MECC UCSB Business Proposal

efficiensea
Powering the Sea

Students: Nicholas Won, Joseph Nahm, Christina Le, Chad Treppa, Martin Jordan, Jordan LeClaire
Faculty: Tyler Susko, Doug Bradley
Sponsors: Navy EXWC

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1 Executive Summary

We know less about what lies in the depths of our oceans than we do about the surface of the moon. The UCSB marine energy collegiate competition team (efficiensea) is striving to turn this fact around. Advised by naval and academic experts, our team has developed a novel concept for remote power generation, specifically to spur the development of ocean research and remote data collection.

According to Allied Market Research, the global renewable energy market was valued at $ 928.0 Billion in 2017, and is expected to reach $ 1.5 Trillion by 2025. This potential growth in the market uniquely positions our team to fill a severely untapped niche in powering remote ocean devices.

Introducing Proto-Power, a self contained power source that can power devices and sensors at sea indefinitely. Our name, Proto-Power, originates from the definition of *Proto*, meaning first or original. Using the first known source of power, the sun, our team aims to produce the first self-contained power source that can operate remotely indefinitely. Historically, sensors and devices stationed on the seafloor have been powered by batteries and must be serviced relatively often. These servicing costs quickly add up and produce unneeded waste in the form of labor, emissions, and expenses. If successful, Proto-Power will save environmental and government agencies alike millions of dollars per year.

Our final concept includes three different modules. The first module that we designed is a solar module which can continuously generate 50 W of power per module and be stationed at different depths in the ocean. The second module is a battery module equipped with a 512 Wh lithium iron phosphate battery that has a significantly longer lifetime than traditional lithium ion batteries. The third module is our winch system which will lower solar modules to avoid collisions with ships and avoid excessive tension caused by large swells. The modules can then be linked together to expand the system to meet any power requirements. Our innovative modular design allows clients to have their needs perfectly met while minimizing waste and maximizing research potential.

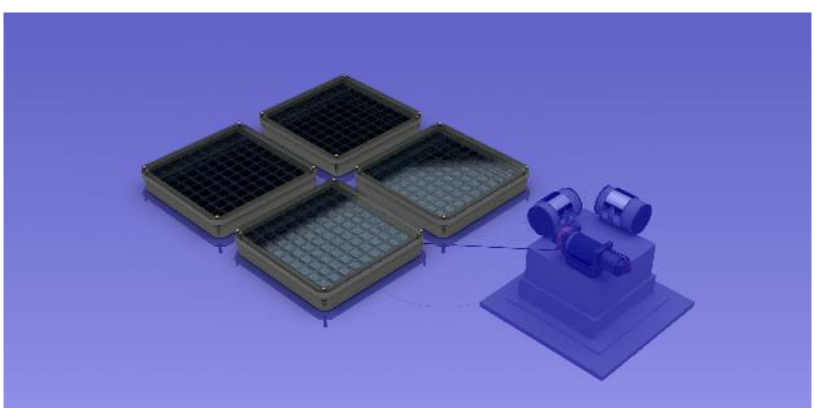


Figure 1: EfficienSea Proto-Power System: 4 Solar Modules, 2 Battery Modules, 1 Winch

2 Business Plan

2.1 Concept Overview

Using Proto-Power researchers, oceanographers, engineers, and environmental agencies will be able to have their unique needs met perfectly. Whether it is devices mounted to the seafloor, devices used to monitor ocean currents, or even ROV (underwater remote operated vehicle) charge stations, our Proto-Power aims to be the one-stop solution for all.

Proto-Power has three main components: a solar module, an energy storage module, and a winch system. The solar module is a custom-designed housing for high-efficiency gallium indium phosphide solar panels. These solar panels are designed specifically for use in ocean environments and are shown to have significantly greater energy capture than traditional solar cells. The energy storage module is a custom-designed enclosure that houses specialized lithium iron phosphate batteries which last over twice as long as traditional lithium ion batteries. A cable winch system is attached to the solar module to create an adjustable depth in cases of boat traffic or extreme weather conditions. Proto-Power is designed to be modular which means that customers can connect as many of each module they need in series to fulfill their unique project requirements.

The final iteration of our product will be sold in a direct-to-consumer model. This would allow our team to more effectively address customer's specific needs on a case to case basis dependent upon their power requirements. Costs will directly be a function of how many modules a client needs as well as which types. When clients employ our solution, they can expect to see dramatic decreases in servicing and maintenance costs as well as a reduction in generated waste.

2.2 Key Stakeholders

The current stakeholders of this project include primarily researchers as well as governmental regulatory and defense agencies. The implementation of our project will allow researchers at agencies such as NOAA and Scripps, and potentially many more, to dive deeper into their research by extending the service life of their undersea devices. With regards to defense, the Navy employs the use of a variety of sensors mounted to the seafloor. A power source like the one our team is developing will help to reduce cost a significant amount through the reduction of maintenance. Interviews with university researchers and former Navy staff have guided our team's decision to pursue a modular design.

2.3 Market Opportunity

Presently, there exists no way to reliably collect and transfer power to the seafloor or out miles from the coast. Current solutions are to either run a wire from power stations on shore to the devices customers need to supply energy to or to use batteries that must be maintained, switched out, and eventually recycled or thrown away. Researchers and agencies spend large amounts of money to upkeep and service these types of devices. The expedition's needed to replace and service these batteries run into the hundreds of thousands of dollars per trip. Interviews with multiple sources, researchers at UCSB's Bren School of Environemental Science and the Office of Naval Research, have indicated that limited battery life is a significant limiting factor in the amount of data that researchers are able to gather. Working with a limited power supply limits the amount of sensors that researchers can use and the frequency at which data can be collected. Proto-Power would allow researchers to gain access to data that is of much higher fidelity and resolution by eliminating power restraints. The only other company working on a solution similar to our project is a small startup based out of San Diego using linear alternators instead of photovoltaics. This niche is extremely unique with very little competition.

We are providing customers with a means of extending the service life of their devices by multiple years if not indefinitely. Our modular power solution is designed to be scaled up to meet a wide variety of energy needs. The modular design allows for flexibility when customers are describing their needs and will allow us to reduce costs by manufacturing standardized modules that can be easily connected and disconnected from each other.

Our customers will choose our product because of the dramatic decrease in operating costs. A large portion of the budget for researchers is dedicated to the maintenance, servicing, and planning of the deployment of their sensors and devices. It can cost up to $ 500K to rent a ship and organize a crew to replace the battery in a single device. By reducing the amount of times that their equipment needs to be serviced, our product will be a very attractive solution for their needs. The pricing of our product will be heavily determined by the amount of potential savings made available to clients as a result of implementing our product. Considering that maintenance and servicing costs are on going, we project that the final product will still be an attractive option at price points that exceed the production costs by 2-3x.

2.4 Development and Operations

Our team has already conducted a large amount of development and research as a result of refining our prototypes. This was conducted through means of reading many research papers, researching existing technologies, and interviewing industry experts. As a team we were able to identify a multitude of current wave energy technologies that are used to generate large amounts of power to be sent back to power grids on shore. Some of these technologies included the use of linear alternators, hydraulic kinetic energy harvesters, hydrothermal energy capture, deep sea wave turbines, and wave pressure conversion. After identifying all of these different technologies, our team performed a cost-benefit analysis of each technology and came to the conclusion that the best technologies to build upon would be either photovoltaics or wave motion using linear alternators. Our team developed small-scale prototypes to test each technology and found that when using linear alternators, it was extremely difficult to produce a sufficient amount of energy to meet our minimum power goals at the scale of our project. Current commercially available linear alternators that take advantage of wave motion are extremely large, weighing over 8,000 kg per unit. The massive size of current technology, combined with the shortcomings our team faced when carrying out initial tests, pushed us to pursue photovoltaics as the most reliable and feasible option. One of the biggest considerations that needed to be made during the decision process of what technology to pursue was how we would take our design from a final minimum viable product prototype to a scalable commercial product ready for use. We chose to pursue a design that makes the use of photovoltaics to generate power as we believe it is the simplest and most cost effective technology to scale, as shown by our modular design. In the future, our partnership with our sponsor, Navy EXWC, will be invaluable during the process of scaling up from minimum viable product to commercial product as they can provide our team with a list of their current manufacturers and materials sources.

There are quite a few technical barriers that our team has considered throughout the design process and would need to address before a final production model could be constructed. These are the the barriers that our team considers to be the most important. First, biofouling is the largest factor that would decrease our Proto-Power's efficiency. The proposed solution for this is to use hydrophobic coatings combined with a wiper mechanism to discourage the growth of any organisms on the photovoltaic cover. Secondly, the effect of the weight of mooring and power cables on the buoyancy of the solar enclosure must be considered. To ensure that the solar enclosure maintains an optimal depth or to stay on the surface, inflatable ballasts could be implemented into our design. Third, the vertical oscillating motion of the ocean will produce both slack and tension on the devices mooring lines. To compensate for this, a weight can be added to the middle of the anchoring line to ensure there is constant tension while still allowing for slack when swells are large. Lastly, the water pressure exerted on the large area of our solar modules will undoubtedly cause the material to bow. Currently our team is addressing this by ensuring there is sufficient head room inside of the module and the material is of sufficient thickness. In the future, our team would like to incorporate a pressure regulator that would internally equalize the pressure inside our enclosure to the water pressure. While we are currently unable to address these in our minimum viable product prototype, these are the potential solutions that our team has developed to mitigate the possible issues that would be seen in the future.

Our product is intended to replace the current solutions, which are either batteries or cables-to-shore. The final iteration of our Proto-Power would have the ability to be deployed in the most remote areas of the sea, reducing costs of cables-to-shore, and have a significantly longer lifetime than batteries. Ideally, the final iteration would never need to be serviced if the aforementioned technical barriers are fully overcome, but a reasonable expectation of a maintenance and service intervals can be expected to be in the range of 10 years if reasonable mitigations are developed.

2.5 Financial Benefits Analysis

Clients would see dramatic decreases in servicing and maintenance costs by using our product. An interview with a former Navy contractor estimated that, depending on the circumstances, expeditionary costs to service devices at sea can be upwards of $ 500,000 for just the boat. He also estimated that the Navy alone may have around 5,000 sub-sea sensors deployed. Another university researcher quoted that smaller expeditions cost approximately

$ 75,000 for just the boat alone. Over the course of a month long expedition, this is just over $ 2.25 million.

