mg/m³

** Association Advancing Occupational and Environmental Health*

Section 9 – Physical & Chemical Properties

Flammable Properties

Battery (Finished Product)

Flash Point: Not Applicable		Autoignition Temperature: Not Applicable
Flammable Limits:	LFL: Not Applicable	Flammability Classification: Non-Flammable Solid (Per 29 CFR 1910.1200)
	UFL: Not Applicable	

Hydrogen (Emission)

Flash Point: Gas @ normal temperature		Autoignition Temperature: 500º C (932º F)
Flammable Limits:	LFL: 4.1%	Flammability Classification: Flammable Gas (Per 29 CFR 1910.1200)
	UFL: 74.2%	

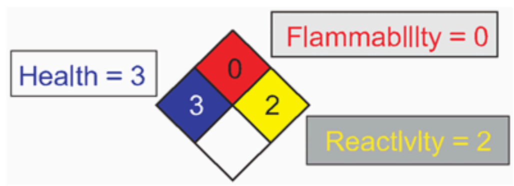
Hazard Ratings

NFPA Hazard Rating

(for Sulfuric Acid)

Rating Hazard Rating Key:

Flammability (Red) = 0
Health (Blue) = 3
Reactivity (Yellow) = 2



0 = minimal
1 = slight
2 = moderate
3 = serious
4 = severe

Component Properties

Components	CAS Number	ACGIH * TLV	OSHA PEL	NIOSH REL	NIOSH IDLH	Quebec PEV
Appearance	Silver-Grey Metal	White Powder	Brown Powder	Clear Colourless Liquid	White Fibrous Glass	Colourless Solid
Odor	None	None	None	None to Acidic	None	None
Odor Threshold	N/A	N/A	N/A	Greater than 1 mg/m^3	N/A	N/A
Physical State	Solid	Solid	Solid	Liquid or Gas	Solid	Solid
pH	N/A	N/A	N/A	2 or lower	N/A	N/A
Melting point	327.4º C (621.3º F)	1070º C (1958º F)	290º C (554 º F)	N/A	800º C (1472º F)	817º C (1502º F)
Freezing Point	N/A	N/A	N/A	11º C (51.8º F)	N/A	N/A
Boiling point	1740º C (3164º F)	1170º C (2134º F)	1070º C (1958 º F)	114º C (237º F)	Unknown	6135º C (11,075º F)
Evaporation rate	N/A	N/A	N/A	> 1	Unknown	Unknown
Flammability	N/A	N/A	N/A	N/A		Unknown
Upper flammability explosive limit	N/A	N/A	N/A	Unknown	Unknown	Unknown
Lower flammability explosive limit	N/A	N/A	N/A	Unknown	Unknown	Unknown
Vapour pressure	1.3 mm Hg @ 970º C	Unknown	Unknown	0.00120 mm Hg @ 20º C	Unknown	Unknown
Vapour density	N/A	N/A	N/A	Unknown	Unknown	Unknown
Specific gravity	11.34	6.2	9.375	1.290 ±.010	2.6	1.020
Solubility in Water	None	0.43 mg /l @ 15º C (59º F)	None	100%	None	Infinitely Soluble
Partition coefficient: n-octanol/water	N/A	N/A	N/A	N/A	N/A	Unknown
Auto-ignition temperature	N/A	N/A	N/A	Unknown	N/A	Unknown
Decomposition temperature	N/A	N/A	N/A	Unknown	N/A	Unknown
Molecular Formula	Pb	$PbSO_4$	PbO_2	H_2SO_4	N/A	As

In the above table N/A represents Not Applicable

Section 10 – Stability & Reactivity

Stability: The battery and its contents are stable.

Conditions to avoid: Overheating and overcharging as Sulfuric acid mist and hydrogen can be generated.

Materials to avoid: Strong alkaline materials, conductive metals, organic solvents, sparks and open flame.

Hazardous decomposition of byproducts: Hydrogen gas may be generated in an overcharge condition, in fire or at very high temperatures. In fire may emit Carbon Monoxide (CO), Carbon Dioxide (CO2), Hydrogen (H), sulfur oxides as well as toxic fumes from decomposition of case material.

Hazardous polymerization: Hazardous polymerization will not occur.

Section 11 – Toxicological Information

Non-spillable batteries are sealed and do not leak or vent gasses under normal conditions. Venting of sulfuric acid gas and hydrogen can occur under severe overcharge conditions. If battery is ruptured or damaged exposure to sulfuric acid electrolyte and lead can occur. Exposure is a significant risk during reclaim operations.

Information on Likely Routes of Exposure

Inhalation: In the event of exposure to contents of an open or damaged battery: dust/mist may irritate respiratory system. Difficulty in breathing. Frequent inhalation of dust over a long period of time increases the risk of developing lung diseases.

Skin contact: In the event of exposure to contents of an open or damaged battery: dust/mist may irritate skin.

Eye contact: In the event of exposure to contents of an open or damaged battery dust/mist may irritate the eyes.

Ingestion: In the event of exposure to contents of an open or damaged battery: may cause discomfort if swallowed.

Symptoms related to the physical, chemical and toxicological characteristics: In the event of exposure to contents of an open or damaged battery, dust may irritate the eyes and the respiratory system.

Acute Toxic Data

Components	CAS Number	OSHA Regulatory Status	LD_{50}	LC_{50}
Lead (Pb)	7439-92-1	Hazardous	Unavailable	Unavailable
Lead Dioxide (PbO2)	1309-60-0	Hazardous	Unavailable	Unavailable
Lead Sulfate (PBSO4)	7446-14-2	Hazardous	Unavailable	Unavailable
Calcium (Ca)	7440-70-2	Hazardous	2000 mg/Kg (rat, oral)	Unavailable
Sulfuric Acid (H2SO4)	7664-93-9	Hazardous	2140 mg/Kg (rat, oral)	510 mg/m^3/ 2 hours (rat, inhalation)
Arsenic (As)	7440-38-2	Hazardous	763 mg/Kg (rat, oral)	Unavailable

See “Section 2 – Hazards Identification” for more information on human toxicity.

Subchronic Toxicity Data

See “Section 2 – Hazards Identification” for more information on human toxicity.

Carcinogenicity

Lead (Pb)

Several reports have been published indicating that certain lead compounds administered to animals in high doses are carcinogenic, primarily inducing renal tumors. Salts demonstrating carcinogenicity in animals are usually soluble salts. No studies have shown a relationship between lead exposure and cancer in lead workers. However, one study of lead-exposed workers demonstrated a statistically significant elevation in the standardized mortality ratio for gastric and lung cancer in battery plant workers.

Lead (Pb):	Lead has been deemed carcinogenic by the following agencies
ACGIH:	Classes Lead as an A3 Animal Carcinogen
OSHA:	Possible select carcinogen
IARC:	Group 2B carcinogen (Animal)
State of California:	Carcinogen; initial date 10/1/92
NTP:	Reasonably anticipated to be a human carcinogen.

Sulfuric Acid (H2SO4)

Many studies have reported more cancer of the larynx, and to a lesser extent the lungs, than expected, in a wide variety of processes involving the use of strong inorganic acids including sulfuric acid. Throughout these studies, sulfuric acid mists were the most common exposure, and in two studies, the number of cancers increased as exposure increased. Several of the studies had design weaknesses, such as exposure to other potentially carcinogenic chemicals at the same time. Nevertheless, some studies were well conducted and the overall trends indicate that occupational exposure to strong inorganic mists containing sulfuric acid is carcinogenic to humans.

