# Solar Splash Technical Report

Boat #1

The University of New Mexico

# Executive Summary

The Solar Splash competition is an annual showcase of the hard work of collegiate teams across North America to build solar powered boats and demonstrate their design prowess. The University of New Mexico (UNM) has participated in the competition since 2016 and managed to accrue a solid record of performance. The highest placement achieved by the team was third overall in the 2021, 2022, and 2023 competition. Last year's competition performance was the result of refining an in-house hull and solar panel setup.

The current market for mass-produced solar-powered boats is mainly limited to maximum range cruising boats. This project's goal is to design a high performance solar powered boat that not only has a reliable and competitive range but also has the capability for high-speed operation. The boat should be able to attain and sustain speeds for a period of time far exceeding the current commercially available models.

Increasing restrictions on cars using internal combustion engines will likely carry over to boats in the future. This project seeks to mirror the introduction of reliable hybrid and electric vehicles to the automotive industry by supporting the design of reliable electric vehicles to the small boat market. The option of having reliable electric vehicles will also become more appealing with rising energy costs, and the integration of solar systems to power these electric vehicles will become a valuable feature. As a result, this technology and its continued development is important for the future of the market.

The UNM team is one of few that competes in the Solar Splash competition with an entirely in-house designed and constructed hull. Last year, fabrication of a new carbon fiber hull was the primary objective for the team. This year the team worked to further reduce overall weight with multiple in house-built carbon fiber components and improve drive train components according to the 2025 Solar splash Rules [1].

The 2025 team is using solar panels from Sungold [2]. Six 120W panels are being used – the panels are arranged in three sets of two panels in series with the three sets connected in parallel to comply with the rules for commercially purchased solar systems. 120W panels were selected as they provide the easiest method of getting as close to the allowed 720W maximum while also providing an easy way to connect the solar system to the MPPT in a balanced and safe manner.

During 2025, the team made updates to the previous electrical system used in 2024. The old dual motor setup was forgone for a single Peregrine P-40 motor from DHX. In addition, the dual Curtis motor controllers were switched out for a single Kelly motor controller. The battery box received an upgrade with Newport batteries that provide a larger capacity while still remaining below the 100lbs weight restriction.

The steering system was changed from a single rudder to a dual rudder setup. This moves the rudder from behind the propeller in the wash into a more advantageous position. The new rudders were made in-house as well as all of the carbon fiber components of the steering system.

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# I. Overall Project Objectives

The UNM team placed third overall in the 2024 Solar Splash competition. This year, the team wanted to continue improving upon the 2024 team's design.  To accomplish this, the team modified the carbon fiber hull, beginning with its carbon fiber rim. The previous year's resin was not cured correctly due to colder weather. The old carbon fiber rim was removed, and new strips were added, along with additional carbon fiber reinforcement for mounting components.

After the restoration of the hull rim the team began to reassemble the boat and prepare for a lake test. The boat was re-assembled with a motor setup like that used by the UNM team in endurance events in 2022 and 2024. Even with the lightweight hull, the results from the in-water testing with a single LEM motor yielded a top speed of 16.8 mph, which was deemed unsatisfactory.

*Figure 1: 2025 Team Lake test day 1*

*Figure 2: 2025 lake test day in water trial run*

Based on the test results and component availability, a decision was made to keep the single-motor configuration but to redesign the entire drivetrain with new batteries, motor, controller and additionally create an all-new dual rudder steering system. The team also focused on reducing the weight of preexisting components by manufacturing them out of carbon fiber. The team took on the challenge of designing its own prop to maximize its top speed and endurance capabilities.

The 2025 team replaced the motor controllers used on the 2024 boat with a single new controller. The previous Curtis motor controllers could no longer be utilized, and a new powertrain system would be implemented. Although the previous 2024 Curtis controllers did solve the overheating issue, the new Kelly controller is a water-cooled controller, so a radiator system had to be implemented as well.

## II. Solar System Design

### *A. Solar System Design*

The solar system consists of six 120W flexible solar panels from Sungold [2]. The panels are arranged in three sets of two panels in series. These modules are then connected in parallel and connected to the MPPT. A simplified schematic of the panel connections is provided in Figure 1.

Each panel is rated for an open-circuit voltage of $V_{oc} = 23.3V$, a maximum operating voltage of $V_{mp} = 17.8V$, and a maximum operating current of $I_{mp} = 6.74A$. This means with the panels connected as described above, the net solar system maximum open circuit voltage is $\Sigma V_{oc} = 2 * 23.3V = 46.6V$, the net maximum load voltage is $\Sigma V_{mp} = 2 * 17.8V = 35.6V$, and the total solar system power output is $P_{sys} = \Sigma I_{mp} * \Sigma V_{mp} = 20.22A * 35.6V = 719.832\ W$.

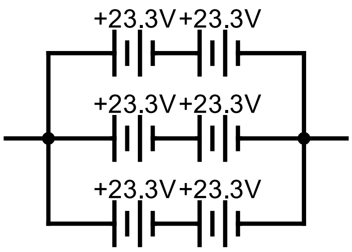


*Figure 3: Schematic of Solar Panel Connections*

With these specifications and schematics, the solar system is compliant with the 2025 rulebook. The total system power output is less than the maximum rating of 720W (Rule 7.3.3), the maximum rated operating voltage does not exceed 36VDC, and the maximum open circuit voltage does not exceed 52VDC (Rule 7.3.6).

### *B. Solar System Mounting and Fixturing*

The 2024 competition team repurposed a previous year's solar system mounting system which consisted of large carbon fiber decks that sat on top of the hull of the boat. The decks consisted of three layers of 3K 2×2 twill carbon fiber and a foam core material to increase stiffness. The solar panels were then bolted to the decks. These decks were originally used as a backing for in-house built solar arrays which, unfortunately, became damaged and unusable in previous years. These decks were relatively heavy and contained much more material than was necessary for panel mounting. To reduce weight, a different mounting system was developed.

In conjunction with an advanced manufacturing group at Sandia National Laboratory, carbon fiber angle bars were manufactured with pre-impregnated carbon fiber and an autoclave. These angle bars were assembled into frames that the solar panels were mounted to. The frames are then mounted to the hull via carbon fiber angle brackets and bolts.

There are three main solar panel sections: the bow, the stern, and the midships. The stern section consists of two panels mounted side by side along the width of the boat overhanging the back. The midships section consists of three panels mounted side by side along the length of the boat just in front of the cockpit and dashboard. The bow section consists of the remaining panel mounted with the long axis of the panel parallel with the long axis of the boat.

The main requirement for the new mounting system was that the power-electrical system of the boat be easily accessible. Two design alternatives were considered to satisfy this requirement: make the midship frame easily removable or add a simple hinge to the midships frame allowing two of the three panels to be folded over towards the bow. It was decided that adding a hinge to the midship panels would not be difficult and allowing the panels to fold over would make accessing the electronics much easier than having to un-fasten and remove the entire midships frame every time.

To achieve the folding functionality, two of the three midships solar panels are assembled into one frame and the third midships panel is assembled into a standalone frame. The two frames are then attached to one another by a pair of commercial-off-the-shelf low profile hinges. The standalone midships frame is fastened semi-permanently to the hull while the double midships frame is fastened in a way such that it is easier to free the frame from the hull, which makes it trivial to unfasten and fold the panels over towards the bow. The folding panels are laid out in such a way that even if the double midships frame were to become unfastened from the hull while the boat is in motion the airflow would force the panels into the boat instead of being blown open.