Our team estimates that a final product would cost approximately $ 15,000 to produce and would sell for upwards of $ 50,000 per unit, dependent upon various factors such as the number of modules used. There would be no extraneous operating expenses as the system is designed to be fully self-supporting. The only costs to be expected besides the cost of the device would be deployment and retrieval costs. Our power units will be able extend the service lives of the numerous sensors and devices at sea, we save clients millions by decreasing the number of expeditions that must be carried out.

As a result of our partnership with Navy EXWC, the most ideal scenario for scaling up and gathering capital in order to complete the research and development of the final product would be through a government contract. This would provide our team stable income through the research and development process. Once this process is completed, the team would then be able to explore other options such as selling to researchers from other agencies, universities, and the private sector.

3 Detailed Technical Design

3.1 Overview

Our current minimum viable product overview consists of three main parts. 1. Solar module 2. Battery module 3. Anchor weights and winch system. The solar module is intended to utilize photovoltaics to produce energy which will be sent to the battery module via cabling. The solar module can either rest on the surface of the ocean for maximum energy collection or at a specific depth below the surface to avoid collision with surface vessels. The winch system will be able to control this depth with the assistance of an acoustic sensor. Clients will then be able to connect their various devices and sensors into the battery modules to ensure consistent and reliable power delivery.

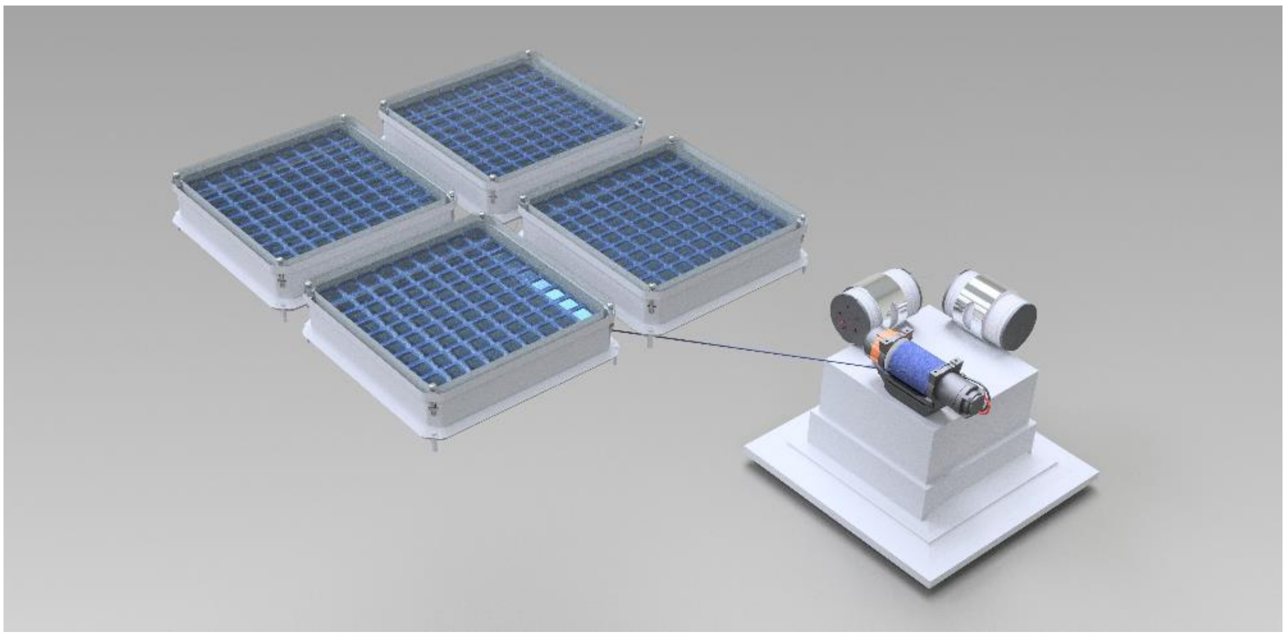


Figure 2: EfficienSea Proto-Power System: 4 Solar Modules, 2 Battery Modules, 1 Winch

3.2 Target Specifications

The following table represents the specifications that our team will be able to achieve with our minimum viable product prototype. These specifications were developed in conjunction with our sponsors at Navy EXWC to create a power system that would most accurately address their needs regarding the various sensors they currently have deployed at sea. As a result of the modular nature of our design, many of the listed specifications are variable and dependent upon the number of different modules used. For example, the amount of power that Proto-Power is able to achieve will scale with the amount of solar modules being used.

Specification	**Current Projected Prototype Specifications**
Continuous power generation (W)	50 W (Modular)
Sea Depth	131 feet (Battery Enclosure Limit)
Battery Storage	512 Wh (Modular)
Number of Moving Parts	1 (Winch)
Length of Anchoring Chain	Environment Dependant
Duration of Energy Source	Load and Module # Dependant
Time Before Corrosion	No part corrosion, Efficiency loss due to biofouling environmentally dependant
Weight of Device	w/o anchor: 70 lb
Battery Cycle Count	>1000