Sulfuric Acid (H2SO4):	Sulfuric acid vapour has been deemed carcinogenic by the following agencies
IARC:	Group 1 carcinogen (Human) (Applies to vapour but not to liquid state).
NTP:	Known human carcinogen (Applies to vapour but not to liquid state).

Mutagencity

Lead (Pb):	No Data Available
Sulfuric Acid (H2SO4):	There was a significantly higher number of sister chromatid exchanges, micronuclei and chromosomal aberrations in cultured lymphocytes (white blood cells) from workers exposed to sulfur dioxide in a sulfuric acid factory. There was no correlation with length of service. No conclusions can be made based on these observations.

Teratogenicity

Lead (Pb):	Lead penetrates the placental barrier and has caused fetal abnormalities in animals. Excessive exposure to lead during pregnancy has caused neurological disorders in infants.
Sulfuric Acid (H2SO4):	No human information is available. One animal study indicated that sulfuric acid is not teratogenic, even at maternally toxic doses.

Reproductive Effects

Lead (Pb):	Reproductive effects from lead have been documented in animals of both sexes.

In battery workmen with a mean exposure of 8.5 years to lead, there was an increased frequency of sperm abnormalities as compared to a control group.

Neurotoxicity

Lead (Pb):
Subtle neurological effects from lead have been demonstrated with relatively low blood levels of lead. The performance of lead workers on various neurological tests was mildly deduced when compared with a control group. Anxiety, depression, poor concentration, forgetfulness, mild reductions in motor and sensory nerve conduction velocities have been documented in lead-exposed workers.
Sulfuric Acid (H2SO4): No human or animal information is available.

Irritancy of Product

Lead (Pb):	Lead dust may cause skin irritation.
Sulfuric Acid (H2SO4):	Sulfuric acid can cause severe burns to eyes and skin.

Sensitization (Potential Allergen)

Lead (Pb):	Lead and lead compounds are not known to be skin sensitizers.
Sulfuric Acid (H2SO4):	Sulfuric acid can cause severe burns to eyes and skin. There is no data available on sensitization.

Potential for Accumulation

Lead (Pb): Lead accumulates in the body throughout one's lifetime.

Sulfuric Acid (H2SO4):
Sulfuric acid is absorbed through mucous membranes, ultimately into the bloodstream. The sulfate anion becomes part of the pool of sulfate anions in the body and is excreted in the urine in combination with other chemicals in the body. It is unlikely to accumulate in the body.

Battery terminals contain lead. After contact with terminals, wash hands before eating, drinking, smoking, applying cosmetics or handling contact lenses.

Section 12 – Ecological Information

Lead and lead compounds can pose a threat if released into the environment. Lead is an extremely stable metal. While some corrosion may be expected in soil, generally an inert coat of insoluble salt will form and limit further corrosion. Lead particles will sink in water and stay in the sediment, however in fast moving water lead may be spread. Small amounts of lead in water can lead to accumulation in living organisms over time. Batteries in landfill sites have contributed to lead leaching into ground water.

Sulfuric acid is harmful to aquatic life even in very low concentrations. It may be dangerous if it enters water intakes. Aquatic toxicity for Bluegill (Lepomis macrochirus) in fresh water was 24.5 ppm / 24 hrs, which was lethal. LC50 for Flounder was 100 to 330 mg / 1 / 48 hrs.

Section 13 – Disposal Considerations

Waste Disposal Method:
Non-spillable batteries are recyclable. It is an offence to dispose of lead-acid batteries by any means other than recycling. Do not dispose of in regular household garbage. Contact UPS Battery Center Ltd. for information on disposal.

Ontario:
Must be recycled in an Ontario Ministry of the Environment approved facility, permitted to receive Ontario Waste Class 112.

United States:
U.S. law requires that chemical waste generators must determine whether a discarded material is classified as hazardous waste. Use U.S. EPA guidelines for the classification of hazardous waste listed in 40 CFR 261.3. Additionally, consult state and local hazardous waste regulation to ensure complete and accurate classification.

Hazardous Waste Class/Code:
Not applicable to finished product as manufactured for distribution into commerce. Batteries are considered hazardous goods (UN2800) when being transported for reclamation (recycling). US EPA hazardous waste code D002 (corrosivity) and D008 (lead) apply to spent batteries only.

Section 14 – Transport Information

United States

U.S. Department of Transportation (DOT): Non-spillable wet electric storage batteries are regulated by the U.S. DOT under the Hazardous Materials Regulations (HMR). Exemptions are made if certain criteria are met. UPS Battery Center batteries meet the test requirements for “nonspillable wet electric storage batteries”, as provided in 49 CFR 173.159(d), and therefore are non-regulated by DOT, for surface transportation, when protected against short circuits and securely packaged. (These data refer to undamaged batteries). The outer packaging must be plainly and durably marked “NON-SPILLABLE”.
This exemption does not apply to spent batteries being transported for reclamation (recycling). When shipping spent batteries the following applies:

Proper shipping name:	Batteries, wet, non-spillable
Hazard Class/Division:	8
Identification Number:	UN2800
Packing Group:	III
Label Required:	No (Class 8) label required

Canada

Transport Canada:
Non-spillable wet electric storage batteries are regulated by Transport Canada under the Transportation of Dangerous Goods Act (TDG). Exemptions are made if certain criteria are met. UPS Battery Center Ltd. batteries meet the test requirements for “batteries, wet, non-spillable”, as specified in Schedule 2 Special Provision #39 (2) of the TDG, and therefore are exempt and non-regulated by Transport Canada, for surface transportation, when protected against short circuits and securely packaged. (These data refer to undamaged batteries). The outer packaging must be plainly and durably marked “NON-SPILLABLE”.
This exemption does not apply to spent batteries being transported for reclamation (recycling). When shipping spent batteries the following applies:

Proper shipping name:	Batteries, wet, non-spillable
Hazard Class/Division:	8
Identification Number:	UN2800
Packing Group:	III
Label Required:	No (Class 8) label required

International

IATA (International Air Transport Association):
UPS Battery Center Ltd. batteries are safe for air transport, as they have met the testing requirements put forth in Special Provision # A67 of the IATA Dangerous Goods List. No label required.

IMO (International Maritime Organization):
UPS Battery Center Ltd. batteries are safe for marine transport, as they have met the testing requirements put forth in Special Provision SP238 of the IMDG code. No label required.
Certificate of Testing documentation for the above exemptions and special provisions is available from UPS Battery Center Ltd. on request.

Section 15 – Regulatory Information

U.S. Federal Regulations

TSCA (Toxic Substances Control Act)
The following ingredients are listed in the TSCA Registry as follows: CAS# 7439-92-1 (lead), CAS# 1309-60-0 (lead dioxide), CAS# 7446-14-2 (lead sulfate), CAS# 7440-70-2 (calcium), CAS# 7440-31-5 (tin), CAS# 7664-93-2 (sulfuric acid), CAS# 7440-38-2 (arsenic).

RCRA (Resource Conservation and Recovery Act)
Spent lead-acid batteries are not regulated as hazardous waste when recycled. Spilled sulfuric acid is a characteristic hazardous waste; EPA hazardous waste number D002 (corrosivity). Exposed lead is a hazardous waste; EPA hazardous waste number D008 (lead).

CERCLA (Comprehensive Response Compensation, and Liability Act)
Reportable quantity (RQ) for spilled 100% sulfuric acid (CAS# 7664-93-2) under CERCLA is 1000 lbs. (454 Kg). State and local reportable quantities for spilled sulfuric acid may vary.

SARA Title III (Superfund Amendments and Reauthorization Act)
Supplier Notification: This product contains toxic chemicals that may be reportable under Section 313 Toxic Chemical Release Inventory (Form R) requirements. CAS numbers and % by weight information is provided in the table in Section 3 of this document.