# III. Electrical System

This year, the team improved the boat's electrical system by replacing the Curtis motor controllers and dual brushed motors with a Kelly KLS 8080N controller and PEREGRINE Brushless Motor, with the expectation of improving efficiency and reducing overheating. The new powertrain system utilizes liquid cooling, which necessitated the addition of a cooling system. The key box's organization was streamlined to transplant it into a smaller chassis. Many wires and connectors were also replaced for simplification and to allow use with the new Kelly controller. The cooling system uses dual radiators from a Kawasaki kx250F motorcycle, which were chosen for their light weight and efficiency. The radiators are connected in parallel to the motor and motor controller to disperse heat more rapidly, further addressing the overheating issues of previous years. Manuals of the Motor and controller can be found in Appendix G and H

# IV. Power Electronics System

## A. *Current Power Electronics System*

Pairs of solar panels are connected in series to produce 48V nominal. The pairs are connected in parallel with three similarly arranged sets and wired to an MPPT charge controller to provide power to the batteries. The MPPT steps the voltage down to 36V to match the voltage of the batteries. Three 12V, lead-acid, deep-cycle marine Newport Vessels batteries are connected in series to create a nominal 36V power system. This is the maximum voltage allowed by the Solar Splash competition rules. These batteries each weigh 30 lb. and can produce a total of 150 Ah of capacity. More information about these batteries is provided in

Appendix A. The total weight of the three batteries is 90lb, which meets the competition restriction for a maximum weight of 45.5kg (100.3 lb.). Power from the batteries is then passed through a series of safety fuses, switches, and a meter to monitor the system power. The motor speed is controlled through a potentiometer which sends a low power signal to the Kelly controller which is then sent to the motor to turn the drivetrain.

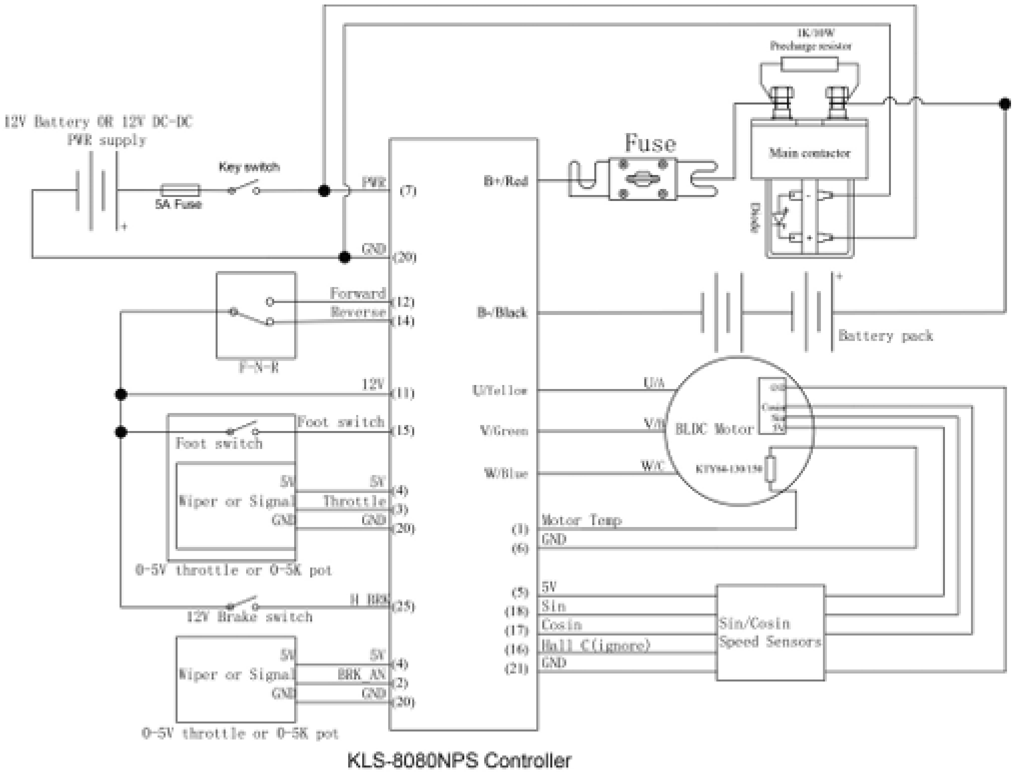


*Figure 4: Circuit Diagram of the Current Power Electronics Configuration*

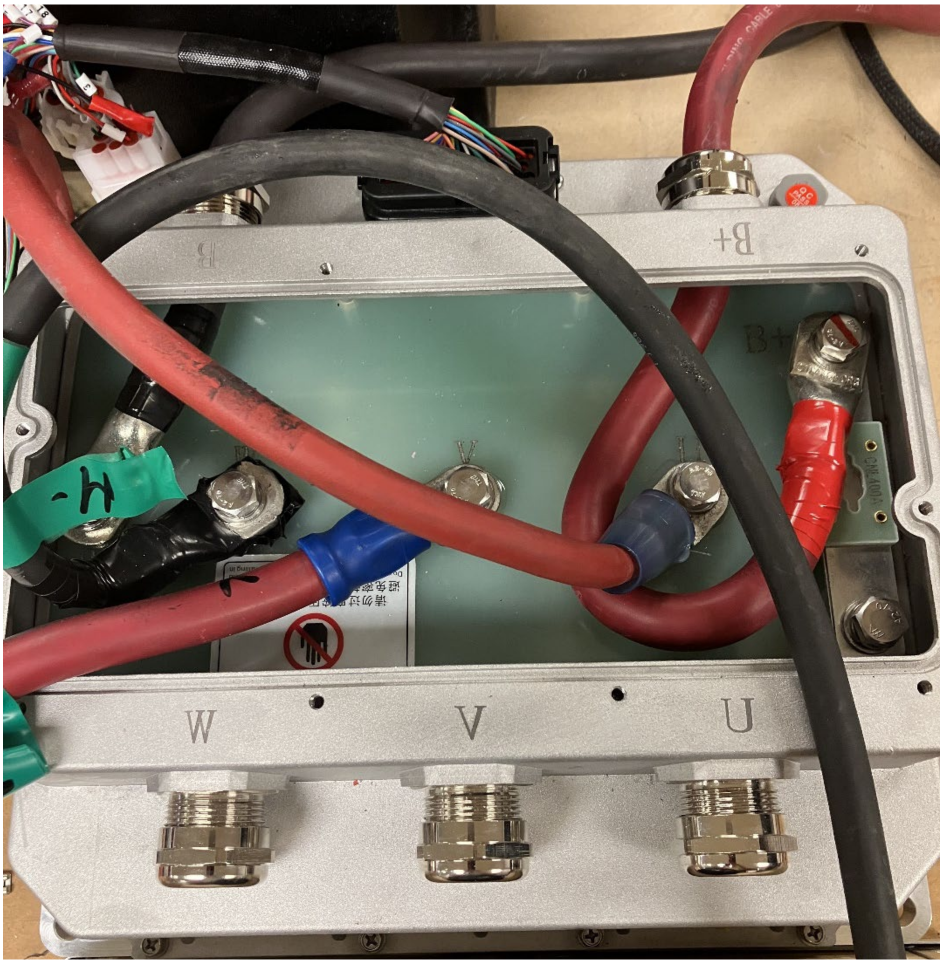

*Figure 5: Set-up for Motor Controllers*

### *B. Analysis of Design Concepts*

The goal of the power electronics system is to ensure successful and efficient operation of the boat. This is accomplished through processing high currents to generate power, which can then be delivered to the drivetrain. The system is powered by a solar array and thus generates DC power. The batteries also output DC power, which is then used to power the boat.

### *C. Improvements to the Power Electronics System*

The main improvement made to the Power Electronics system this year is replacing the Curtis motor controllers with the liquid cooled Kelly motor controller. During the 2021 competition, the team noticed a problem with the Alltrax controllers overheating. The 2022 team addressed this issue by vertically mounting the motor controllers and implementing a cooling system for the controllers using a 3D-printed fan mounted to the drive shaft.

In the fall, the 2023 team had the opportunity to open a damaged Alltrax controller to examine the controller design. It was found that the metal heat sink for the controller was encased in plastic – a major design flaw which was likely causing previous teams' overheating problems. The team concluded that acquiring new motor controllers with heat sinks free from plastic casings was the optimal strategy for progress. After researching, the team found motor controllers from Curtis were compatible with the current power electronics system requirements.

For the 2025 team, to avoid further overheating issues, it was decided to use a Kelly KLS-8080N motor controller with a brushless PEREGRiNE motor. Both the motor and controller feature liquid cooling. The motor and controller are cooled in parallel by a pair of Tusk Aluminum Radiators from a 2016 Kawasaki KX250F motorcycle. The radiators are cooled by a set of electronically controlled pull fans. To conserve power, the fans are wired to a digital controller that activates the fans when the radiators reach a certain temperature. The new motor controller is also an inverter which allows for the use of an alternating current brushless motor. This greatly reduces the internal resistance of the motor, allowing the boat to have overall improved endurance and be less susceptible to overheating.