Table 1: Target Specifications

3.3 Assembly Drawing

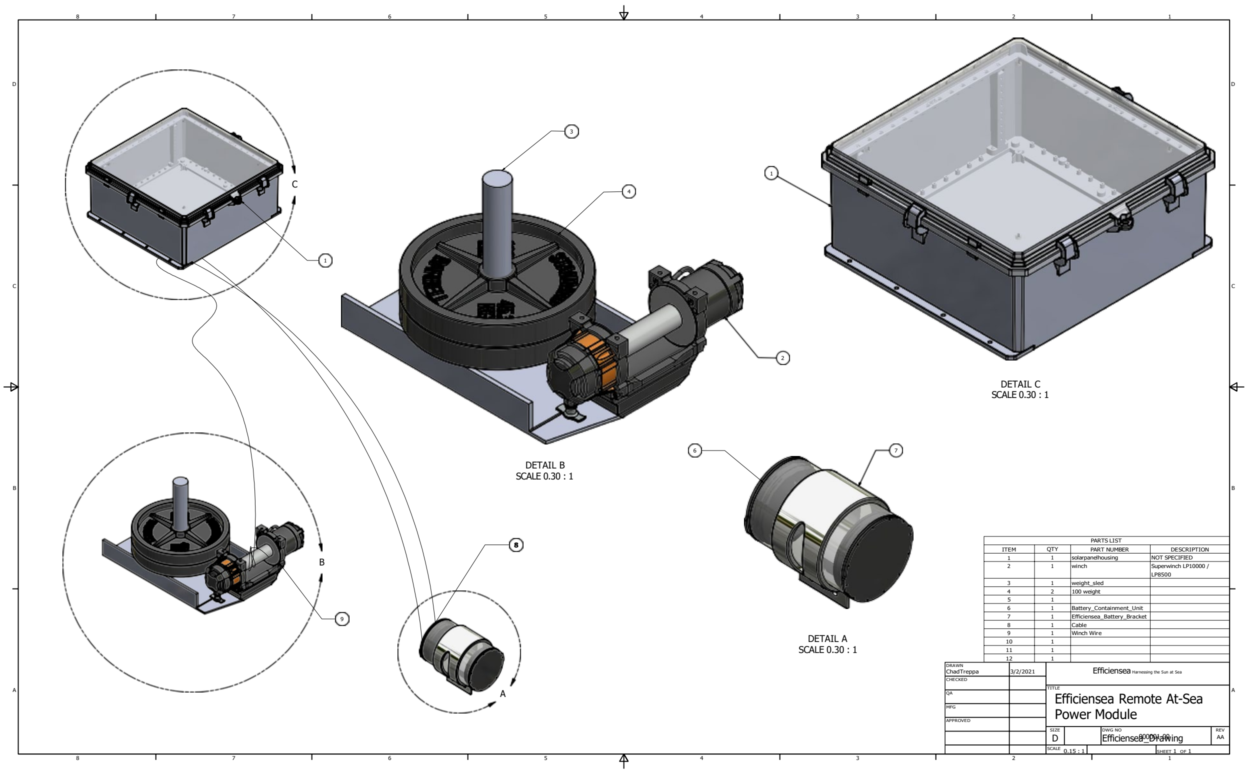


Figure 3: EfficienSea Remote At-Sea Power Module

3.4 Sub-Assembly Drawings

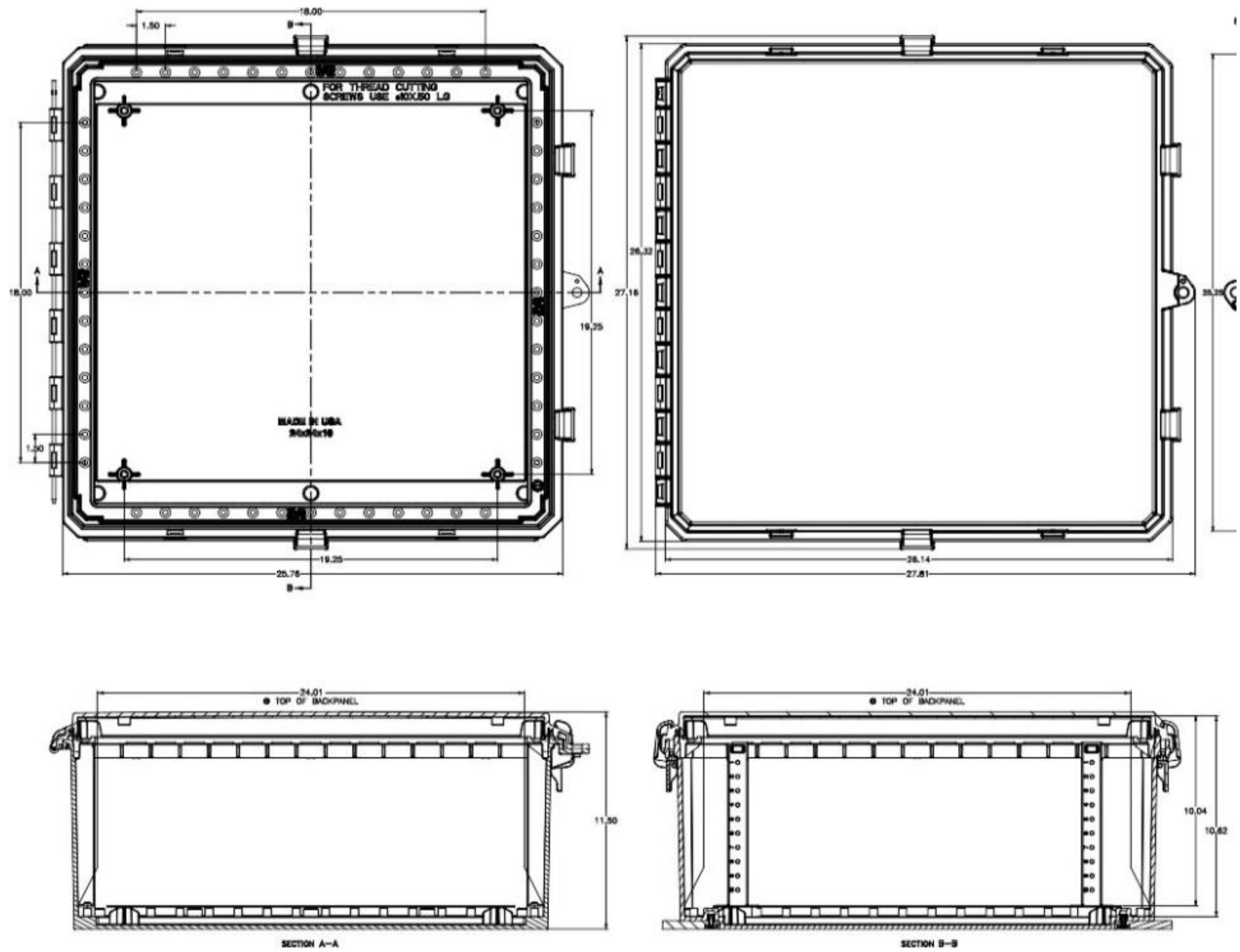


Figure 4: Integra Solar Enclosure

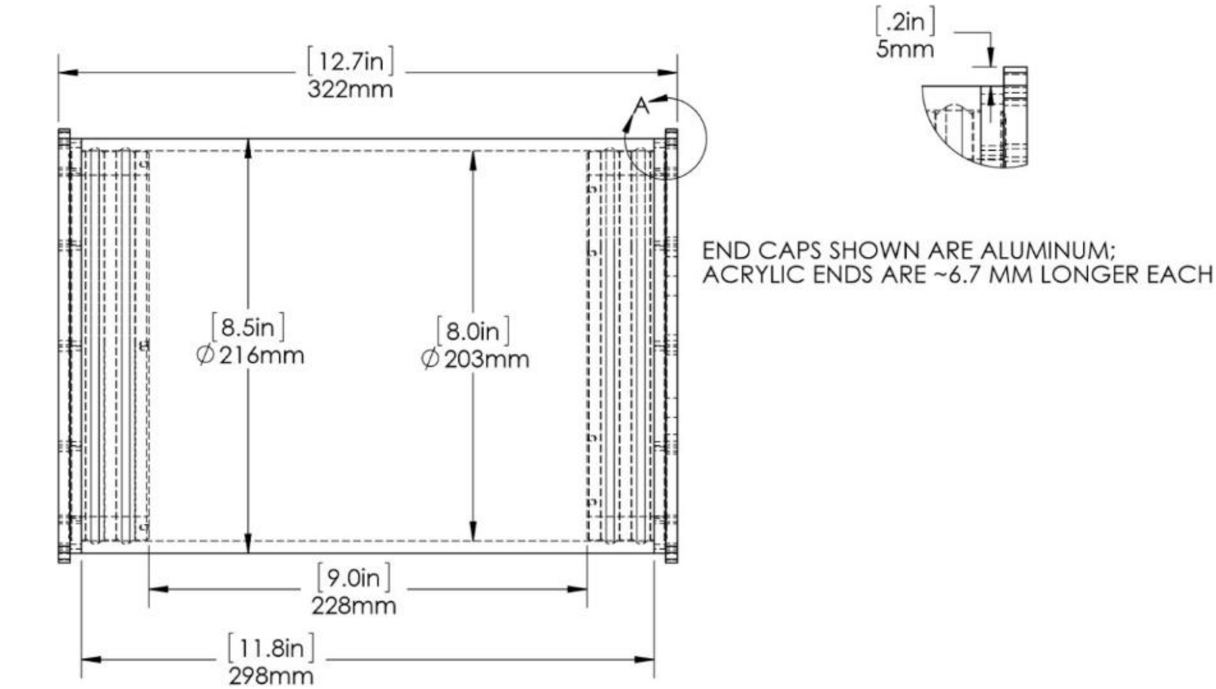


Figure 5: Blue Robotics Watertight Battery Enclosure

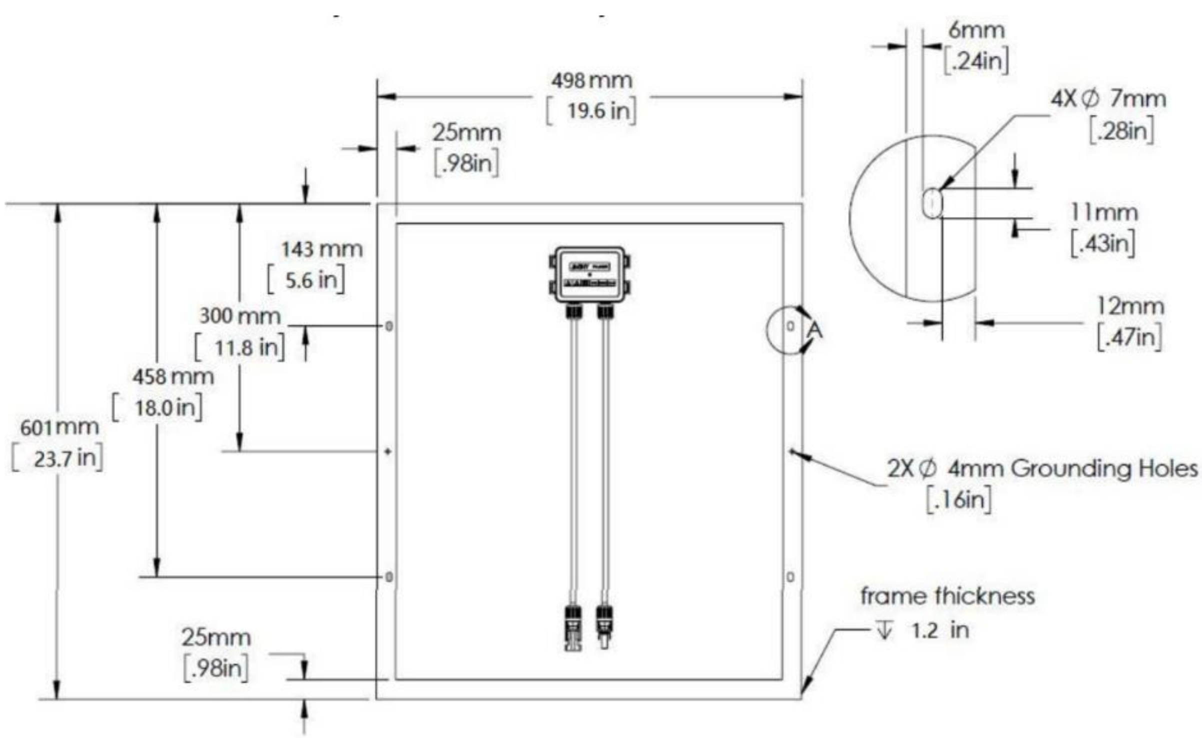


Figure 6: Renogy Panel Drawing

3.5 Detail working drawings (list)

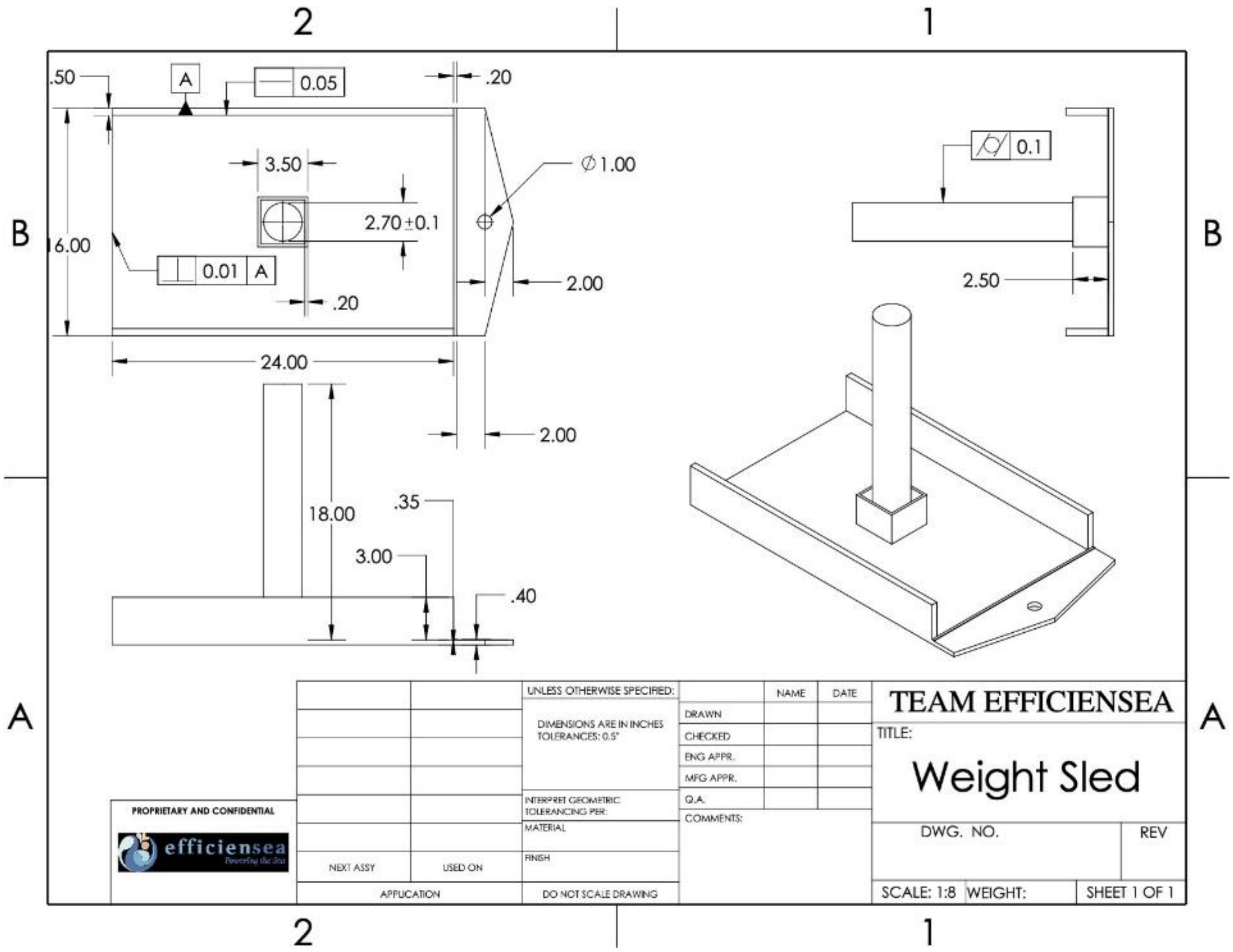


Figure 7: Weight Sled Drawing

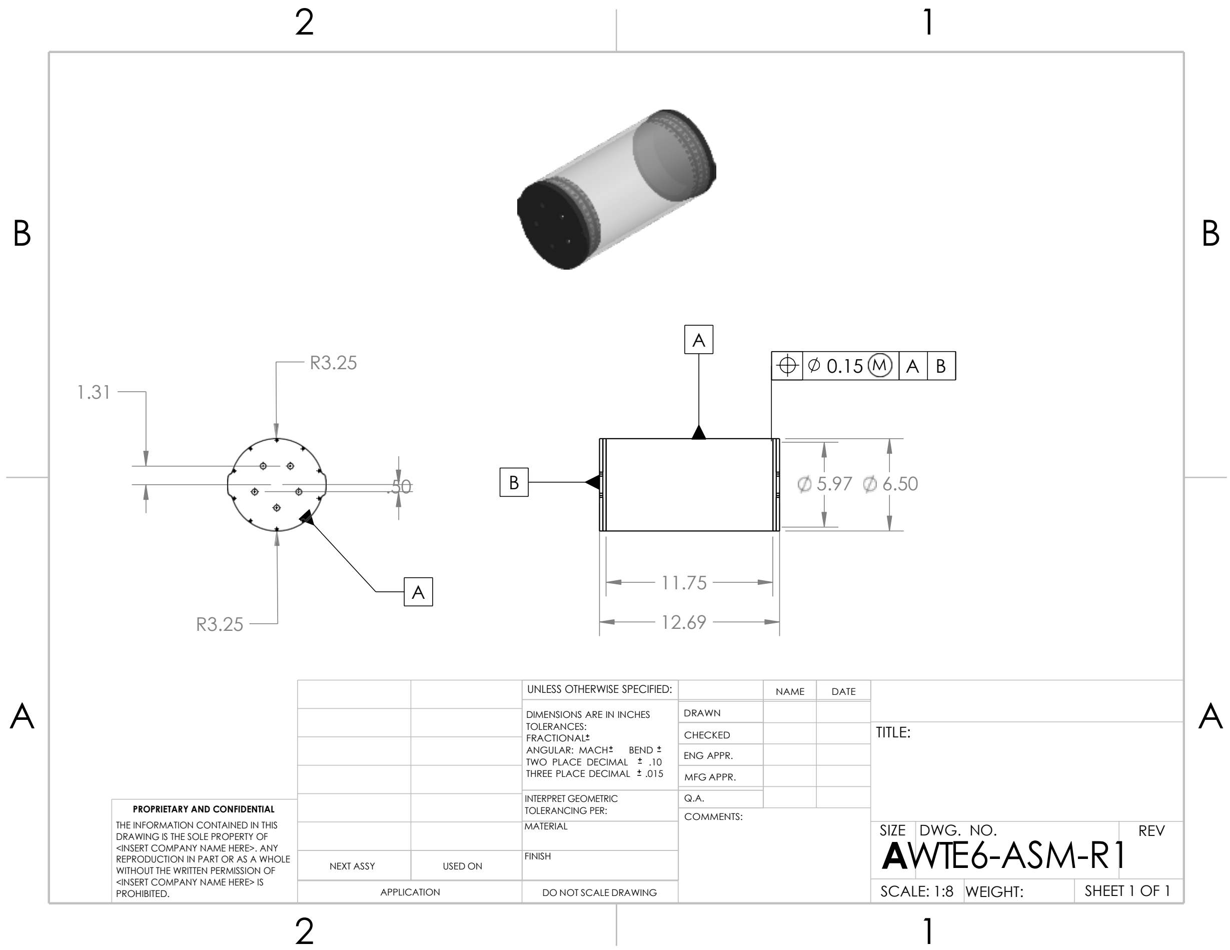


Figure 8: EfficienSea Battery Enclosure

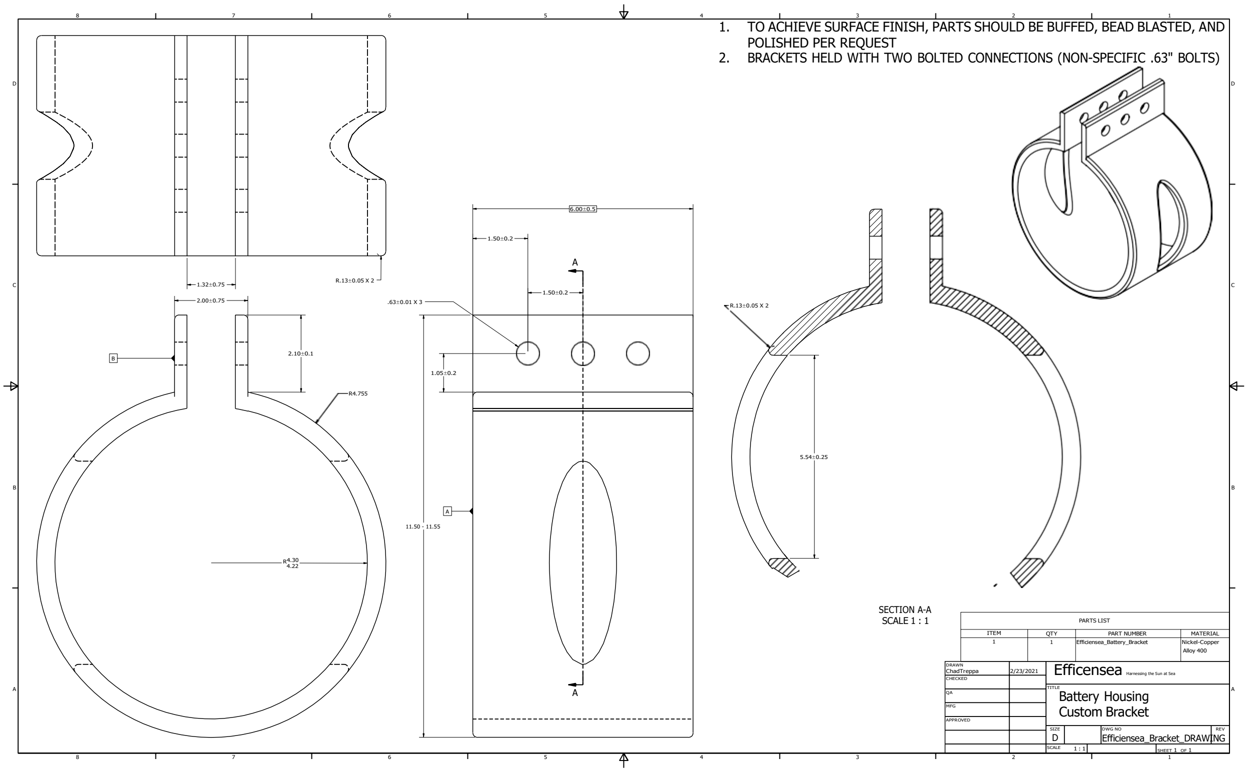


Figure 9: EfficienSea Battery Bracket

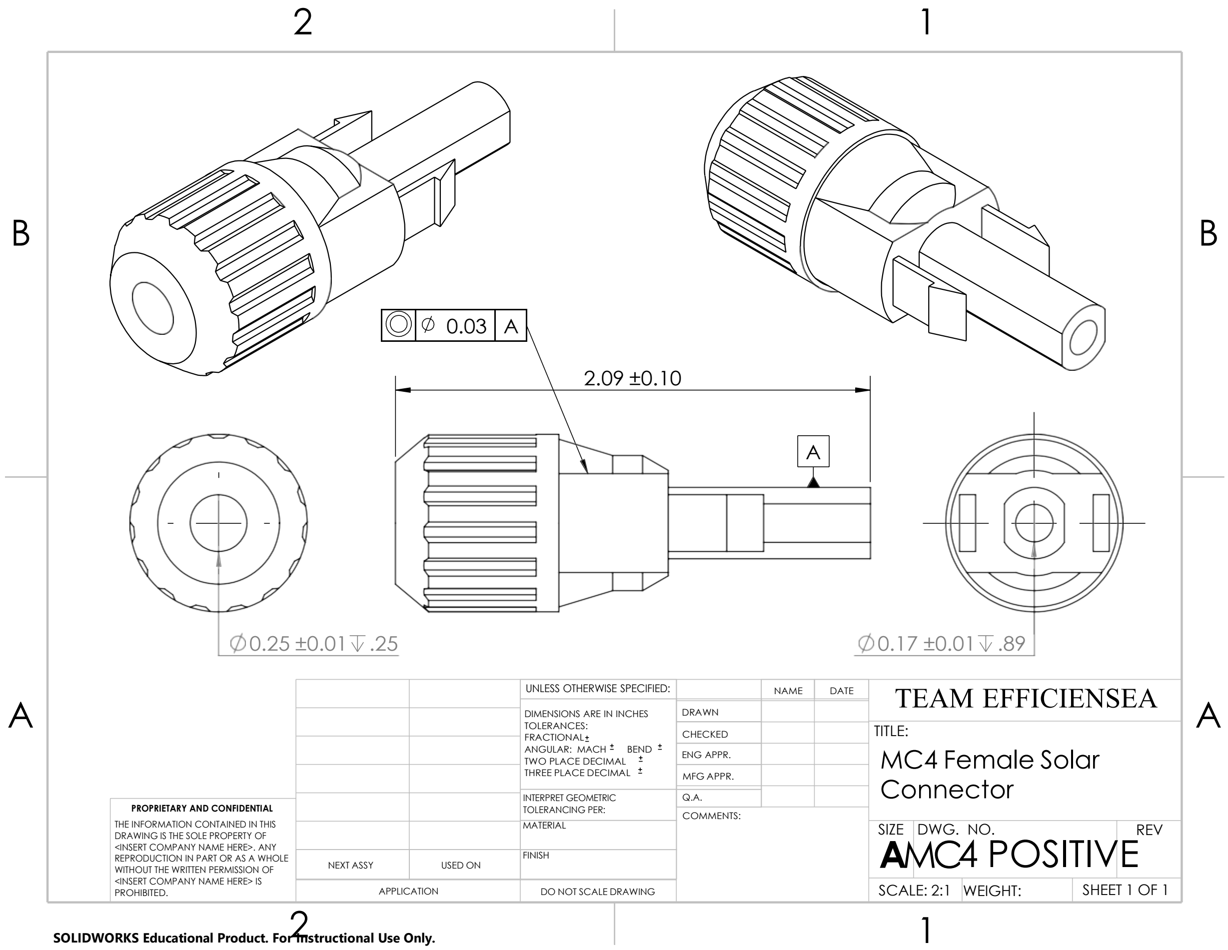