EPCRA (Emergency Planning and Community Right to Know Act)
Sulfuric acid is listed “Extremely Hazardous Substance” under EPCRA with a Threshold Planning Quantity (TPQ) of 1000 lbs. (454 Kg).

a) Section 302 notification is required if 1000 lbs (454 Kg) or more of sulfuric acid is present at one site. The average non-spillable battery contains less than 2 lbs. (0.9 Kg) of sulfuric acid.
b) Section 312 Tier Two reporting is required for non-automotive batteries if sulfuric acid is present in quantities of 500 lbs. or more and / or if lead is present in quantities of 10,000 lbs. or more.

Clean Air Act (CAA): This material does not contain any hazardous air pollutants.
This material does not contain any Class 1 ozone depletors.
This material does not contain any Class 2 ozone depletors.

Clean Water Act (CWA): Sulfuric acid is listed as a Hazardous Substance under the CWA.

State Regulations

California Proposition 65

The following chemicals identified to exist in the finished product as distributed into commerce are known to the State of California to cause cancer, birth defects, or other reproductive harm: Arsenic, Sulfuric Acid and Lead. CAS numbers and % by weight information is provided in the table in Section 3 of this document.

California Proposition 65 Label

Warning: Battery, posts, terminals and related accessories contain lead, lead compounds and other chemicals known to the State of California to cause cancer or birth defects and other reproductive harm. Wash hands after handling.

California Consumer Product Volatile Organic Compound Emissions

This Product is not regulated as a Consumer Product for purposes of CARB/OTC VOC Regulations, as-sold for the intended purpose and into the Industrial /Commercial supply chain.

Right to Know Legislation

Sulfuric acid, lead and lead compounds, calcium, tin and arsenic can be found on the following state right to know lists: California, New Jersey, Florida, Pennsylvania, Minnesota, and Massachusetts.

Canadian Regulations

Canadian Domestic Substance List (DSL)

All ingredients remaining in the finished product as distributed into commerce are included on the Domestic Substances List.

WHMIS Classifications

Class E: Corrosive materials present at greater than 1%. This product has been classified in accordance with the hazard criteria of the Hazardous Products Regulations (HPR) and the SDS contains all of the information required by those regulations. Lead, lead dioxide, lead sulfate, calcium, tin, sulfuric acid and arsenic are listed on the DSL list and the Ingredient Disclosure List. CAS numbers and % by weight information is provided in the table in Section 3 of this document.

National Pollutant Release Inventory (NPRI) and Ontario Regulation127/01

This product contains the following chemicals subject to reporting requirements of Canada NPRI and/or Ontario Regulation 127/01: Lead, Sulfuric Acid.
CAS numbers and % by weight information is provided in the table in Section 3 of this document.

European Regulations

European Inventory of Existing Commercial Chemical Substances (EINECS)

All ingredients remaining in the finished product as distributed into commerce are exempt from, or included on, the European Inventory of Existing Commercial Chemical Substances.

European Communities (EC) Hazard Classification according to:

Dangerous Substances Directive 67/548/EEC and Dangerous Preparations Directive 1999/45/EC.
R-Phrases: 35, 36, 38, 45, 51
S-Phrases: 2, 26, 30, 45

Classification, Labeling & Packaging (CLP) Regulation no.1272/2008 and Registration, Evaluation, Authorization and restriction of Chemicals (REACH) Regulation no.1907/2006.
These products are manufactured articles and not subject to CLP and REACH registration requirements.

Restriction of the use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) UPS Battery Center Ltd. batteries are exempt from RoHS restrictions for lead content. Supporting information is available from UPS Battery Center Ltd. on request.

Section 16 – Other Information

This entire document has been revised to comply with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) for SDS in order to maintain consistency throughout Canada (HPR & WHMIS), the United States (ANSI Z400.1-2004), Europe (Directive 91/155/EEC & CLP) and Japan (MITI Official Notice #1). Every effort has been made to ensure that this document meets all the requirements of these standards at the time of publication. (October 4, 2018).

Vendee and third persons assume the risk of injury proximately caused by the material if reasonable safety procedures are not followed as provided for in the SDS. Vendor shall not be liable for injury to vendee or third persons proximately caused by abnormal use of the material even if reasonable procedures are followed.

All persons using this product, all persons working in an area where this product is used, and all persons handling this product should be familiar with the contents of this SDS. This information should be effectively communicated to employees and all others who might come in contact with this product.

The information contained herein is based on data considered accurate as of the date hereof, however, no warranty is expressed or implied regarding the accuracy of these data or the results obtained from the use thereof.

Figure 20.

2) Mighty Max Battery ML18-12 Safety Data Sheet

Material Safety Data Sheet

1. PRODUCT AND COMPANY IDENTIFICATION

Product Name	**Valve Regulated Maintenance Free Lead-Acid Batteries: ML and YT Series**
Recommended Use	Lead acid battery. Sealed Motorcycle Battery
Supplier Address	

Mighty Max Battery
3775 Park Avenue
UNIT 3B
Edison, NJ 08820
Phone:855- 378 - 7135

Sales@MightyMaxBattery.com

2. HAZARDS IDENTIFICATION

Emergency Overview

NOTE: Under normal conditions of battery use, internal components will not present a health hazard. The following information is provided for battery acid and lead exposure that may occur during battery production or container breakage or under extreme heat conditions such as fire.

In case of rupture:

Corrosive

The product causes burns of eyes, skin and mucous membranes

Appearance: No information available. **Physical State:** Solid. **Odor:** Odorless

Potential Health Effects

Principle Routes of Exposure	Skin contact.
Acute Toxicity	
Eyes	Corrosive to the eyes and may cause severe damage including blindness.
Skin	Causes burns.
Inhalation	Harmful by inhalation. Contact with moist mucous membranes of the respiratory system can cause caustic condition resulting in burns.
Ingestion	Harmful if swallowed. Can burn mouth, throat, and stomach.
Chronic Effects	Lead compounds may be absorbed by ingestion, by inhalation and through the skin. Lead may damage kidney function, the blood forming system and the reproductive system. Avoid repeated exposure.
Main Symptoms	Severe exposures can lead to shock, circulatory collapse, and death Lead poisoning is characterized by a metallic taste in the mouth, loss of appetite indigestion, nausea, vomiting, constipation, sleep disturbances and overall weakness
Aggravated Medical Conditions	None known.

Environment Hazard See Section 12 for additional Ecological Information

3. COMPOSITION/INFORMATION ON INGREDIENTS

.

Chemical Name	CAS-No	Weight %
Lead	7439-92-1	65～75
Sulfuric acid	7664-93-9	10～20
ABS resin	9003-56-9	～5
Tin	7440-31-5	＜0.5
Calcium	7440-70-2	＜0.1

4. FIRST AID MEASURES

General Advice First aid is upon rupture of sealed battery.

Eye Contact Immediate medical attention is required. Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Keep eye wide open while rinsing. Do not rub affected area.

Skin Contact Immediate medical attention is required. Wash off immediately with soap and plenty of water removing all contaminated clothes and shoes.

Inhalation Move to fresh air. Call a physician or Poison Control Center immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.

Ingestion Immediate medical attention is required. Call a physician or Poison Control Center immediately. Do NOT induce vomiting. Drink plenty of water. Never give anything by mouth to an unconscious person. Remove from exposure, lie down.

Notes to Physician Treat symptomatically.

Protection of First-aiders Use personal protective equipment. Avoid contact with skin, eyes and clothing.