# V. Carbon Fiber Manufacturing

### *A. Carbon Fiber Hull*

### *IV. Analysis of Design Concepts:*

Construction of a carbon fiber hull was accomplished in 2024, yielding a much lighter hull than the previous marine-grade plywood hull. This process involved using the older boat as a male mold, thermoforming the foam core, and then completing another layup onto the core. The use of a carbon fiber hull propelled the 2024 team to a 3$^{rd}$ place that would not have been possible without the extreme weight reduction. The 2025 team opted not to replace the hull, and to instead reduce weight in other areas.

### *V. Composites Fabrication Process*

The carbon fiber layup process consists of a three-step process of preparing and designing the mold, laying up the composite material, and post-processing. The design process of the mold is generated using CAD, or by thermoforming Gurit Corcell structural foam core using a heat gun to form the shape of the mold. It is important to ensure that the surface of the mold is clean, smooth, and ideally coated with a mold release agent to prevent sticking. Once the mold is prepared, the carbon fiber fabric is cut to the size and shape of the mold. The stacking sequence of the carbon fiber depends on the structural integrity required for the design. For components requiring a lower amount of load, reducing the number of layers is essential to achieve a lightweight product. The orientation of each layer was 90° for our dry and pre-impregnated carbon twill weave. Materials were cut out to apply to the mold to prevent the carbon fiber from sticking. These materials include peel ply, breather cloth, and a vacuum bag to seal the mold.

Once the materials were prepared, the layup process was conducted by first applying a layer of peel ply to the mold, followed by a coating of epoxy resin. The dry carbon fiber was then applied one layer at a time followed by another coating of epoxy resin. For pre-impregnated carbon fiber, the resin is already imbedded into the fabric, and the layers are placed and consolidated. Once the desired number of layers is constructed with epoxy resin applied, another layer of peel ply and a layer of breather is placed onto the surface of the carbon fiber. The entire mold and carbon fiber is wrapped in a vacuum bag that is pulled from a pump to compress the layers tightly. The vacuum process takes 24-hours to allow for the resin to cure in a room temperature environment for dry carbon fiber, or at 212° for 120 minutes for pre-impregnated carbon-fiber.

Post-processing of completed carbon fiber composite layups includes trimming, clear coating, assembly, and in some cases adhesion to a honeycomb core for additional support. In the case of the 2025 Solar Splash team, the wet layups were taken from the vacuum bags by first removing the vacuum from the layup and setting aside vacuum puck and pump. The composite is covered in excess resin due to the decreased pressure inside the vacuum bag layup, so the layers of material need to be peeled off carefully. Starting with the breather material that absorbs the excess resin, which can be easily peeled off the perforated material which is used to evenly distribute resin as it is infused with the carbon fiber. The peel-ply material is removed next, and is used for easy removal of the carbon fiber to the preceding materials. The carbon fiber composites are then trimmed to size using a Dremel and proper PPE to prevent carbon fiber dust inhalation. After trimming, the carbon fiber composites are clear-coated to prevent the carbon from getting wet, as well as aesthetics. From here, the composites are ready to be mounted to the boat for assembly, using a drill and standard hardware.

*Figure 6: Forming Gurit Corecell Foam Mold to the Hull*

# VI. Drive Train and Steering

### *A. Drive Train and Propeller*

Previous UNM Solar Splash teams designed and implemented an inboard motor system for the boat. A single motor was used for the endurance configuration, and two motors were used for the sprint configuration. Based on the calculations conducted by previous teams, which analyzed the pros and cons of both inboard and outboard motors, it was concluded that an inboard motor would be the most suitable option. Additionally, considering the previous team's calculations to determine the ideal number of motors and their configuration for each race, the 2025 team is assured that the newly manufactured hull will require only one motor for both the endurance and sprint races.

*Figure 7: Fiberglass Layup to Form Mold for Carbon Fiber*

*Figure 8: Final Fiberglass Mold to Use for Carbon Fiber Layup*

The 2025 team had reviewed motor and drive train setups from earlier years of the competition. It was determined that the single motor setup was optimal for the events that the boat would be competing in: the dual-motor setup shown in Figure 9 carries a weight penalty for the endurance race which was run on one motor. The single-motor setup eliminates the weight of the second motor and the second controller and simplifies the system. The 2024 hollow carbon fiber driveshaft was reused with a small adaptation to the aluminum adaptor on the keyed end at the vibration damper connection. This required turning the aluminum driveshaft end down slightly from 25.4 mm to 25 mm to accept the same vibration damper as the motor, removing the need for the previous designs elaborate shaft adaptor, and allowing the motor to move rearwards. The driveshaft also reviewed a new axial retention system including a thrust clamp and axial bearing (riding against the stern side of the driveshaft carrier bearing plate) to prevent axial forces from the propeller from damaging the motor.

New mounting plates for the motor and driveshaft carrier bearing were fabricated from 0.25” 6061 Aluminum (as opposed to .125” sheet aluminum from previous design) to adapt to the setup, their location was updated to streamline the design. A new vibration damper assembly was added to allow the new motor to mate to the driveshaft. This new driveshaft support and motor interface design not only simplifies but reinforces the strength and rigidity of the drivetrain, while aiming to minimize unnecessary wear on the motor.

Two distinct propeller designs were developed based on the performance characteristics of the P40 motor. The acceleration propeller was designed to maximize thrust output by matching the blade geometry to the motor’s peak torque under peak current load conditions. Using the motor’s torque and RPM specifications, the blade pitch and chord distribution were optimized to generate high thrust at low to moderate speeds, providing superior acceleration during the sprint race and maneuvers which require fast acceleration.

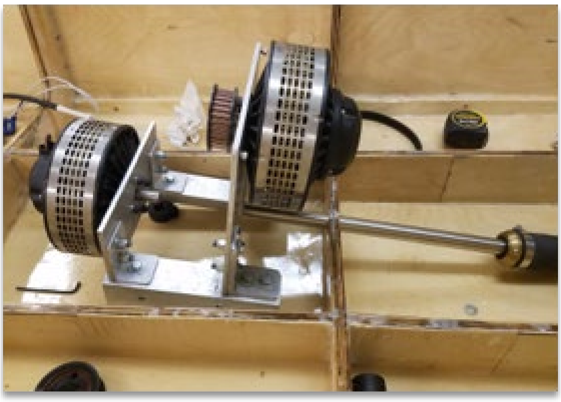

*Figure 9: Previous Motor and Driveshaft Setup for Drivetrain*

Conversely, the efficiency propeller was designed with a focus on minimizing energy consumption while maintaining a competitive cruising speed. Although it produces significantly less thrust compared to the acceleration propeller, the efficiency propeller was carefully optimized to match the designed nominal cruising speed. This ensures that the boat remains competitive during endurance phases while extending operational time by reducing overall power draw.

Both propellers were fabricated using PPA-CF filament, a carbon-fiber reinforced nylon material. PPA-CF was selected for its combination of exceptional mechanical strength, dimensional stability, and low weight, all critical factors for high-performance marine applications. The lightweight nature of the material reduces rotational inertia, enhancing motor responsiveness and overall system efficiency, while the carbon-fiber reinforcement ensures durability under continuous hydrodynamic loads.

The two propeller designs offer complementary performance characteristics tailored to specific race strategies, both contributing to the overall competitiveness and adaptability of the overall design. Design specifications of each of the propellers are as follows.

| | Acceleration | Efficiency |
|---|---|---|
| Design speed | 5 m/s | 5 m/s |
| Design thrust | 3 kN | 1.5 kN |
| Peak RPM | 2800 | 1500 |
| Motor power | 15 kW | 7.5 kW |
| Blade profile | NACA 66 | NACA 65A010 |

Figures 10-12 provide further information about the propeller characteristics and an illustration of the CFD results.

### *B. Steering*

The team's current steering system design is our best to date, with a more intuitive steering system than in previous years. Implemented in 2022, this design replaced the previous tiller and handlebar throttle with a 12.5" diameter steering wheel with a suicide knob for one-handed steering control, see Figure 13, and a lever-based throttle controller (Figure 14).