Figure 10: MC4 Female Solar Connector Drawing

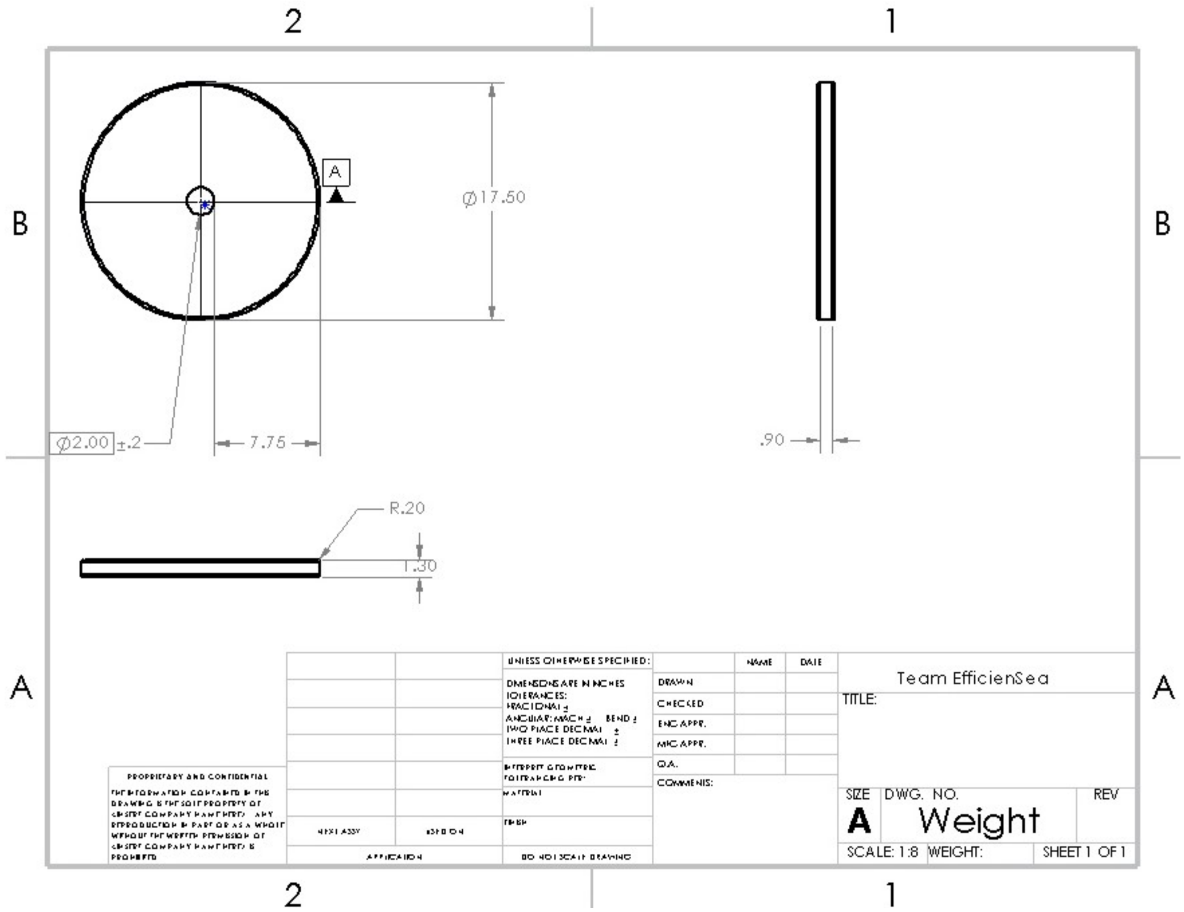


Figure 11: Olympic Weight Plate

3.6 Physical Connectors

The SubConn connectors shown on the right are for quick detachment and reattachment between solar housing and battery. The SubConn Micro Circular connectors are available with 2 to 21 contacts rated at 300 V from 5 to 10 A in the standard inline version and in bulkhead versions. We are looking into the 4 contact connector to use as the detachble cables for our system. The red connectors shown on the left attach directly into side of the solar housing, and the potting compound and epoxy resin mixture seals the entry hole watertight. Additionally, the waterproof