5. FIRE-FIGHTING MEASURES

Flammable Properties Not flammable.

Flash Point Not determined.

Suitable Extinguishing Media Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

Uniform Fire Code Corrosive: Acid-Liquid

Hazardous Combustion Products Hazardous metal fumes and oxides.

Explosion Data Sensitivity to Mechanical No.

Impact Sensitivity to Static Discharge No.

Specific Hazards Arising from the Chemical The product causes burns of eyes, skin and mucous membranes. Thermal decomposition can lead to release of irritating gases and vapors. In the event of fire and/or explosion do not breathe fumes.

Protective Equipment and Precautions for Firefighters

As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

NFPA **Health Hazard** 3 **Flammability 0** **Stability 2** **Physical and Chemical Hazards**

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions Use personal protective equipment. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Do not get in eyes, on skin, or on clothing.

Environmental Precautions Refer to protective measures listed in Sections 7 and 8.

Methods for Containment Prevent further leakage or spillage if safe to do so.

Methods for Cleaning Up In case of rupture: Use personal protective equipment. Dam up. Soak up with inert absorbent material. Take up mechanically and collect in suitable container for disposal. Clean contaminated surface thoroughly.

Other Information Refer to protective measures listed in Sections 7 and 8.

7. HANDLING AND STORAGE

Handling Handle in accordance with good industrial hygiene and safety practice.

Storage Keep containers tightly closed in a dry, cool and well-ventilated place.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Guidelines

Chemical Name	ACGIH TLV	OSHA PEL	NIOSH IDLH
Lead 7439-92-1	TWA: 0.05 mg/m3	TWA: 50 µg/m3 Action Level: 30 µg/m3 Poison, See 29 CFR 1910.1025	IDLH: 100 mg/m3 TWA: 0.050 mg/m3
Sulfuric acid 7664-93-9	TWA: 0.2 mg/m3 thoracic fraction	TWA: 1 mg/m3 (vacated) TWA: 1 mg/m3	IDLH: 15 mg/m3 TWA: 1 mg/m3
Tin 7440-31-5	TWA: 2 mg/m3	TWA: 2 mg/m3 Sn except oxides (vacated) TWA: 2 mg/m3	IDLH: 100 mg/m3 TWA: 2 mg/m3

ACGIH TLV: American Conference of Governmental Industrial Hygienists - Threshold Limit Value.

OSHA PEL: Occupational Safety and Health Administration - Permissible Exposure Limits.

NIOSH IDLH: Immediately Dangerous to Life or Health.

Other Exposure Guidelines Vacated limits revoked by the Court of Appeals decision in AFL-CIO v. OSHA, 965 F.2d 962 (11th Cir. , 1992).

Engineering Measures Showers
Eyewash stations
Ventilation systems

Personal Protective Equipment
Eye/Face Protection Tightly fitting safety goggles.
Skin and Body Protection Wear protective gloves/clothing.

Respiratory Protection No protective equipment is needed under normal use conditions. If exposure limits are exceeded or irritation is experienced, ventilation and evacuation may be required.

Hygiene Measures Handle in accordance with good industrial hygiene and safety practice.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	No information available	**Odor**	Odorless.
Odor Threshold	No information available	**Physical State**	Solid
pH	No information available		
Flash Point	No information available.	**Auto-ignition Temperature**	No information available
Decomposition Temperature	No information available	**Boiling Point/Range**	No information available
Melting Point/Range	No information available		
Flammability Limits in Air	No information available	**Explosion Limits**	No information available
Water Solubility	Immiscible in water	**Solubility**	No information available
Evaporation Rate	No information available	**Vapor Pressure**	No data available
Vapor Density	No data available	**Partition Coefficient: noctanol/water**	

10. STABILITY AND REACTIVITY

Stability	Stable under recommended storage conditions.
Incompatible Products	Incompatible with strong acids and bases. Incompatible with oxidizing agents.
Conditions to Avoid	Exposure to air or moisture over prolonged periods.
Hazardous Decomposition Products	Thermal decomposition can lead to release of toxic/corrosive gases and vapors
Hazardous Polymerization	Hazardous polymerization does not occur.

11. TOXICOLOGICAL INFORMATION

Acute Toxicity

Product Information Product does not present an acute toxicity hazard based on known or supplied information.

Irritation Causes severe irritation and or burns

Component Information

Chemical Name	LD50 Oral	LD50 Dermal	LC50 Inhalation
Sulfuric acid	= 2140 mg/kg (Rat)	-	= 510 mg/m3(Rat) 2 h

Chronic Toxicity

Chronic Toxicity Lead compounds may be absorbed by ingestion, by inhalation and through the skin. Lead may damage kidney function, the blood forming system and the reproductive system. Avoid repeated exposure.

Carcinogenicity The table below indicates whether each agency has listed any ingredient as a carcinogen.

Chemical Name	ACGIH	IARC	NTP	OSHA
Lead	A3	Group 2A	Reasonably Anticipated	X
Sulfuric acid	A2	Group 1	Known	X
ABS resin		Group 3		

ACGIH: (American Conference of Governmental Industrial Hygienists)
A2 - Suspected Human Carcinogen
A3 - Animal Carcinogen
IARC: (International Agency for Research on Cancer)
Group 1 - Carcinogenic to Humans
Group 2A - Probably Carcinogenic to Humans
NTP: (National Toxicity Program)
Known - Known Carcinogen
Reasonably Anticipated - Reasonably Anticipated to be a Human Carcinogen
OSHA: (Occupational Safety & Health Administration)
X - Present

Reproductive Toxicity	Product is or contains a chemical which is a known or suspected reproductive hazard.
Developmental Toxicity	Contains ingredients that have suspected developmental hazards. Inorganic lead compounds can cause developmental damage.
Target Organ Effects	None known.

12. ECOLOGICAL INFORMATION

Ecotoxicity

The environmental impact of this product has not been fully investigated.

Chemical Name	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Lead		LC50: 0.44 mg/L (96 h semi-static) Cyprinus carpio LC50: 1.17 mg/L (96 h flow-through) Oncorhynchus mykiss LC50: 1.32 mg/L (96 h static) Oncorhynchus mykiss		EC50: 600 µg/L (48 h) water flea
Sulfuric acid		LC50: > 500 mg/L (96 h static) Brachydanio rerio		EC50: 29 mg/L (24 h) Daphnia magna

13. DISPOSAL CONSIDERATIONS

Waste Disposal Methods	This material, as supplied, is a hazardous waste according to federal regulations (40 CFR 261). Should not be released into the environment.
Contaminated Packaging	Do not re-use empty containers.
US EPA Waste Number	D002 D008

Chemical Name	RCRA	RCRA - Basis for Listing	RCRA - D Series Wastes	RCRA - U Series Wastes
Lead - 7439-92-1	(hazardous constituent - no waste number)	Included in waste streams: F035, F037, F038, F039, K002, K003, K005, K046, K048, K049, K051, K052, K061, K062, K064, K065, K066, K069, K086, K100, K176	= 5.0 mg/L regulatory level	

California Hazardous Waste Codes 792

This product contains one or more substances that are listed with the State of California as a hazardous waste.