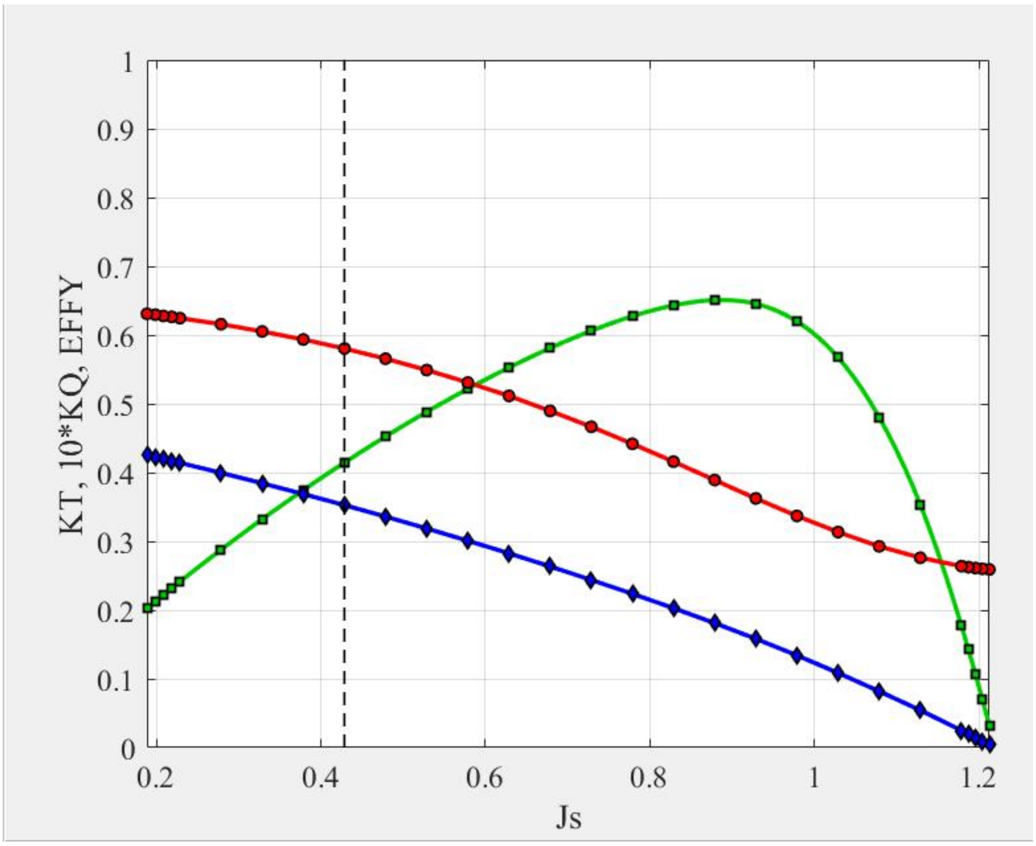


*Figure 10: Acceleration Propeller data, green is efficiency*

*Figure 11: Acceleration Propeller CFD analysis*

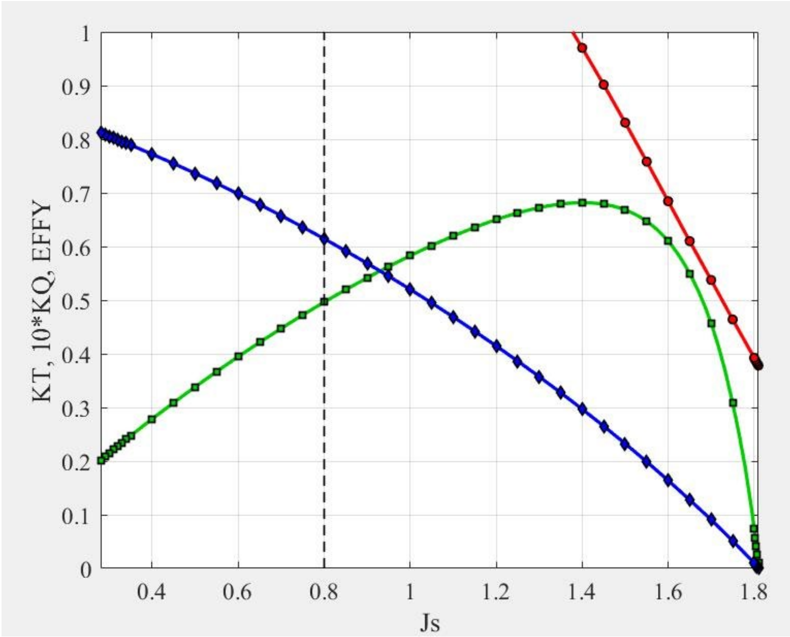


*Figure 12: Endurance Propeller  Data, green is efficiency*

The wheel has a 5" inner diameter wired to a pintle that controls the rudder system. The design allows a maximum rudder movement of 1.22 radians, which allows for 35 degrees of rudder rotation in each direction. Like an automotive steering system, the boat's steering wheel system is designed to undergo several rotations before locking occurs in one direction. The decision was made that two complete rotations before the steering wheel locks is the optimal number of rotations, with the angle between the two locking ends computed as 12.6 radians. This leads to a turning ratio of 1:10.32.

*Figure 13: Steering Wheel with Suicide Knob*

In addition to the user controls for steering and acceleration implemented in 2023, the previous steering mechanism, manufactured using a rope strung through four pulleys fixed to the side of the boat, was almost entirely redone. The rope was replaced with braided steel wire, providing higher strength, while the two aft-most pulleys were replaced with custom tensioned pulleys. This was done to address issues with the rope becoming slack when the wheel is fully turned, the spring-loaded pulleys allow for the tension to persist on the steel rope through the entire turning cycle, resulting in more precise turns. In addition, the steel rope enables the use of a turnbuckle which allows the skipper or support team to fine tune the steering tension easily and fast, improving rider comfort by making steering smoother.

*Figure 14: Throttle and Composite Steering Pintle*

The previous single-rudder design, sporting a single Balsa wood rudder (Figure 15) affixed to an aluminum rod, was entirely replaced with a fully carbon fiber double-rudder system. The single-rudder design ran the aluminum rod through an opening on the back of the boat, where its end was secured to the rope of the steering mechanism. Movement of the rope would then translate to the movement of the rudder, resulting in the steering specifications mentioned above. The double-rudder design mirrors this concept by replacing the aluminum rod with a carbon fiber beam. The carbon fiber beam is fixed at a point on the back of the boat using a bearing, allowing for smoother turns. The beam is then attached to a cross piece, also manufactured using carbon fiber, where the cross piece is fixed to the carbon fiber rudders using bearings. As the beam is attached to the steering mechanism in essentially the same way, the steering specifications experience no change between the two systems, while also significantly improving the steering performance.

*Figure 15: Balsa Wood Rudder*

The carbon fiber rudders were manufactured by the UNM Solar Splash team and ultimately replaced Balsa wood as a rudder material due to being significantly lighter and stiffer; the single Balsa wood rudder weighs approximately 11.9 pounds, while the carbon fiber rudders weigh approximately 5.4 pounds each. The shape and size of the carbon fiber rudders were modeled to mimic the Balsa rudder shown in the figure above. Using carbon fiber as the rudder material also ensures that these rudders have a much greater strength to weight ratio than the wood and aluminum alternatives. This is due to having been manufactured with multiple layers of carbon fiber and clear coating. Furthermore, having two lightweight rudders provides a sharper turning response, allowing for more leverage on the water, as well as a tighter turning radius. In summary, the increased rudder surface area leads to a stronger turning force, which makes it easier for the skipper to maneuver the boat [3].

*Figure 16: New Carbon Fiber Rudder with Old Balsa Wood Rudder*

The manufacturing of the twin rudders began with an Owens Corning Foamula 250 foam core, which was cut and sanded into the appropriate geometry. This included sanding the foam into the right thickness as well as getting the air foils on both sides of the rudders rounded and feasible for water applications. Once the sanding was complete, a single carbon fiber layup was completed. This was done with an epoxy solution consisting of 5 parts West System 105 epoxy resin, 1 part West System 206 slow hardener, and 3 parts Fiberglast 23 silica. This layup was a success, only leaving a few rough edges after curing and sanding. To increase strength and provide full carbon fiber rudders, a second carbon fiber layup was applied to the original, leaving the team with two lightweight, carbon fiber rudders. A clear coat was swiftly added for aesthetics and to reduce any water intake vulnerability. The final twin rudders can be seen in Figure 17.