synthetic cable will connect through the solar housing enclosure flanges as well as to the battery for easy raising and lowering. In summary, the red connector allows cables to be connected to the electronic components in the enclosure, while the SubConn connectors are used as cables that can be connected/disconnected underwater to the sensor device.

3.7 System and Sub-System Block Diagram

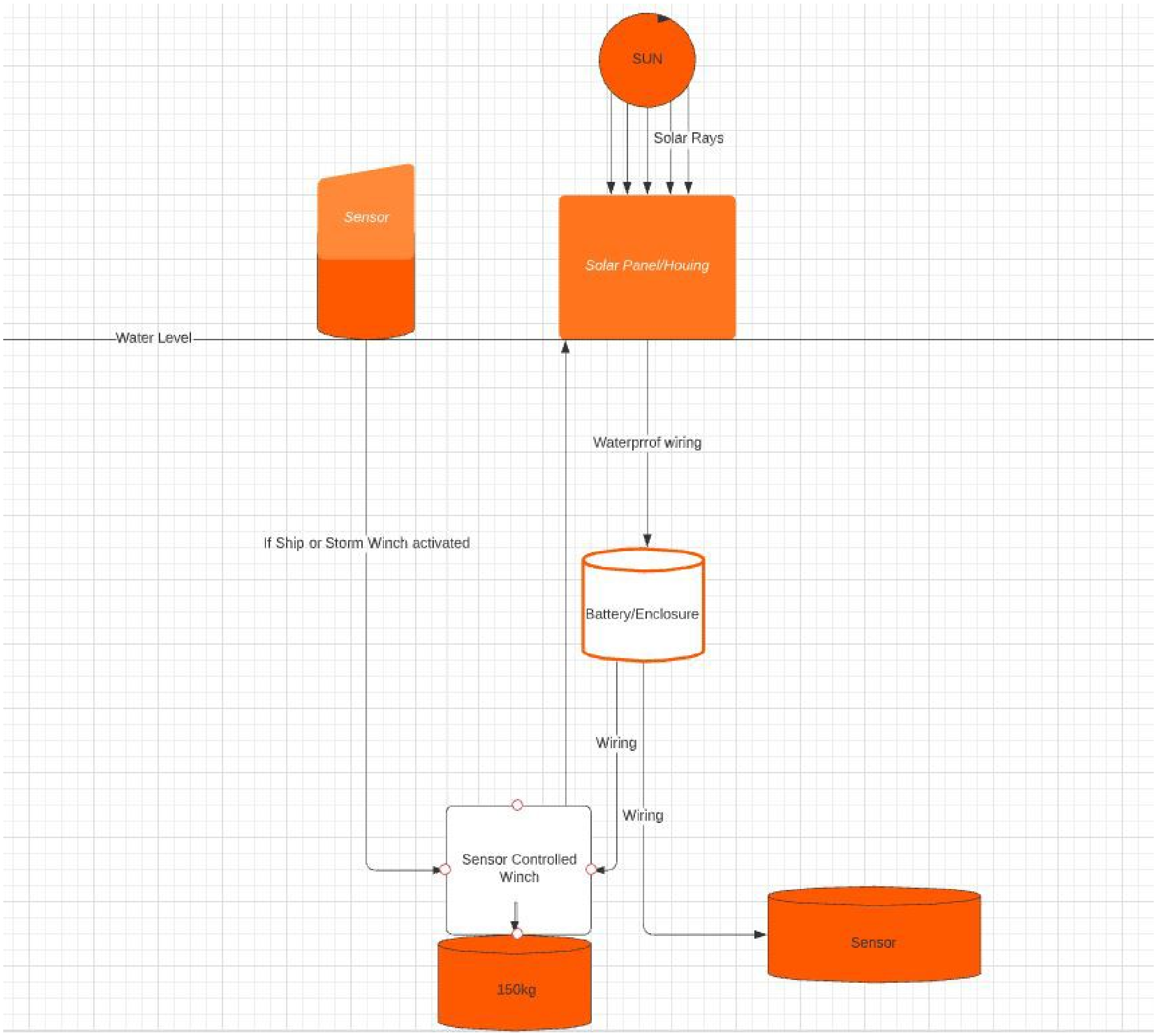


Figure 12: Solar Panel Block Diagram

3.8 Operational Flowcharts

Since the full scale prototype is set offshore, deployment of the solar panel will involve a ship crew. **Figure 13** illustrates the operational steps in setting up the solar panel and the frequency of reservicing.