Chemical Name	California EHW	California Carc	California Hazardous Waste	California Waste - Part 2
Lead			Toxic	TCLP(forCA Toxicity): 5.0 mg/L
Sulfuric acid			Toxic Corrosive	
Calcium	Ignitable Reactive			

14. TRANSPORT INFORMATION

Note:	Exempt from hazardous materials regulations per 49CFR173.159 (d).
DOT Description	NOT REGULATED NON-SPILLABLE BATTERY
TDG Description	Not regulated NON-SPILLABLE BATTERY
MEX Description	Not regulated NON-SPILLABLE BATTERY
ICAO Description	Not regulated NON-SPILLABLE BATTERY
IATA Description	Not regulated NON-SPILLABLE BATTERY
IMDG/IMO Description	Not regulated NON-SPILLABLE BATTERY

15. REGULATORY INFORMATION

International Inventories

TSCA	Complies
DSL	Not determined

U.S. Federal Regulations

SARA 313
Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) . This product contains a chemical or chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372:

Chemical Name	CAS-No	Weight %	SARA 313 - Threshold Values %
Lead	7439-92-1	65～75	0.1
Sulfuric acid	7664-93-9	10～20	1.0

SARA 311/312 Hazard Categories Health Hazard	**Acute**	Yes
Chronic Health Hazard		Yes
Fire Hazard		No
Sudden Release of Pressure Hazard		No
Reactive Hazard		No

Clean Water Act
This product contains the following substances which are regulated pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42):

Chemical Name	CWA - Reportable Quantities	CWA - Toxic Pollutants	CWA - Priority Pollutants	CWA - Hazardous Substances
Lead		X	X	
Sulfuric acid	1000 lb			X

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product contains the following substances which are listed hazardous air pollutants (HAPS) under Section 112 of the Clean Air Act:

Chemical Name	CAS-No	Weight %	HAPS data	VOC Chemicals	Class 1 Ozone Depletors	Class 2 Ozone Depletors
Lead	7439-92-1	65～75				

CERCLA
This material, as supplied, contains one or more substances regulated as a hazardous substance under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302):

Chemical Name	Hazardous Substances RQs	Extremely Hazardous Substances RQs
Lead	10 lb	
Sulfuric acid	1000 lb	1000 lb

U.S. State Regulations

California Proposition 65
This product contains the following Proposition 65 chemicals:

Chemical Name	CAS-No	California Prop. 65
Lead	7439-92-1	Carcinogen Developmental Female Reproductive Male Reproductive
Sulfuric acid	7664-93-9	Carcinogen

U.S. State Right-to-Know Regulations

Chemical Name	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Lead	X	X	X	X	X
Tin	X	X	X		
Calcium	X	X	X		
Sulfuric acid	X	X	X	X	X

International Regulations

Mexico - Grade Minimum risk, Grade 0

Chemical Name	Carcinogen Status	Exposure Limits
Lead	A3	Mexico: TWA= 0.15 mg/m3
Tin		Mexico: TWA 2 mg/m3 Mexico: STEL 4 mg/m3
Sulfuric acid	A2	Mexico: TWA 1 mg/m3

Canada

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

WHMIS Hazard Class
D2A Very toxic materials E Corrosive material

Chemical Name	NPRI
Lead	X
Sulfuric acid	X

Legend
NPRI - National Pollutant Release Inventory

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and .may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

End of Material Safety Data Sheet

16. Issuing Date: OCT. 1st, 2016

Appendix B. Flotation Calculations

Component Weights

Component	Weight (lbs)
Solar Array	86
Batteries	100
Drivetrain (Outboard, Motor, Cooling)	63
Hull	225
Control Electronics	130
TOTAL:	504
TOTAL x 120% for Rule 7.13.4	605

The hull displacement can be approximated by creating an line of best fit that follows the specifications that come from our design. Salt Boatworks provides two datapoints, 2 inches at 250 pounds and 5 inches at 850 pounds. We combined these two and added one of zero inches at zero pounds to get a fit curve of our designed displacement. This can be seen in the figure below, with our summed weights with and without the driver.

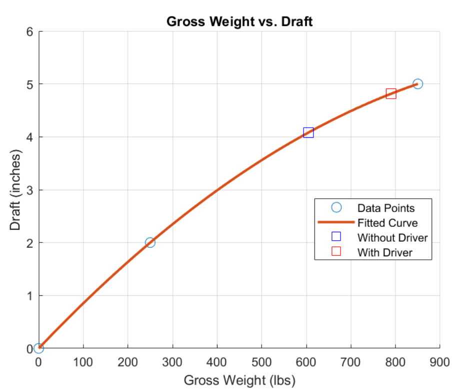


Figure 18: Gross Weight vs. Draft

The necessary displacement was calculated to float our boat by calculating the weight of our hull and components, then applied a twenty percent increase as a factor of safety. Our components with the factor of safety weigh 605 pounds. To float these, our hull must be able to displace the appropriate amount of water, and also have sufficient foam onboard to keep that volume of water out.

$$Displacement\ Needed\ =\ (Weight\ Sum)/(Density\ of\ Water)$$

$$9.6953\ ft^3 = 604.8\ lbs\ /\ 62.38\ \ lbs/ft^3$$

The following equation can be used to find the volume of foam needed to prevent sinking in the event of catastrophic water ingress.

$$Foam\ Volume\ =\ (Weight\ Sum)/(Density\ of\ Water\ -\ Density\ of\ Foam)$$

$$10.0164\ ft^3\ =\ (604.8\ lbs)/(62.38\ lbs/ft^3\ -\ 2\ lbs/ft^3)$$

Our hull displacement is overestimated to account for a wide margin of error in our weights across the board due to potentially faulty scales and part variance.

Our boat is filled in most of its bulkheads with expanding foam for flotation purposes. We have approximately 11 cubic feet of foam inside our boat, and each cubic foot can maintain floatation for 60.38 pounds outside of it's own weight. This exceeds the minimum requirements for our boat as outlined in rule 7.13.4.

The code of all calculations is on the following pages.

Table of Contents

UD Solar Splash Floatation Calculations

03/04/2025 Michael J. Wolf

```
clear
clc
close all
```

```
g = 386.1; % in/s2
```

Weights

```
driver = 154; %lbs

pkPanel = 43;
panelTotal = 2*pkPanel;

controlPanelWeight = 3;
speedControllerWeight = 4;
wiringWeight = 20;
chargeControllerWeight = 3;
batteriesWeight = 100;
controlElectronicsTotal = controlPanelWeight+speedControllerWeight+...
    wiringWeight+chargeControllerWeight+batteriesWeight;

hull = 225; %lbs

motorWeight = 12;
radiatorWeight = 1;
pumpWeight = 2;
outboardWeight = 37; % Includes Prop
coolantWeight = 11;
drivetrainTotal = motorWeight+radiatorWeight+pumpWeight+...
    outboardWeight+coolantWeight;

totalWeightLoaded = driver+controlElectronicsTotal+hull+drivetrainTotal...
    +panelTotal; %lbs
totalWeightUnloaded = totalWeightLoaded-driver;

rhoFoam = 2/(12^3); %lb/in3
```

Calculating Bouyant Force & Displacement

```
rhoWater = 0.0361; % Freshwater = 0.0361, Saltwater = 0.0370;
rhoWaterFt = rhoWater*(12^3);

forceSafetyLoaded = 1.2*totalWeightLoaded; %lbs
forceSafetyUnloaded = 1.2*(totalWeightUnloaded);

vDisplacementUnloaded = forceSafetyUnloaded/(rhoWater)
vDisplacementUnloadedFt = vDisplacementUnloaded/(12^3)

vDisplacementLoaded = forceSafetyLoaded/(rhoWater)
vDisplacementLoadedFt = vDisplacementLoaded/(12^3)
```

```
vDisplacementUnloaded =

   1.6753e+04


vDisplacementUnloadedFt =

    9.6953


vDisplacementLoaded =

   2.1873e+04


vDisplacementLoadedFt =

   12.6577
```