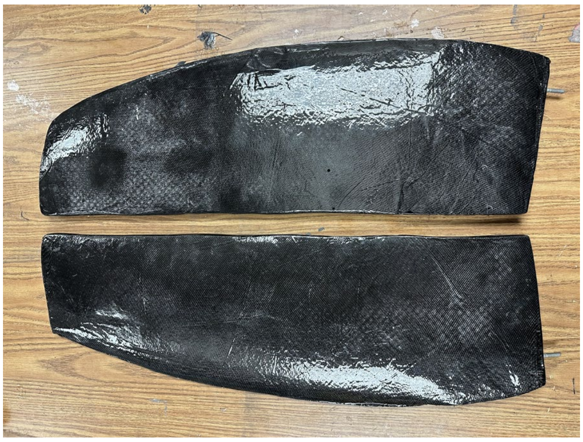

*Figure 97: Twin Carbon Fiber Rudders*

## VII. Data Acquisition and Communications

In the past few years, the data acquisition system has not been as high of a priority for the team as modifications to the hull, solar array, and drivetrain assembly. Regrettably, the team did not have time this year to make improvements to this system but does recognize its importance and suggests that future teams make a dedicated effort to improve the boat's data acquisition and communication system.

The team currently uses GPS speedometers to gather information about the boat's top speed during on-the-water testing and races at competition. This provides the team with a numerical comparison between different tests where the number of motors, battery voltage, propeller, and placement of items in the boat are varied.

Along with the speedometers, an aerial drone with an on-board camera and recording capabilities was used to obtain visual information about on-the-water tests. The footage from this camera allowed the team to observe the angle that the hull makes with the water at various speeds. Thus, making it possible to determine whether or not hydroplaning was achieved during a test. The video also illustrated the depth of the water displaced by the back end of the boat – which is emblematic of its drag. This meant that the team was able to compare the effects that different setups had on the boat's drag.

Additionally, the team uses an application that can be downloaded from Google Play and the Apple App Store created by Victron Energy [4]. This app is compatible with both the current boat's Victron battery box and Victron maximum-power-point-tracking (MPPT) solar charge controller. The app allows the user to access real-time information about the output of the solar array (wattage, voltage, current) from the MPPT, and information about the state of the batteries (remaining voltage, voltage draw, total amp-hours consumed). The team uses data from the app to perform calculations during the endurance event to determine the optimal speed of the boat which ensures complete depletion of the batteries during the 2-hour race.

## VIII. Project Management

### *A. Team Members and Leadership Roles*

The UNM Solar Splash team continued its egalitarian leadership style that was adopted in 2022. Each member of the team was considered an equal, and every member was expected to contribute the same amount of effort to the project.

With this year's leadership style, small groups were formed to carry out specific tasks, but team members were encouraged to participate in multiple projects in order to improve communication. Instead of designating team leads, more experienced members trained the new team members to ensure that everyone was up to speed on the status and function of each of the boats' systems. The remaining management duties were split up among the team – such as purchasing, writing meeting summaries, and sending out updates about team activities.

### *B. Project Planning and Schedule*

The UNM 2025 Solar Splash team was formed in August of 2024. One of the primary goals of the team was to reduce overall weight and maximize power. The team prioritized the weight reduction due to long lead times on power systems parts. Weight reduction included new decking for solar panels, a carbon fiber dashboard and a carbon fiber dual rudder system. In addition to reducing weight, the dual rudder system provides less drag and better steering response. While new power systems parts were on order the team used the legacy dual motor setup for the on-water tests. A complete overhaul of the power electronics system was required, which was put on top priority once the parts were in hand. Most planning occurred with exceedingly short turnaround periods as relevant tasks surfaced. Subsequently, all electromechanical parts were securely attached in their finalized positions, marking the completion of the assembly process.

### *C. Financials and Fundraising*

The team relied on a website to attract more donors and to recruit more students to the project. This website provides potential donors with information about the UNM Solar Splash team, past accomplishments, current work, and the competition. There is also a page solely dedicated to sponsors: https://solarsplash.unm.edu/donate.html. This page contains information about how to donate to the team and what can be donated (funds, parts, tools, technical expertise, etc.). There is also a section to thank all the team's current sponsors by posting their company logos.

### *D. Strategy for Team Continuity and Sustainability*

As mentioned in the preceding section, the team relied on the existing website. In addition to the information for potential sponsors, there is also a significant amount of material dedicated to attracting new team members – including detailed instructions on how to join the team. Flyers, such as the one in Figure 18, were printed and displayed in the UNM engineering buildings pinboards and were emailed out to all mechanical and electrical engineering students at UNM via departmental list service.


*Figure 18: Example of Recruitment Flyer*

Finally, the UNM Solar Splash team is designed to consist of both undergraduate and graduate students. This helps to ensure team continuity because students who are participating on the team as seniors this year can continue as graduate team members next year. These more experienced members will be able to mentor the new team members in the fall.

### *E. Discussion and Self-Evaluation*

Supply chain issues were of great detriment to the team this year and were pervasive throughout the ordering process. The team adapted to these setbacks by making as many improvements as possible with the supplies that could be obtained, and as new materials arrived. This meant completing tasks in a different order as planned and giving preference to items that could be bought at local stores.

# IX. Conclusions and Recommendations

The team's primary objective this year was to reduce the overall weight of the boat. This improvement should lead to improved performance in all three races in the competition. The hull weighs approximately 85.6 lbs. Major weight reduction was completed with the new solar panel mounts, and new steering system.

The team did not make significant changes to the boat hull. The electrical system was improved with larger capacity batteries, new motor controller, and a new motor. The team chose to use the same solar array as the 2024 team after performing a careful assessment. Additionally, the drive train was simplified, and the steering system was upgraded to a dual rudder setup. This will allow the skipper to steer the boat more easily using a steering wheel and lever throttle. Finally, no major changes were made to the data acquisition and communication system this year.

Overall, the majority of the team's time and effort this year was dedicated to the manufacturing of lightweight parts and upgrading of major components. The team encourages future members to analyze these systems and compare them with boats that ranked higher than UNM at competition to identify areas that could be improved upon when more time is available.

The team members this year learned many important skills related to fabrication with composite materials and the wet lay-up process. This hands-on experience was beneficial in demonstrating the importance and function of the engineering design and manufacturing process. Furthermore, the students can utilize their composites expertise in their future careers.

## References

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[4] V. Energy, "Victron Connect," [Online]. Available: https://www.victronenergy.com/panel-systems-remote-monitoring/victronconnect. [Accessed 27 04 2023].

## Acknowledgements

The UNM Solar Splash team would like to thank all our sponsors for their generous support of our project. Roger Koerner, Exxon Mobile, and Roy Hogan have made monetary donations to our team which provided funding for purchasing materials for the project and for travel to the Solar Splash competition. Gurit donated PET foam core for the construction of a new carbon fiber hull.

The team would also like to thank Dr. Peter Vorobieff for his mentorship and support throughout the year.

# Appendix A: Flotation Calculations

The buoyancy force of the hull was calculated using its volume. To find the volume of the hull, it was modeled in Solidworks and the 'Mass Properties' tool was used to find the volume of the solid body. This is shown in Fig. 22. The volume of the hull was found to be 9444.25 $in^3$ which when converted to cubic feet gives 5.466 $ft^3$. The volume of the other components inside of the boat which were estimated to be 4.5 $ft^3$. From here, the buoyant force was calculated using Archimedes' Principle, which states that the buoyant force is the product of the specific weight of the fluid and the volume of the body [7].

$F_B=\gamma V$ $FB=\gamma V$

In this case the fluid used is water which has a specific weight of 62.4 $lb/ft^3$ [7]. Multiplying the specific weight by the sum of the components' volumes gives a buoyancy force of 621.5 lb.