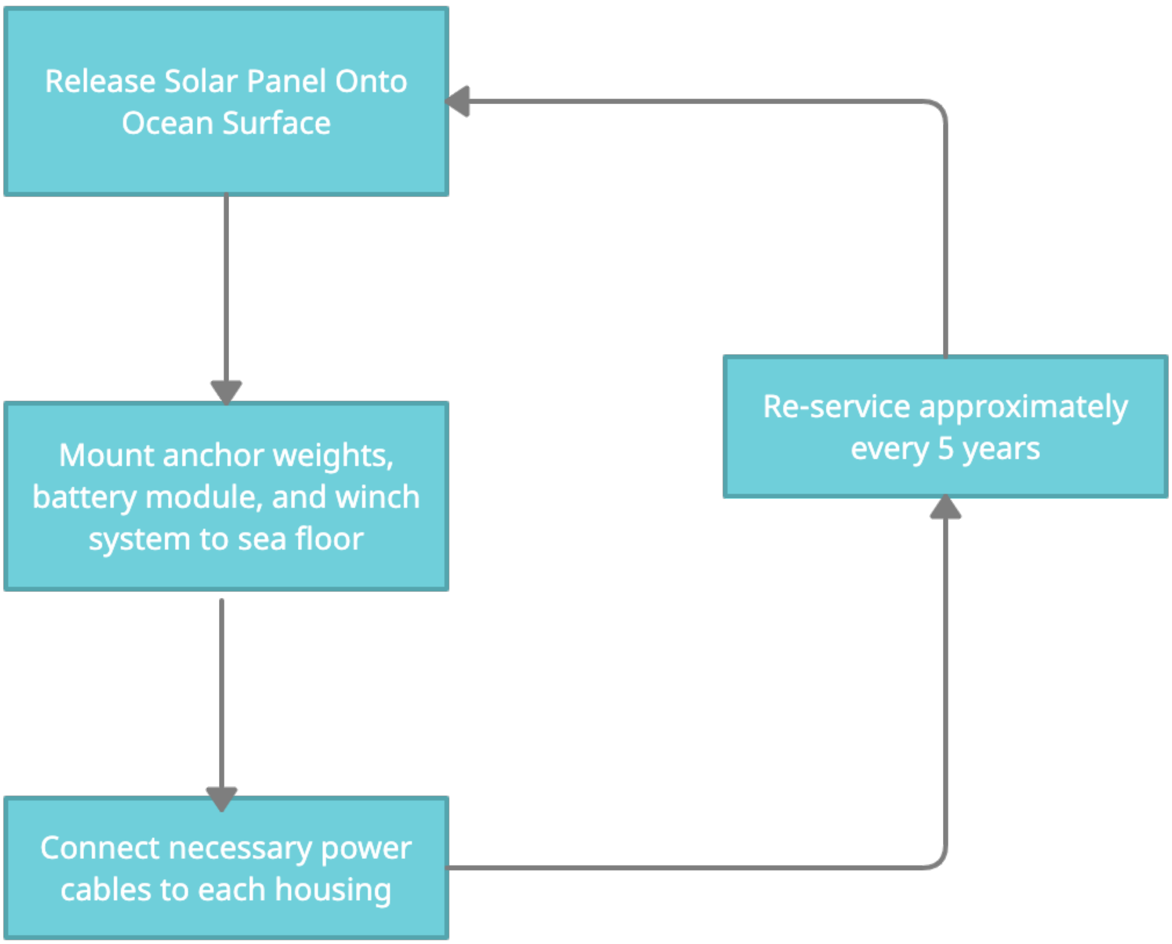
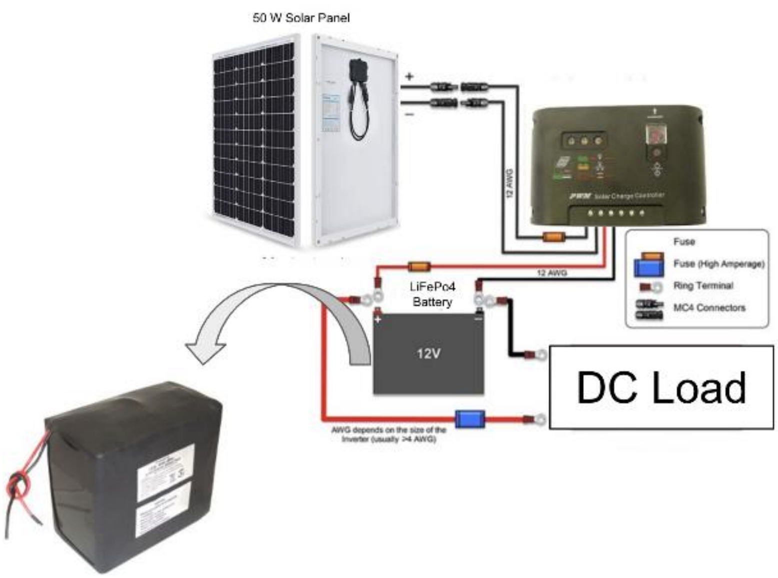


Figure 13: Solar Panel Operational Flow Chart

3.9 Circuit Schematic and Wiring Diagram

In order to stick with the off-the-shelf Integra solar enclosure, we needed a solar panel that had a cross sectional area below 24" x 24". This was a challenging optimization problem since it still had to provide sufficient power even despite our modular design. With all these things considered, we decided to use Renogy's 50 W compact design solar panel. Renogy is one of the more efficient, commercially available panels, and their compact design has dimensions of 23.7" x 19.6", so it will fit snugly into our solar housing. Aside from the solar panel, a solar circuit typically also contains a charge controller, which acts as a voltage and current regulator for the battery. Sometimes inverters are used to convert the DC output of a panel to AC; however, we are focusing mainly on the power generation of our minimum viable prototype, and so inverters were left for future iterations of our design, and we will instead power a DC load, such as a rack of LED lights. For the battery, we went with a custom lithium iron phosphate battery that is rated for 12.8 V and 512 Wh. We found data that showed an average of 5.62 hrs of peak sunlight in our local region of SB, and multiplying this by the average 50W output of our panel, and allowing for inefficiencies in our system, we get an output of at least 256 Wh, which is half the rating of our current battery. This allows us to add another solar housing module if our budget allows it. The charge controller comes from the same manufacturer and is made to pair with our custom battery, which is why we chose that over a typical Renogy charge controller.



Solar Panel	50 W Renogy Solar Panel (Compact Design)
Charge Controller	120W, 12.8 V & 10 A rated for LFP battery
Battery	Custom Polymer LiFePO4 Battery Pack - 12.8V 40 Ah (512 Wh)

Figure 14: Circuit Diagram

3.10 Prototypes and Testing

After consolidating our choice for a solar application, questions arose that we needed to test. Doing such tests helped to prove the feasibility of moving forward with our design. The questions were:

- Is the IP68 enclosure watertight?
- How deep can the solar housing be submerged?
- Is the solar output sufficient?

Our team ran several small-scaled tests to determine the effectiveness of the solar housing and solar panel. They are listed below.

- In the fall quarter, a small solar panel was submerged in a container of murky water and still proved to be efficient. This test used a small scale solar panel which was submerged in a box filled with sediment and water. When stirred up so that the water was visibly murky, the solar panel experienced a minimal reduction in output voltage.

Figure 15: Small Scale Solar Testing

- This quarter, our team dropped the solar enclosure into the ocean to determine if is indeed, watertight. This test proved that our enclosure was waterproof, but it raised an important point that the enclosure is highly buoyant and therefore difficult to submerge. We combatted this difficulty using weights and took advantage of the buoyancy to keep the cable taut.

Figure 16: Ocean Testing

- We also submerged the solar panel inside the housing in a pool and observed the output. This proved to be difficult once again, because of the buoyant forces. A future test using ballasts to compensate the enclosure's buoyancy to barely positive will yield more accurate results.

Potential future barriers were listed earlier along with proposed solutions. Addressing these concerns, our team would like to pose the following questions for future testing:

- What is the best way to deter bio-fouling for extended periods of time?
- What is the best way to ensure proper cable tension and slack, especially during periods of intense weather?
- Is internally pressuring the solar modules or increasing enclosure thickness the best way to deal with increases in water pressure?

3.11 Analysis and Modeling

Prefacing our analysis, the main concern of our whole design rests on the polycarbonate cover of our solar housing. Since the area of the cover is around 576 in^2, when subject to pressure at large depths, the cover will deform and bow. This poses a significant problem since the edges of our cover are where the static O-ring seals keep water out. Unlike the battery housing, which uses a cylindrical volume to minimize the surface area, the rectangular prism shape for the solar housing poses more of a risk in the face of high pressures. Thus, the bulk of our analysis focuses on this cover. (**Figure 17**) also shows the dimensions of the panel. We have about 0.4” of tolerance for the panel to fit into the enclosure.