Calculating Foam Volume & Weight

```
rhoFloat = rhoWater-rhoFoam;
rhoFloatFt = rhoFloat*(12^3);

vFoam = forceSafetyUnloaded/rhoFloat %in3
vFoamFt = vFoam/(12^3) %ft3

foamWeight = vFoam*rhoFoam %lbs
```

```
vFoam =

   1.7308e+04


vFoamFt =
```

```
   10.0164

foamWeight =

   20.0329
```

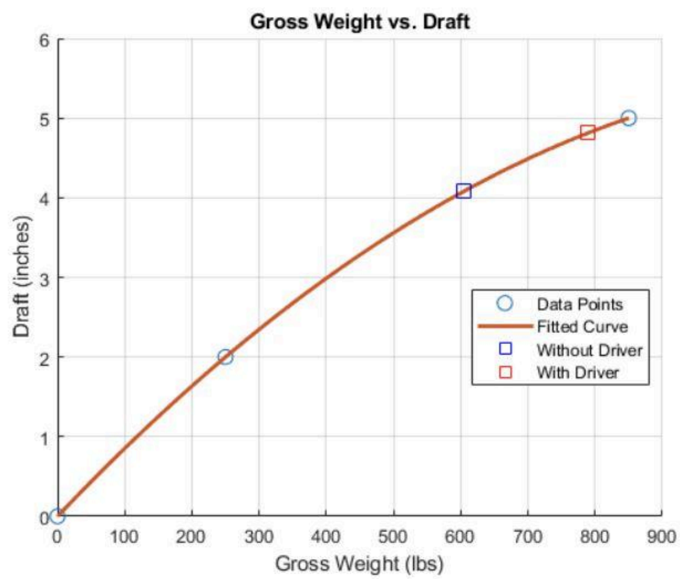
Calculating Draft as a Function of Gross Weight

Define discrete data points

```
weights = [0, 250, 850]; % Loaded weights in lbs
drafts = [0, 2, 5]; % Draft in inches

% Fit a cubic spline to the data
fitObj = fit(weights', drafts', 'cubicspline');

% Generate data for plotting the fitted curve
weights_fit = linspace(min(weights), max(weights), 100); % Fine-grained
 weights
drafts_fit = feval(fitObj, weights_fit); % Evaluate the fit

% Generate draft predictions
ladenDraftPrediction = feval(fitObj, forceSafetyLoaded)
unladenDraftPrediction = feval(fitObj, forceSafetyUnloaded)

% Plot the data and the fitted curve
figure;
hold on;
plot(weights, drafts, 'o', 'MarkerSize', 8, 'DisplayName', 'Data Points'); %
 Original points
plot(weights_fit, drafts_fit, '-', 'LineWidth', 2, 'DisplayName', 'Fitted
 Curve'); % Fitted curve
plot(forceSafetyUnloaded, unladenDraftPrediction, 's', 'MarkerSize',
 10, 'DisplayName', 'Without Driver', Color='b'); % Draft Prediction without
 Driver
plot(forceSafetyLoaded, ladenDraftPrediction, 's', 'MarkerSize',
 10, 'DisplayName', 'With Driver', Color='r'); % Draft Prediction with Driver
hold off;

% Add labels, title, and legend
xlabel('Gross Weight (lbs)');
ylabel('Draft (inches)');
title('Gross Weight vs. Draft');
legend('Location', 'best');
grid on;
```

```
ladenDraftPrediction =

    4.8130
```

```
unladenDraftPrediction =

    4.0810
```



Published with MATLAB® R2023a

Appendix C. Proof of Insurance

ACORD®

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY): 06/22/2023

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must have ADDITIONAL INSURED provisions or be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
Marsh USA LLC
1717 Arch Street
Philadelphia, PA 19103-2797

CN103088283-Dayto-GUP-23-24

CONTACT NAME:
PHONE (A/C, No, Ext): **FAX (A/C, No):**
E-MAIL ADDRESS:

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : Pinnacle Consortium of Higher Ed VT RRRG	11980
INSURER B : N/A	N/A
INSURER C :	
INSURER D :	
INSURER E :	
INSURER F :	

INSURED
University of Dayton
Attn: Robin Oldfield
300 College Park
St. Mary's Hall, Rm 301
Dayton, OH 45469-1642

COVERAGES **CERTIFICATE NUMBER:** CLE-007008898-03 **REVISION NUMBER:** 0

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	X COMMERCIAL GENERAL LIABILITY			PCHE2023-18	07/01/2023	07/01/2024	EACH OCCURRENCE	$ 5,000,000
	CLAIMS-MADE / X OCCUR						DAMAGE TO RENTED PREMISES (Ea occurrence)	$ 5,000,000
							MED EXP (Any one person)	$ 2,500
							PERSONAL & ADV INJURY	$ 5,000,000
	GEN'L AGGREGATE LIMIT APPLIES PER:						GENERAL AGGREGATE	$ 10,000,000
	X POLICY / PRO-JECT / LOC						PRODUCTS - COMP/OP AGG	$ 5,000,000
	OTHER:							$
	AUTOMOBILE LIABILITY						COMBINED SINGLE LIMIT (Ea accident)	$
	ANY AUTO						BODILY INJURY (Per person)	$
	OWNED AUTOS ONLY / SCHEDULED AUTOS						BODILY INJURY (Per accident)	$
	HIRED AUTOS ONLY / NON-OWNED AUTOS ONLY						PROPERTY DAMAGE (Per accident)	$
								$
	UMBRELLA LIAB / OCCUR						EACH OCCURRENCE	$
	EXCESS LIAB / CLAIMS-MADE						AGGREGATE	$
	DED / RETENTION $							$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y / N						PER STATUTE / OTH-ER	
	ANYPROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBEREXCLUDED? (Mandatory in NH) N	N / A					E.L. EACH ACCIDENT	$
	If yes, describe under DESCRIPTION OF OPERATIONS below						E.L. DISEASE - EA EMPLOYEE	$
							E.L. DISEASE - POLICY LIMIT	$

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)

CERTIFICATE HOLDER
University of Dayton Proof of Insurance
300 College Park
Dayton, OH 45469-1642

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE
Marsh USA LLC

ACORD 25 (2016/03) The ACORD name and logo are registered marks of ACORD

Appendix D. Team Roster

Name	Year	Major	Responsibilities
Kaitlin Niebauer	Sophomore	BEE Electrical Engineering	**President**
Michael Wolf	Senior	BME Mechanical Engineering	**Interim President**, data acquisition system design
Ellie Opalek	Sophomore	BME Mechanical Engineering	**Treasurer**
Brian Piper	Senior	BME Mechanical Engineering	**Motor Team Lead**, outboard design & manufacturing
Sydney Guerin	Sophomore	BME Mechanical Engineering	**Hull Team Lead**
Jack Mueller	Sophomore	BCpE Computer Engineering	**Electrical Team Lead**
Cory Howley	Senior	BChE Chemical Engineering	**Technical Report Director**, propeller design & manufacturing
Lucy Westbrook	Sophomore	BSBA Marketing	**Business Team Lead**
Jack Erick	Senior	BME Mechanical Engineering	Electronics design
Elliot Stasek	Junior	BEE Electrical Engineering	Hull construction
Nick Yeoman	Senior	BME Mechanical Engineering	Hull construction
Lucas Cosentino	Junior	BME Mechanical Engineering	Outboard design
Courtney Prevost	Freshman	BME Mechanical Engineering	Steering system design