As was described in the Hull Design section of the report, the densities of the materials for the carbon fiber hull were used to obtain a theoretical weight for the new hull since it had not been constructed at the time of writing this report. The estimated weight of the hull was 100 lb. To add an extra level of safety for the floatation calculations, the team is going to overestimate this weight and use a value of 150 lb. for the weight of the hull. The weights of each of the components in the boat are contained in Table 1. With the 20% safety factor on the total weight of 375 lb., a buoyant force of 450 lb. is required, which is far exceeded by the 621.5 lb. buoyant force the boat has.

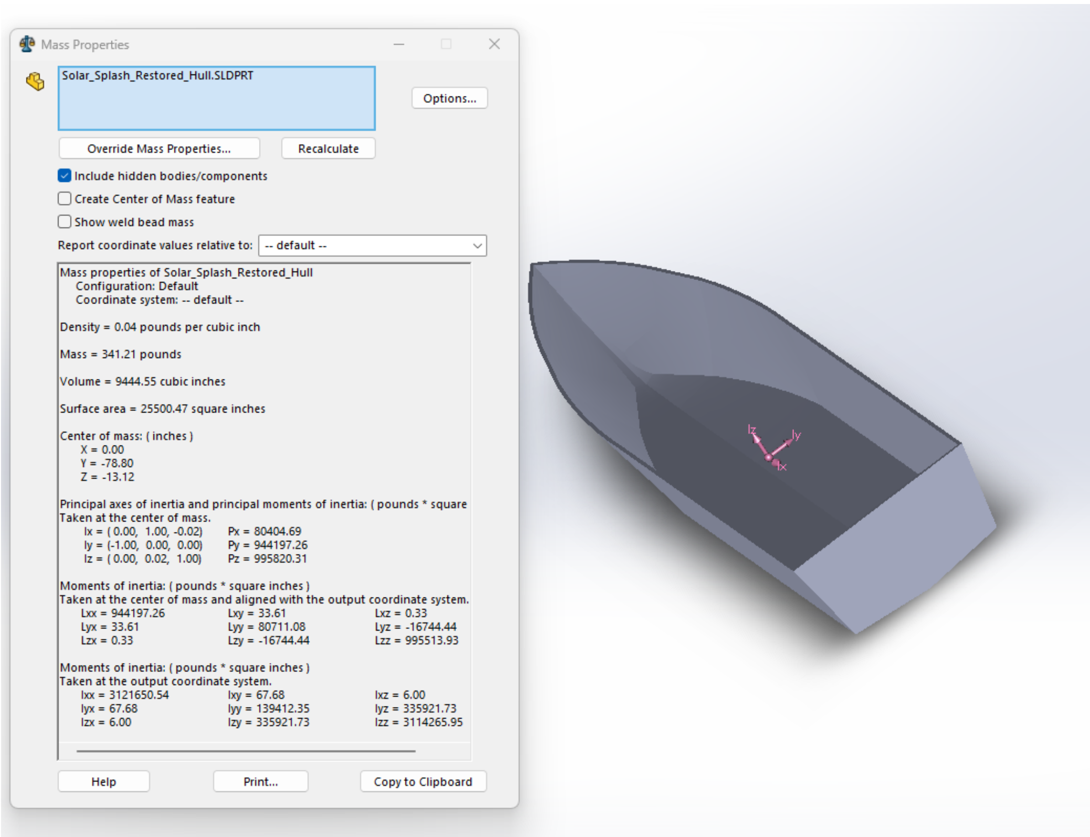



*Figure 10: SolidWorks Volume of the Boat Hull*

*Table 1: Weight of Boat Components*

| Object | Weight (lbf) |
|---|---|
| Hull | 85.6 |
| Motors and Drive Train | 75 |
| Battery Box | 99 |
| Solar Array | 25 |
| Misc. Components | 25 |
| **Total** | **309.6** |

# Appendix B: Battery Info

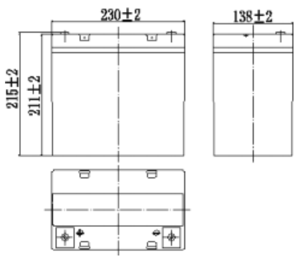
## NPD12-50Ah 12V50Ah

Valve Regulated Lead Acid Battery

● Specifications

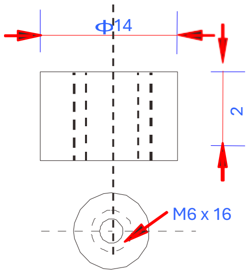
| | | |
|---|---|---|
| Nominal voltage | | 12V (6 cells per unit) |
| Rated capacity (10HR) | | 50Ah/10.8V |
| Dimensions | Length | 230±2mm (9.06inch) |
| | Width | 138±2mm (5.43inch) |
| | Height | 211±2mm (8.31inch) |
| | Total height | 215±2mm (8.46inch) |
| Approx. weight | | 17.30kg (38.10lbs)±3% |

● Outer dimensions (mm)




● Terminal type (mm)

T14




Torque:

● Characteristics

| | | |
|---|---|---|
| Capacity (25°C) | 10HR (10.8V) | 50Ah |
| | 3HR (10.8V) | 39Ah |
| | 1HR (10.5V) | 30Ah |
| Terminal type | | T14 |
| Internal resistance (Fully charged, 25°C) | | Approx. 6.5mΩ |
| Capacity affected by temperature (10HR) | 40°C | 102% |
| | 25°C | 100% |
| | 0°C | 85% |
| | -15°C | 65% |
| Self-discharge (25°C) | 3 months | Remaining capacity: 91% |
| | 6 months | Remaining capacity: 82% |
| | 12 months | Remaining capacity: 65% |
| Nominal operating temperature | | 25°C± 3°C (77°F± 5°F) |
| Operating temperature range | Discharge | - 15°C~ 50°C (5°F ~ 122°F) |
| | Charge | - 10°C~ 50°C (14°F ~ 122°F) |
| | Storage | - 20°C~ 50°C (-4°F ~ 122°F) |
| Float charging voltage (25°C) | | 13.50 to 13.80V Temperature compensation: -18mV/°C/Block |
| Cyclic charging voltage (25°C) | | 14.50 to 15.00V Temperature compensation: -30mV/°C/Block |
| Maximum charging current | | 15A |
| Maximum discharge current | | 500A (5 sec.) |
| Design life | | 10 years for floating (25°C) |
| | | Eurobat (20°C): 10/12 years, long life. |

● Construction

| Component | Positive plate | Negative plate | Container | Cover | Separator | Electrolyte | Safety valve | Terminal |
|---|---|---|---|---|---|---|---|---|
| Raw material | Lead dioxide | Lead | ABS | ABS | AGM | Sulfuric acid | Rubber | Copper |

● Constant current discharge characteristics unit: Ampere/Block (at 25°C, 77°F)

| F.V/Time | 10min | 15min | 30min | 60min | 2h | 3h | 4h | 5h | 8h | 10h | 20h |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.60V | 118 | 90.7 | 54.3 | 33.4 | 19.7 | 14.2 | 11.3 | 9.69 | 6.66 | 5.50 | 2.91 |
| 9.90V | 114 | 88.5 | 53.2 | 32.9 | 19.6 | 14.1 | 11.3 | 9.64 | 6.63 | 5.49 | 2.91 |
| 10.2V | 109 | 85.3 | 51.6 | 32.0 | 19.4 | 14.0 | 11.2 | 9.57 | 6.58 | 5.47 | 2.90 |
| 10.5V | 105 | 82.4 | 50.3 | 31.0 | 19.1 | 13.9 | 11.1 | 9.50 | 6.53 | 5.44 | 2.88 |
| 10.8V | 98.9 | 78.0 | 48.5 | 30.0 | 18.7 | 13.5 | 10.8 | 9.22 | 6.34 | 5.40 | 2.86 |