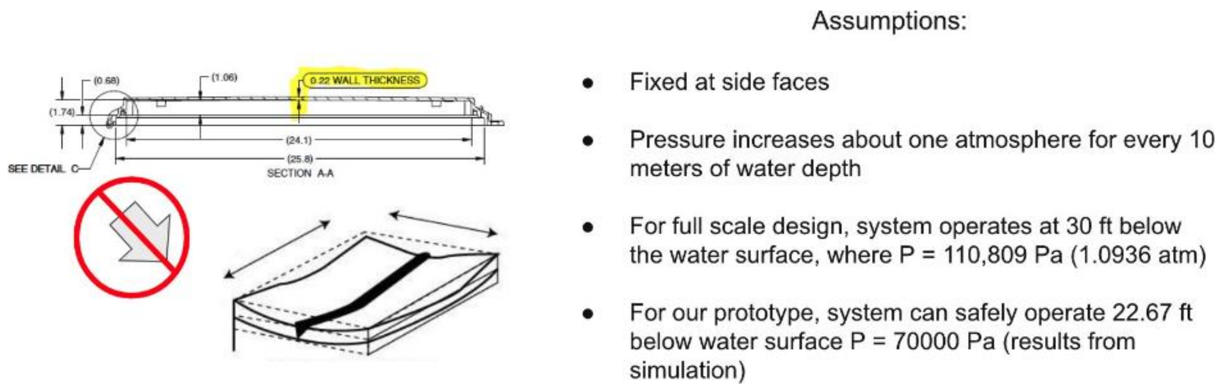


Figure 17: Pressure on Solar Cover

Two questions arise when considering the geometry of the solar enclosure:

- Why did we choose an solar enclosure with such a large depth of 10”
- Why are we not choosing a cylindrical solar housing like our battery enclosure

Addressing Q1, the depth spec was due to the fact that Integra was the only manufacturer who could provide a box rated at IP68, and at the same time offer a clear cover option which would allow the passage of sunlight for our purposes. The option of a custom box was rejected after learning that a custom mold needed to be made that required large volumes and high cost. Addressing Q2, a cylindrical shape for the solar cells would necessitate flexible solar panels, which as shown in (**Figure 18**), would perform poorly in comparison to hard solar cells.

	Traditional	Flexible
Durability/Warranty	20 years	5 years
Lightweight	Heavy	Light
Energy Efficiency	16-20%	12-13%
Cost per Watt	~ $0.60/W	~ $1.20/W
Ease of Transport	Harder	Easier

Figure 18: Hard vs. Flexible Solar performance

Given those constraints, we performed a static finite element analysis on a polycarbonate cover with dimensions of 24”x24”x0.22” inches. The original goal was to get the solar housing to a depth of at least 30 ft (the average ship depth). Our analysis informed us that for safe operation, a max depth of 22.6 ft is recommended. However, sunlight penetration decreases with ocean depth, as shown in **Figure 19** so this raises the concern of how much sunlight will be hitting the solar panel, which in turn would impede our power output. Ideally, the solar panel would be at the surface of the ocean and have an additional use of a winch to allow for variable depth. With variable depth, we would just need to make sure that the housing could withstand pressures at depths great enough to protect the solar housing from passing-by ships (**Figure 20**), and the power output of the panel would not pose a problem as it would remain on the surface of the water for the majority of the day.

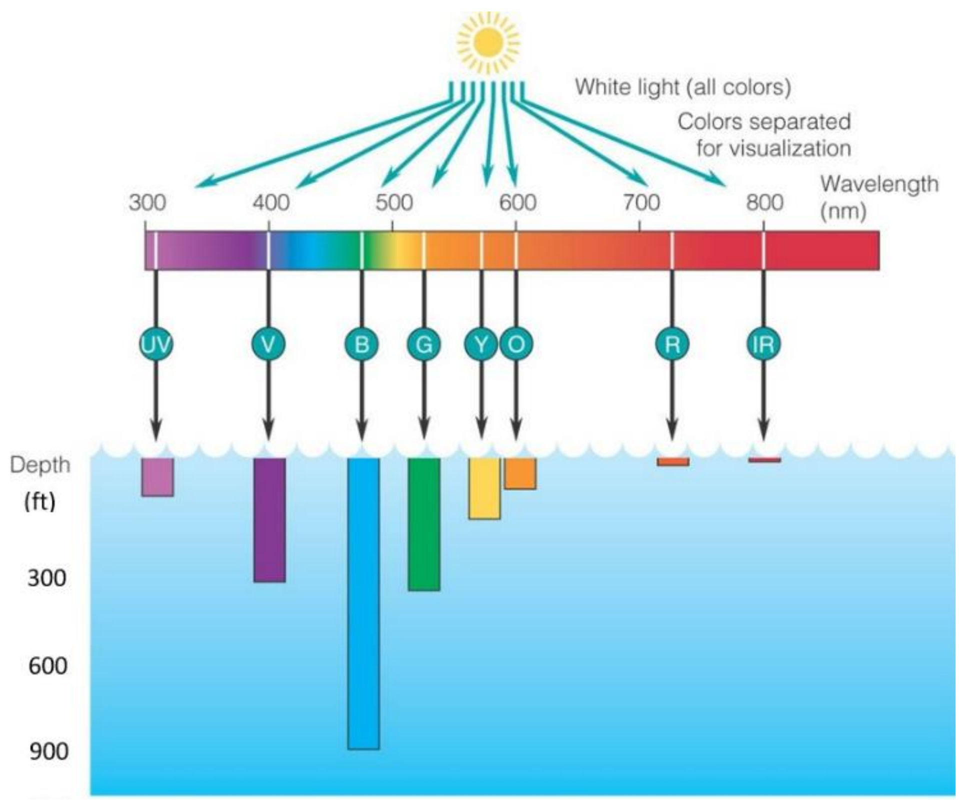


Figure 19: Sunlight Penetration vs. Ocean Depth

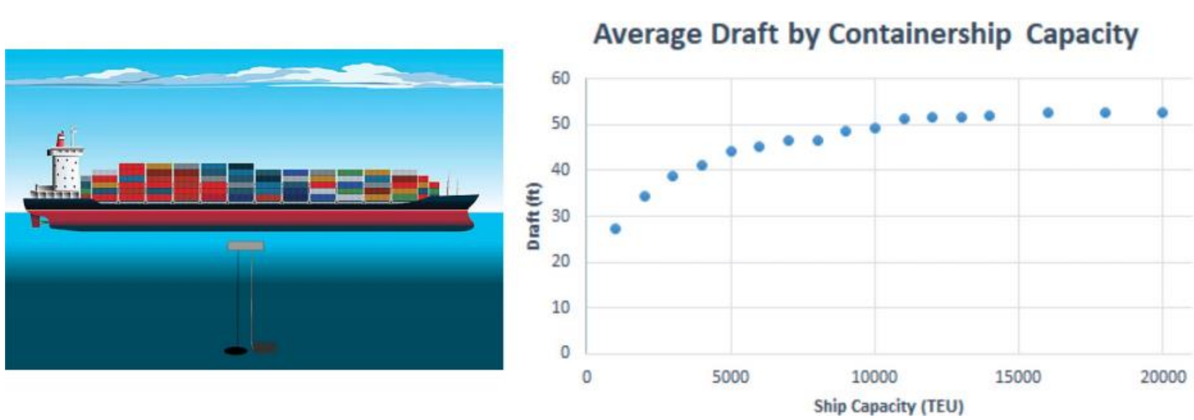


Figure 20: Ship Depth Data

In order to determine the passing criteria of the FEA test, the yield stress of the polycarbonate cover was approximated by creating a relationship between the Elastic Modulus specification Integra supplied, and the mechanical property data from Matweb (**Figure 21**). Our rough approximation came out to be around 52 MPa.

Tensile Strength, Yield	40.0 - 154 MPa	5800 - 22300 psi
Elongation at Break	3.00 - 233 %	3.00 - 233 %
	70.0 - 70.0 % mperature 60.0 - 120 °C	70.0 - 70.0 % @Temperature 140 - 248 °F
Elongation at Yield	4.00 - 110 %	4.00 - 110 %
	2.50 - 4.00 % mperature 60.0 - 120 °C	2.50 - 4.00 % @Temperature 140 - 248 °F
Modulus of Elasticity	1.80 - 6.00 GPa	261 - 870 ksi

Elastic Modulus of Integra cover = 340 ksi

$$Yield\ Strength\ of\ Cover = \left(\frac{340\ ksi}{261\ ksi}\right) * 40\text{ MPa} = 52\text{ MPa}$$

Figure 21: Mechanical Properties of Cover

The analysis began by simulating the 0.22” thick cover at the initial pressures characteristic of 30 ft, and stresses 20 MPa over yield accrued at the edges of the cover. Thus, repeated simulations were performed until the stresses caused by the water pressure matched the yield stress. This was the 22.6 ft specification mentioned earlier. At 22.6 ft, the stresses and displacement are as shown in (**Figure 22**). In order to create a housing that could reach an even larger depth, the thickness of the cover has to increase.

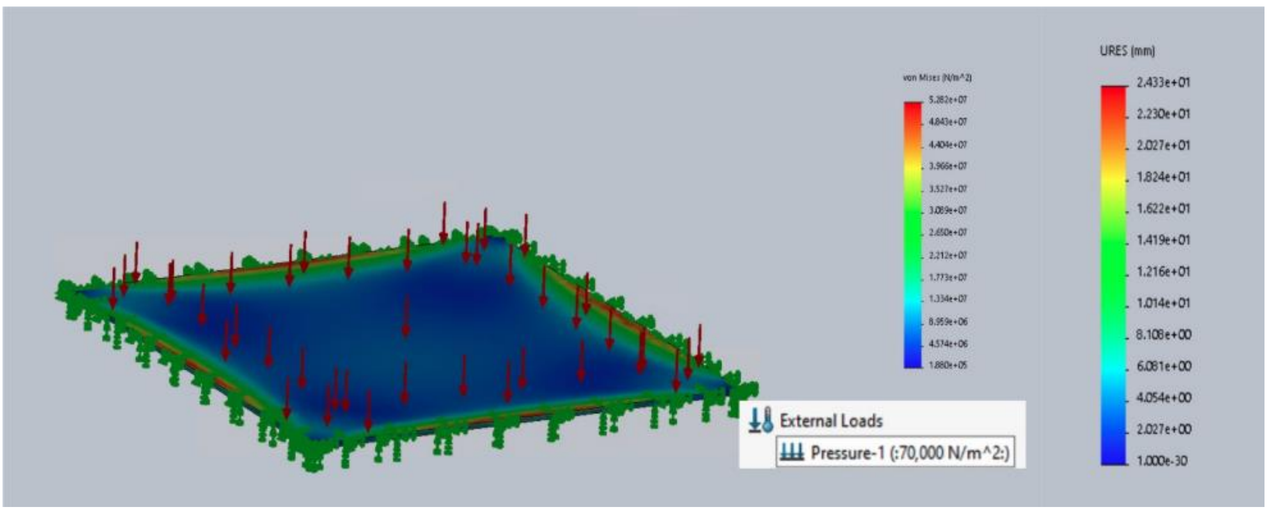


Figure 22: Stress Analysis of Cover

In our simulations, we found that for polycarbonate, doubling the thickness not only decreases the pressure by 20 MPa, but also decreases the displacement by a factor of 1.2 (**Figure 23**). As stated before, this would mean providing our manufacturer with a custom mold, which is not an option for us with our current budget. Thus, we are moving forward with our 0.22” cover, and the main result of these simulations are that we need to leave an air gap of at least 0.1 inches to account for deformities of the cover. We are also investigating use of a depth-regulated pressure compensator connected to a compressed nitrogen tank inside the enclosure to reduce plate pressure to a minimum during submersion cycles.