Name	Year	Major	Responsibilities
Erin Fox	Sophomore	BEE & BCpE Electrical and Computer Engineering	Electrical Enclosure Selection, Electrical Assembly
Brennen Geiger	Sophomore	BME Mechanical Engineering	Outboard Fairing Design
Rachel Guinee	Sophomore	Electrial Engineering	Electrical Enclosure Selection, Electrical Assembly
Molly Eure	Sophomore	BME Mechanical Engineering	General Hull Design and Construction
Brock Smith	Senior	BME Mechanical Engineering	General Hull Design and Construction

Appendix E. Sponsors

Company	**Product Obtained**	**Contact**	**Contact Email**
Ohio Space Grant Consortium (OSGC), Student-Innovative-Creative-Hands-on Project (SICHOP)	Grant	Rydge Mulford	rmulford1@udayton.edu
DHX Motors	*PEREGRiNE* P20 motor	Cameron Andersen, Su Mayor	cameron.andersen@dhxmachines.com, su.mayor@dhxmachines.com
Home Depot	Monetary Donation	N/A	N/A
Inmotion Technologies	ACS Gen 7 motor controller	Kaylan Sheally	kaylan.sheally@evs-inmotion.com ryan.kleiman@evs-inmotion.com
Kokosing	Monetary Donation	Jared Cebulski	jcebulski@kokosing.biz
Salt Boatworks	Flats River Skiff 14 - Microskiff Plans	Adam Parchman	adam@saltboatworks.com
UDRI	2x Wheel Chocks	Eric Troidl, Jake Browning	eric.troidl@udri.udayton.edu, browningj3@udayton.edu
UPS Batteries	3x UPS TLV12500F11 Batteries	Anton K.	anton@upsbatterycenter.com

Appendix F. 2024 Solar Splash Performance Analysis

Event	Heat	Time/Laps	Notes
Sprint	1	124.86	
	2	162.65	Propeller fastening key skipping
	3	131.82	
Endurance	1	18	Fastening issue on one charge controller causing uneven charging and premature battery discharge
	2	12	Key dislodged from propeller fastening, propeller fell off in the lake and was not recoverable
Slalom	1	135.67	
	2	DNF	FDM and fiberglass-reinforced propeller (replacing prop lost in Endurance 2) broke during event

Appendix G. Solar Panel Layout Design Report

Solar Splash Solar Array Technical Report

12/11/2024

Group Members:

John Rypinski

Harper Mitchell

Index:

Figures

Tables

Back Ground:

The Solar Splash Club is a group of students who work together to design and build a boat that runs completely on solar power. They spend weeks and months planning, designing, and creating parts to make their boat better and more efficient.After finishing the boat, they take it to competitions where we race against teams from other schools and compete in different events.

Deliverables:

The Solar Splash team has tasked us with designing a solar array that is both efficient and compact enough to fit on their boat. We need to ensure the design maximizes energy output while staying within the space limitations of the boat. At the same time, we must carefully follow the rules and regulations of the Solar Splash competition to ensure our design meets all the required standards.

Design Requirements:

- Boat specifications
- 13’9” length
- 49 ½” in width
- Driver sits at 7’ from the back of the boat
- Charge controller
- Max amps 35 amps
- Max Voltage 150V
- Batteries three 12 volt batteries

Option 1: New Solar Panels

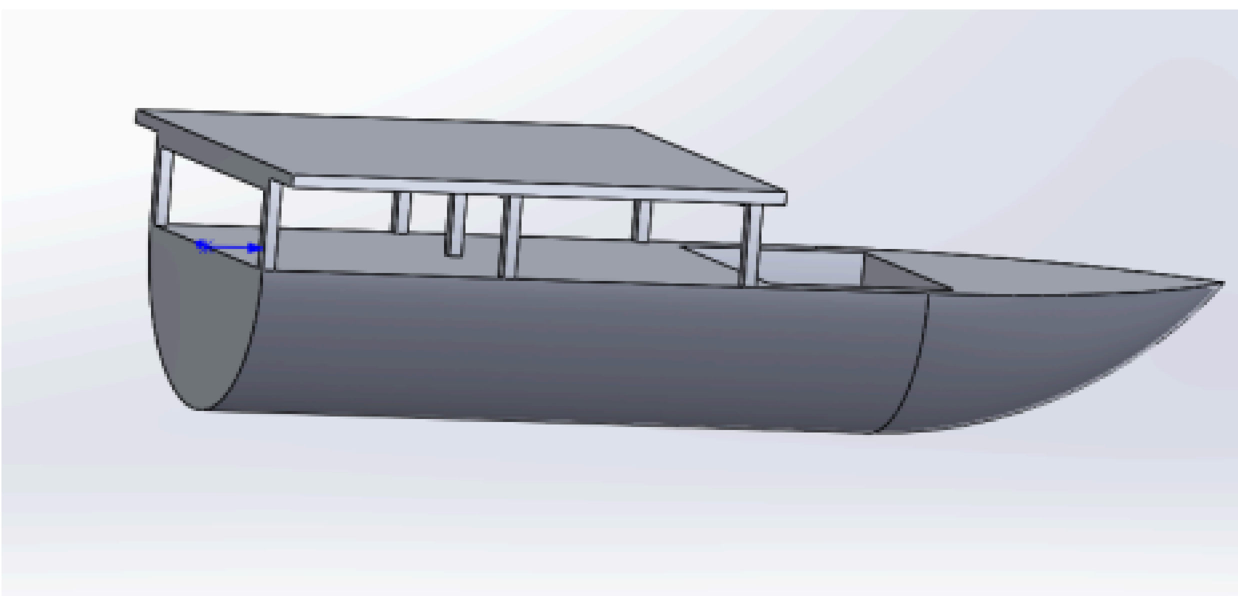


Figure 1: Option 1 Array Design

Option 1 will utilize newer solar panels that will have to be purchased from a third party supplier. Only 2 new panels will have to be purchased for this design as well as 80/20 and water proof wiring. The new panels are 360 watt panels with 120 cells. The panels will be connected in series to produce a total voltage of 68 volts and 10.62 amps. Which will pair well with the newly bought charge controller. The total weight of the panels will be 83 lb with the dimensions of 81.88” by 69.1”. With these dimensions the panels will have an overhang of 9.8” on each side of the vessel. To deal with this overhang we recommend using 80/20 to raise the panels 14” from the top of the boat, this also follows the rules of competition which is 1.5 meters above the boat. Having the panels raised will also eliminate some of the worries of the driver casting a shadow over the panels which will limit the output of the panels.

Cost Break Down and Materials:

Table 1: Option 1 Cost Break Down and Materials

Quantity	Item	Price Per Unit
2	Panasonic 360W Solar Panel 120 Cell EverVolt EVPV360PK	$351.57
3	T-Slotted Framing, Single Four Slot Rail, Silver, 1-1/2" SQ., Hollow, 4" Long	$5.65
7	T-Slotted Framing, Single Four Slot Rail, Silver, 1-1/2" SQ., Hollow, 2" Long	$ 4.41
16	Silver Corner Bracket, 1.5" Long for 1.5" High Rail T-Slotted Framing	$8.80
1	25 ft. 12/2 Gray Solid CerroMax Copper UF-B Cable with Ground Wire	$59.4
	Total Price	$951.16

Option 2: Reusing Current Solar panels

Table 2: Solar Splash's current panels

Panel #	Width [inch]	Height [inch]	Wattage [W]	Used in Last Years Comp.
1	32	52 ½	160	☑
2	32	52 ½	160	☑
3	21	41 ⅞	100	☑
4	21 ¼	47	100	☑
5	34 ⅝	51 ⅛	200	☑
6	32 ½	52 ½	160	✗