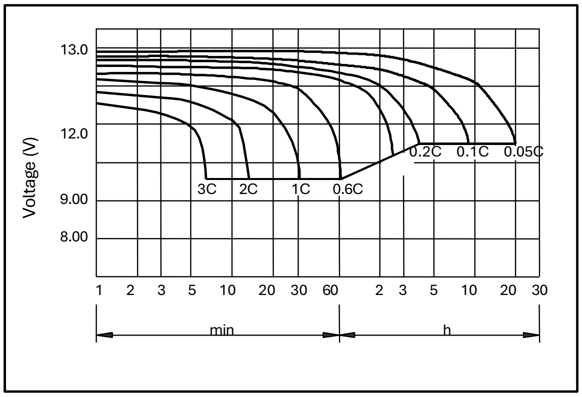
● Constant power discharge characteristics unit: Watt/Block (at 25°C, 77°F)

| F.V/Time | 10min | 15min | 30min | 60min | 2h | 3h | 4h | 5h | 8h | 10h | 20h |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.60V | 1271 | 996 | 609 | 380 | 228 | 167 | 133 | 115 | 79.2 | 65.6 | 35.0 |
| 9.90V | 1233 | 972 | 597 | 375 | 227 | 166 | 133 | 114 | 78.7 | 65.5 | 34.9 |
| 10.2V | 1182 | 936 | 578 | 365 | 225 | 165 | 132 | 113 | 78.2 | 65.3 | 34.8 |
| 10.5V | 1132 | 904 | 564 | 354 | 222 | 164 | 131 | 112 | 77.6 | 64.9 | 34.6 |

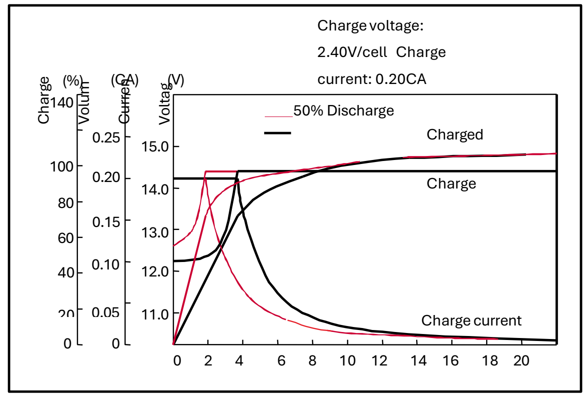
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10.8V | 1068 | 857 | 544 | 342 | 216 | 159 | 127 | 109 | 75.3 | 64.5 | 34.3 |

Note 1: Above characteristics data can be obtained within three charge and discharge cycles.

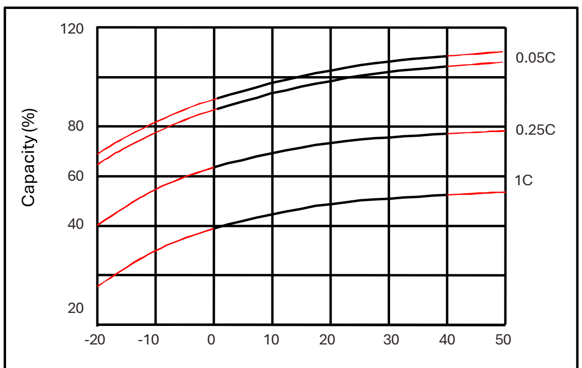
## Discharge characteristics (25°C)



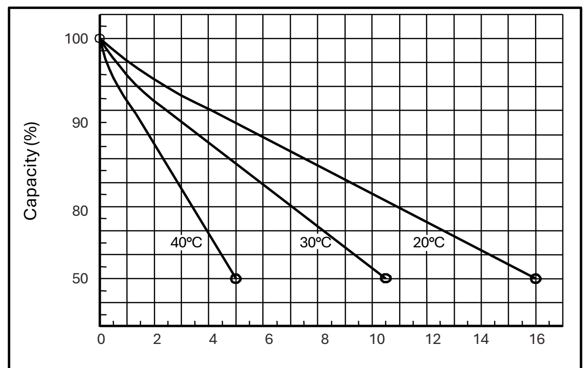

## Charging characteristics (25°C)



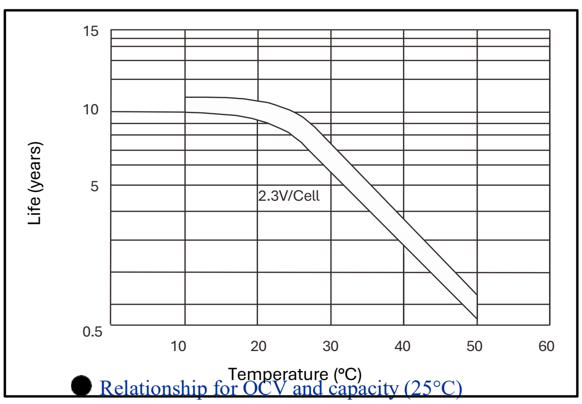

## Temperature effects on capacity



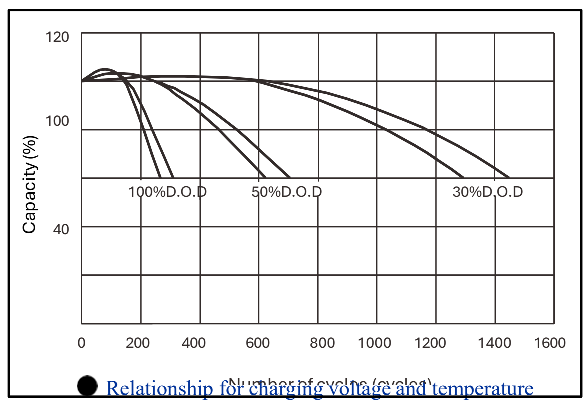

## Self-discharge characteristics



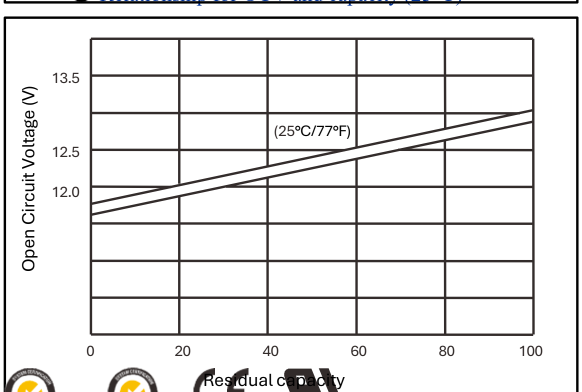

## Floating life on temperature



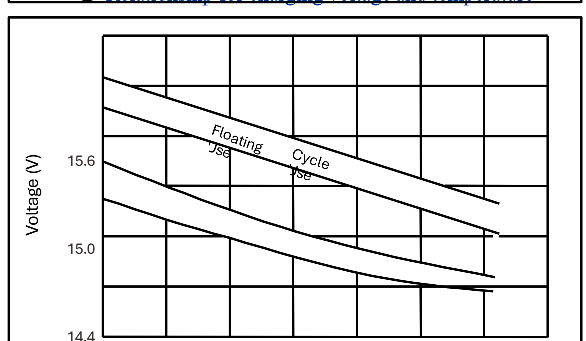

## Cycle life on D.O.D (25°C)




## Relationship for OCV and capacity (25°C)




## Relationship for charging voltage and temperature




www.nppower.com.cn

V0-210224-KK

# Appendix C: Proof of Insurance

NEW MEXICO
GENERAL SERVICES DEPARTMENT
RISK MANAGEMENT DIVISION

## EVIDENCE OF COVERAGE

## MEMORANDUM NUMBER:RMD-EOC-FY23

This Evidence of Coverage is used as a matter of information only and confers no rights upon the Certificate Holder. This Evidence of Coverage does not amend, extend, or alter the coverage afforded by the Tort Claims Act or the applicable Certificates of Coverage or policies for the type(s) of coverage listed below.