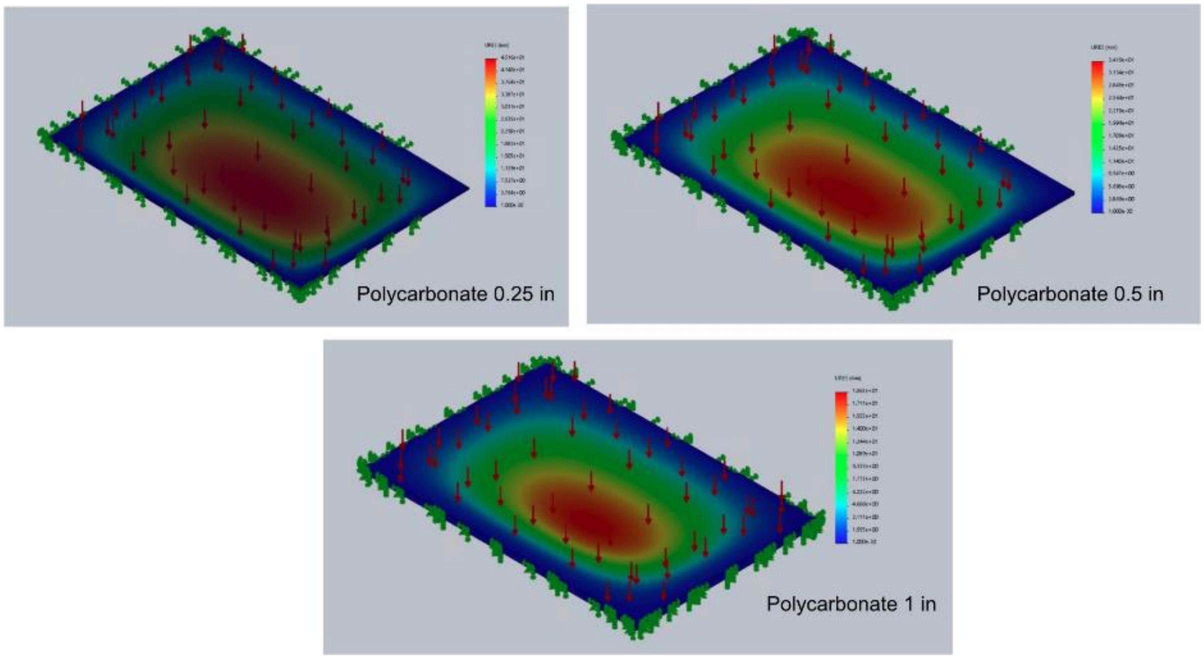


Figure 23: Displacement Analysis of Polycarbonate Cover

The following analysis focuses more on the current final test setup. The goal is to test both the solar and battery enclosure fully submerged in a 6 ft pool. Because drilling into the pool floor is not an option, Olympic weights will act as counterweight to provide the downward force against the buoyancy of our enclosures (**Figure 24**). This buoyant force was the main issue we ran into testing, as stated earlier. As you can see, four 45 lb weights will be required to to counter the buoyancy of the solar housing. For the battery housing, the same process was used to find that the weight required will be around 8 lbs. The weights will be placed onto the weight sled which is connected to the winch. The amount of weight required for anchoring the sled can be reduced by ballasting the solar enclosure, which is also being investigated.

$$BuoyantForce = \rho_{water} g_{gravity} V_{box}$$

$$BuoyantForce = 1000 * 9.81 * 0.094$$

$$W_{panel} = 8.8lbs = 39.1N$$

$$W_{box} = 35lbs = 155.7N$$

$$BuoyantForce - W_{total} = W_{tosink}$$

$$\boxed{W_{tosink} = 731.15N = 169.36lbs}$$

$$W_{Acrylic} = 3.29lbs = 14.6346N$$

$$W_{battery} = 9lbs = 40.0339N$$

$$W_{endcaps} = (1.32 * 2)lbs = 11.74N$$

$$W_{flanges} = (1.52 * 2)lbs = 13.52N$$

$$V_{batteryhousing} = 720.66in^3 = .011m^3$$

$$BuoyantForce = \rho_{water} g_{gravity} V_{housing}$$

$$BuoyantForce = 1000 * 9.81 * .011 = 115.86N$$

$$\boxed{BuoyantForce - W_{total} = 35.918N = 8.07lbs}$$

Figure 24: Buoyancy vs. Weight Calculations

Lastly, to discuss the practicality of using a winch for the full scale design, we refer to (**Figure 25**) The winch will pull 480 W for 2 min per day (1). For our current test setup, the load on the winch is 170 lbs for the 50 W output Renogy panel (2). If we scaled up to the max pulling load of the winch, 1000 lbs, then we can pull down the equivalent of about six 50 W panels, or three 100 W panels (3). The Watt-hr spec of our battery would then be 850 Wh. (4)

Currently, due to budget constraints, the current battery that stores power from the solar panel cannot supply enough power to the winch. However, by scaling up model to include 300 W of solar panel, which would involve using 3 100 W panels, the battery could supply over the 200 W continuous power to the selected sensor device while concurrently powering the winch when triggered by incoming ships.

Specifications:

Model	**EX-1**
Vessel Length	18' - 21'
Spool Size	7" L x 8" Dia.
Power Supply (DC)	12v
Circuit Breaker	40 Amp
Motor (Watts)	480w
Motor Size Diameter	75mm
Gearbox Size	30AA
Max Pulling Load	1,000 lbs.
Max Recommended Working Load	160 lbs.
Net Weight	20 lbs.
Gross Weight	26 lbs.

Assumptions:

5.62 hrs of peak sunlight per day
2 ships per day passing overhead
Winch cycle (retraction and release back to surface) is 1 min
50% loss of power in system

$$P_{required}\,(winch) = 480\ W\ for\ 2\ min \quad (1)$$

$$Current\ F_{load}(winch) = 170\ lbs\ for\ 50\ W\ solar\ panel \quad (2)$$

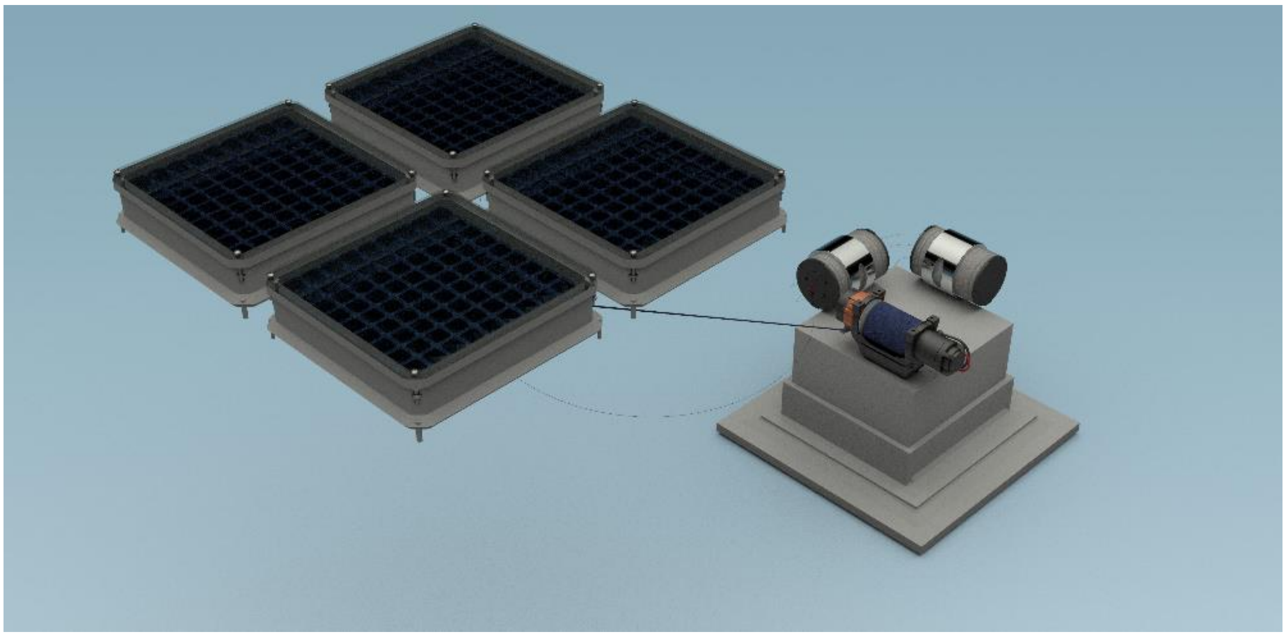
$$\frac{170\ lbs}{50\ W} \approx \frac{1000\ lbs}{300\ W} \quad (3)$$

$$(50\%\ efficiency) * (6\ solar\ panels) * (50\ W) * (5.62\ hrs\ of\ peak\ sunlight) \approx 850\ Wh \quad (4)$$

Figure 25: Practicality of Winch

4 Conclusion

We believe that Proto-Power has the potential to completely revolutionize ocean research. It will not only enable researchers to expand upon their current research, but Proto-Power will allow researchers to open up doors they have never been able to access before. By lowering maintenance and servicing costs, extending service life, and providing a reliable and indefinite source of energy researchers will have access to both higher quantities and quality of data. Furthermore, our innovative modular design ensures that Proto-Power is a universal solution. Whether the client is a small university research team or large governmental agency Proto-Power is guaranteed to have the solution to exactly fit a client's needs. We look forward to Proto-power paving the way in revealing the true mysteries that lie in the depths of our oceans.



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