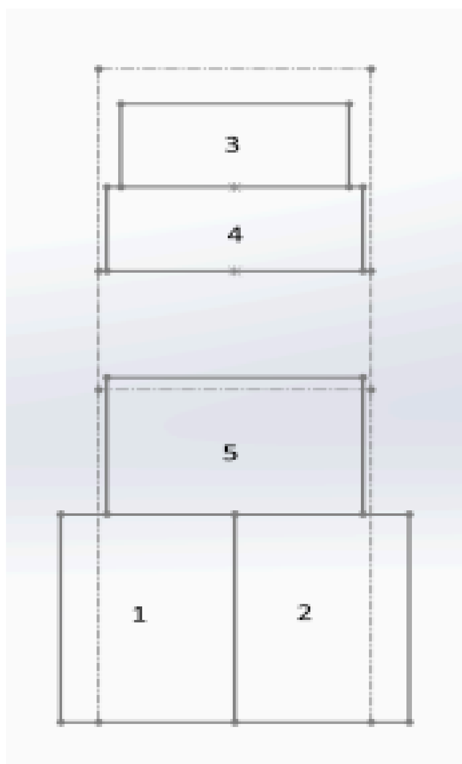


Figure 2: Configuration of current panels

Option 2 uses the newly purchased charge controller and the panels that the team currently owns. The challenge is maxing the panels Voltages at max power as if they are not close to each other it could lead to inefficiencies or damage to the panel with a smaller voltage. In figure 3 below it is shown how to wire the panels to ensure that this will not be a factor while also optimizing the voltage output of all the panels combined. Panels one and two have Vmps of 64.6 V, panel 3 20.4 V, panel 4 18.9V, and panel 5 55.8V. Panels 1 and 3, as well as 2 and 4 can be wired in series then each of those sub circuits would be wired in parallel. Finally panel five could be wired in series to give a final output of 139.3 V. This way of wiring eliminates the concern of damaging the panels while also maximizing the voltage output.

Wiring Diagram For Option 2:

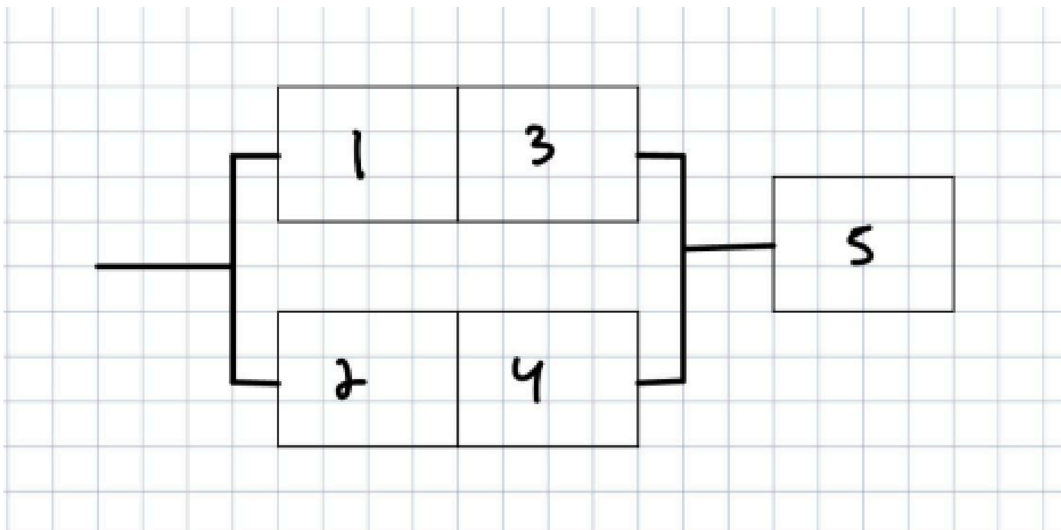


Figure 3: Wiring Diagram for option 2

Cost Break Down and Materials:

Table 3: Option 2 Cost Break Down and Materials

Quantity	Item	Price Per Unit
6	T-Slotted Framing, Single Four Slot Rail, Silver, 1-1/2" SQ., Hollow, 4" Long	$5.65
11	T-Slotted Framing, Single Four Slot Rail, Silver, 1-1/2" SQ., Hollow, 2" Long	$ 4.41
22	Silver Corner Bracket, 1.5" Long for 1.5" High Rail T-Slotted Framing	$8.80
2	25 ft. 12/2 Gray Solid CerroMax Copper UF-B Cable with Ground Wire Total Price	$59.4 $394.81

Decision Matrix:

Table 4: Decision Matrix

Safty	Out put	Cost	Rules	socore	Options
10	7	6	8.5		
100	70	18	85	273	Option 1
55	70	24	85	234	option 2

Conclusion and Recommendation:

In conclusion, we believe that option one is the superior choice, even though it comes at a higher cost of approximately $556.35. The simplified wiring design, with panels connected only in series, makes the solar array significantly more user-friendly and easier to troubleshoot during competition, saving valuable time and effort. Additionally, the newer solar panels in option one offer better performance and efficiency compared to the outdated panels in option two. Option one also reduces surface area coverage while maintaining the same wattage output, minimizing interference for the driver entering and exiting the boat. This improvement enhances both convenience and safety, making option one a more reliable solution. Furthermore, investing in modern technology aligns with long-term sustainability goals and provides a competitive edge. While option two could work for this application, we strongly recommend option one as the most practical, efficient, and forward-thinking choice.

Appendix:

[1]- Link to solar panels for option 1

https://a1solarstore.com/panasonic-360w-solar-panel-120-cell-evervolt-evpv360pk.html?utm_source=google&utm_medium=cpc&utm_campaign=Only_Clients_creativespack1_new20241016&utm_content=top_keywords&utm_term=&gad_source=1&gclid=Cj0KCQiAu8W6BhC-ARIsACEQoDAhEZBRKiDyL6G2QzL-1mQKhH4MT5tp_0UiDZ2yhSM6lAKk5lIzxjEaAoz_EALw_wcB

Appendix H: Monitored Motor and Charge Controller Parameters

Power Element	Controller Module	Data Acquisition Element	Value	Description
Motor	Motor Controller	Raspberry Pi 1	System Status	General status word providing system status information.
			Field Weakening Control Status	Status of the field weakening control
			Analog 1 Value	Value of the first analog input.
			Digital In Status	Status of any digital inputs (on/off or fault conditions).
			n_{ref}	Motor speed reference value
			V_{max}	Peak allowable voltage
			I_{max}	Peak allowable current
			V_{DC}	Inverter bus DC voltage
			I_{DC}	Inverter bus current
			T_{motor}	Motor Temperature
			$T_{inverter}$	Inverter temperature
			$I_{directaxis}$	Direct axis (d-axis) current component
			θ_V	Voltage waveform angle
			n	Motor rotational speed
			I_{RMS}	Root mean square of motor current
			$\mathscr{T}_{real}$	Torque applied to motor
			$\mathscr{T}_{apparent}$	Torque delivered by motor
Solar Array and Batteries	Charge Controller	Raspberry Pi 2	V_{PV}	Solar voltage
			I_{PV}	Solar current
			Battery Status	Battery charging status (bulk, absorption, float)
			V_{bat}	Battery voltage
			I_{bat}	Battery current
			$T_{controller}$	Charge controller temperature
			T_{bat}	Battery temperature

Appendix I: Funding Sources

Table X: UDSS sources of funding for the 2024-2025 school year

Funding Source	Amount
UD SGA Funding	$1,540.00
SICHOP Grant	$5,000.00
Kokosing Funding	$500.00
UD Fund Match	$6,250.00
2023-2024 Funds	$243.57