## NAMED INSURED

**STATE OF NEW MEXICO**
**and**
**UNIVERSITY OF NEW MEXICO (U6900)**

**LOSS PAYEE: TO WHOM IT MAY CONCERN**

**Coverage Period:**
**12:00 AM 07/01/2022 to 11:59 PM 06/30/2023**

This is to certify that the Insured has the coverages listed below for the period indicated. Notwithstanding any requirement, term or condition of any contract or other document with respect to which this Evidence of Coverage may be used or may pertain, the coverages indicated in this Evidence of Coverage are subject to all terms, exclusions, and conditions of the Certificates of Coverage and other insurance policy(s) to which this Evidence of Coverage pertains.

| Type of Coverage | Limit of Liability/Coverage |
|---|---|
| A) Liability<br>i. General Liability<br>ii. Automobile Liability<br>iii. Law Enforcement<br>iv. Civil Rights | Statutory Limit NMSA § 41-4-19 |
| B) Workers Compensation | Statutory Limits NMSA § 52-1-1 et seq. |
| C) Property<br>i. Real and Business Personal Property<br>ii. Auto Physical Damage | <br>Replacement Cost Value (RCV)<br>Actual Cash Value (ACV) |
| D) Medical Malpractice | Statutory Limit NMSA § 41-4-19 |
| E) Fine Arts | $300,000,000.00 |
| F) Boiler & Machinery | $100,000,000.00 Limit |

**Per 66-5-207, NMSA 1978, - A motor vehicle owned by the United States Government, any state, or political subdivision of the state, is exempt from the Mandatory Financial Responsibility Act.**

**Per 66-6-15(E), NMSA 1978, - A vehicle or trailer owned by and used in the service of the State of New Mexico or any county or municipality thereof need not be registered but must continually display plates furnished by the Transportation Services Division of the General Services Department.**

Should any of the above coverages for the Covered Party be changed or withdrawn prior to the expiration date issued above, the State of New Mexico will notify the Certificate Holder, but failure of such notification shall impose no obligation or liability of any kind upon the State of New Mexico, its agents, or representatives.

**Authorized Representative:** Randall Cherry, Director, Risk Management Division, GSD

**Date Issued:** 7-1-2022

For questions please contact the Loss Prevention and Control Bureau at 505-827-2036 or GSD.LPCB@state.nm.us

# Appendix D: Team Roster

A list of the members of the 2023 UNM Solar Splash team is contained in the table below.

*Table 2: Team Roster for the 2025 UNM Solar Splash Team*

| Name | Degree | Graduation | Team Position |
|---|---|---|---|
| Silas Murphy | B.S. Mechanical Engineering | 2025 | Drivetrain |
| David Sabol | B.S. Mechanical Engineering | 2025 | All-Around Fabrication |
| Lyonel Candelaria | B.S. Mechanical Engineering | 2025 | Drivetrain |
| Jesus Martinez Specia | B.S. Mechanical Engineering | 2025 | Electromechanics |
| Isaiah Deane | B.S. Mechanical Engineering | 2025 | All-Around Fabrication |
| Dionicio Maestas | M.S. Mechanical Engineering | 2025 | Electromechanics |
| Annika Tedstrom | M.S. Mechanical Engineering | 2025 | Administrative |
| Emma Sanchez | M.S. Mechanical Engineering | 2025 | Steering Assembly |
| Max Tafoya | M.S. Mechanical Engineering | 2025 | Carbon Fiber Fabrication |
| Isaac Viramontes | M.S. Mechanical Engineering | 2025 | Carbon Fiber Fabrication |
| Melachi Sanchez | M.S. Mechanical Engineering | 2025 | Steering Assembly |
| Cade Sickafoose | M.S. Mechanical Engineering | 2025 | Carbon Fiber Fabrication |
| Kristina Ji | M.S. Electrical Engineering | 2025 | Electromechanics |

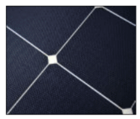
# Appendix E: Solar Panel Specifications

Shenzhen Sungold Solar Co., Ltd

www.sungoldsolar.com

## Product Details

**FLEXIBLE SOLAR PANEL**
**SG-TF-S-120W**

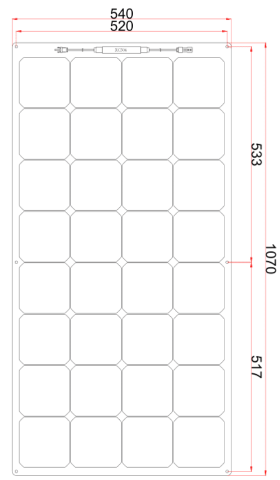


Anti-Slip Surface

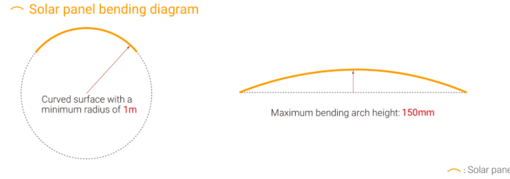
Junction Box

MC4

## Module Diagram




Solar panel bending diagram




## Electrical Characteristics

| | |
|---|---|
| Maximum power(Pmax) | 120W |
| Open-circuit voltage(Voc) | 23.3V |
| Voltage at Pmax(Vmp) | 17.8V |
| Short-circuit current(Isc) | 6.42A |
| Current at Pmax(Imp) | 6.74A |
| Cells Efficiency(%) | 24.40% |
| The maximum system voltage | 200V DC(IEC) |
| Power temperature coefficient | -0.27%/℃ |
| Voltage temperature coefficient | -0.236%/℃ |
| Current temperature coefficient | +0.058%/℃ |
| Output power tolerance | ±3% |
| Operating Temperature | -40℃-+85℃ |

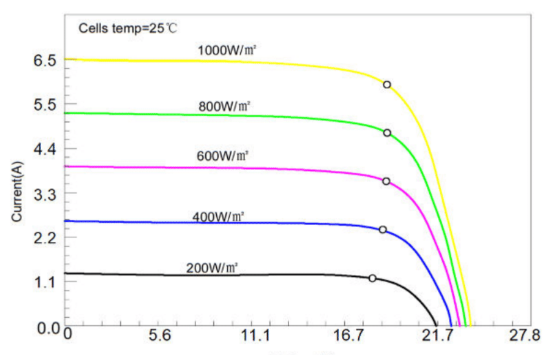
## Product Introduction

Sungold TF series photovoltaic panel is an innovative glass-free solar panel. It adopts proven crystalline silicon solar cell.

Its technology and polymer composite material truly realize glass-free, lightweight, and thin new flexible solar panels, also TF series is as light as 3.5 kg/m2, which is only 30% of rigid solar panels.

## Specifications

| | |
|---|---|
| Solar cell brand | SUNPOWER |
| No.of cells and connections | 32(4*8) |
| Module dimension | 1070*540*3mm |
| Weight | 2.51kg |
| Output cable | JB (2*bypass diodes) + 900mm/4mm² cable+MC4 compatible |
| Waterproof | IP68 |
| Certifications | CE, ROHS |
| Maximum bending arch height | 150mm |
| Warranty | 5 years and service life 20 years |




*SUNGOLD offer customize service,please refer to our website or ask SUNGOLD workers for more sizes and the latest parameters.

+86-0755-29685821 sales@sungoldsolar.cn Wentao Industrial Park, Yingrenshi community, Shiyan Town, Shenzhen City, Guangdong Province, China.

# Appendix F: Carbon Fiber Materials

## HexForce™ 282
**Carbon Fabric**

*Product Data*

| STYLE 282 | | US System | |
|---|---|---|---|
| ***Type of Yarns*** | ***Warp Yarn:*** | 3K Carbon, 33MSI | |
| | ***Fill Yarn:*** | 3K Carbon, 33MSI | |
| ***Fabric Weight, Dry*** | | 5.80 $oz/yd^2$ | 197 $g/m^2$ |
| ***Weave Style*** | Plain | | |

| CONSTRUCTION | | | |
|---|---|---|---|
| ***Nominal Construction*** | ***Warp Count:*** | 12/in | |
| | ***Fill Count:*** | 12/in | |
| ***Fabric Thickness*** | | 10.10 mil | 0.26 mm |

***IMPORTANT***

*All information is believed to be accurate but is given without acceptance of liability. All values have been generated from limited data. The values listed for weight, thickness and breaking strengths are typical greige values, unless otherwise noted. Users should make their own assessment of the suitability of any product for the purpose required. All sales are made subject to our standard terms of sales which include limitations on liability and other important terms. The fabric style listed may not be available from inventory and minimum order quantities may apply.*

***FOR FURTHER INFORMATION, PLEASE CONTACT US***

HEXCEL

1913 North King Street
Seguin, Texas 78155
Phone: 830-379-1580
Fax: 830-379-9544
Customer Service Toll Free: 1-866-601-5430

For European sales office numbers and a full address list, please go to:
http://www.hexcel.com/contact/salesoffices