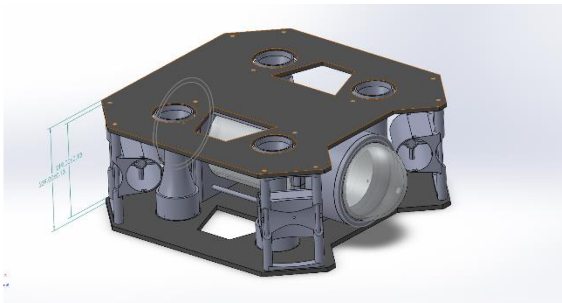
Technical Design Report



I. Abstract

Our team is comprised of three subgroups

- Mechanical
- Electrical
- Software

This has helped us mitigate tasks to play to the strengths of everyone involved in the project. We have remained highly motivated and focused on our goal of competing in the RoboSub competition.

Our submersible has a strong focus on open source, open platform accessibility for lower cost than most on the market robotics options, this has required building many systems from the ground up. Our unique approach sets the stage for many learning opportunities for the students involved.

II. Competition Strategy

Our strategy has been shaped by the limits of our resources and knowledge but has not been limited by our ambition.

In February we began the development of our robot, given funding we were able to acquire we started ordering parts, but many pieces of our robot had to be modeled and manufactured in house to maintain the open platform, open source, low-cost mission of the AUV.

Given this is our first year, our main goal is to qualify and navigate through the gate effectively. Our design has contributed to this goal by keeping it simple and easily maneuverable with 6 axes of motion helping attain our goal of navigating through the gate and completing rolls for extra points.

We also would like to attempt the slalom to challenge the maneuverability of our submersible. We hope to be able to expand on tasks as we compete further and learn from other teams.

Overall, we have learned about what an intense feat this challenge is and have applied it to ourselves accordingly. Our team has been dedicated to our competition goal of completing the first task.

III. Design Strategy

The goal of the Ranger AUV is to compete as a fully autonomous robot. The scope of this project extends beyond use for the RoboSub competition as its modular design allows for easy modification to ensure effective open water navigation.

This is the first time our school has competed in this competition, and we aim to pioneer a future with this robot as a legacy. Through arduous designing and testing we have arrived at our final design. These are some examples of some of the systems comprising our robot.

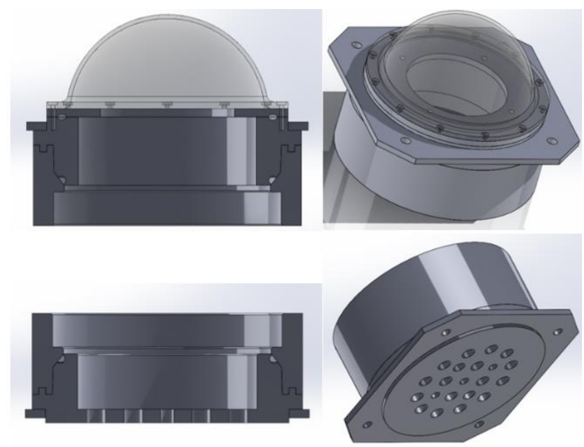
3.1 End-Cap Assembly

The endcap assembly has been revised several times, starting out as a single-piece plug for the 6-inch PVC pressure hull to a 3-part assembly for the rear endcap, and a 5-part assembly for the fore endcap. The rear endcap includes a milled aluminum plug that fits into a milled aluminum adapter which is permanently attached to the end of the PVC tube. The plug has hole placements for all of the outgoing wires and other ports for the submersible.

The fore endcap has the same endcap and collar, instead of wires it supports a spacer ring that the acrylic dome is permanently adhered to. This spacer ring strengthens the acrylic dome and improves the sealing capabilities of the O-ring that is sandwiched between it and the aluminum endcap.

Locking the two endcaps into place are the vice plates, which operate very similarly to a vice clamp. Four stainless steel all-thread rods are used to apply pressure via stainless steel hex nuts to the vice plates on their four corners along the length of the pressure hull. This pressure provides the sealing force for the endcaps to sit onto their O-rings and stops water incursion.

The testing journey for the End Cap Assembly is far from sone but numerous O-ring fit tests have been completed as well as multiple 3-D printed prototypes to ensure fit withing the PVC pressure hull



3.2 Structure Brackets

The AUV's brackets, refined through three design iterations for the OCEC AUV, embody our RoboSub 2025 strategy of adaptability and reliability. Featuring two sets, one at the front and one at the back, the design comprises a top and bottom piece per set, with precisely positioned front holes aligned alongside the PVC pipe to secure through the endcaps on both sides using all-thread rods and nuts, ensuring a horizontally clamped assembly. The upper holes facilitate vertical clamping through the HDPE plate, drawing inspiration from hose clamp mechanisms, as evidenced by the 3D-printed brackets in their clamped and standalone configurations. This meticulously engineered solution delivers a secure, adjustable grip, maintaining watertightness and structural integrity while streamlining assembly, thereby supporting effective task execution.

3.3 Main Power

The UUV will be powered by two 4 cell Lithium polymer batteries from Zee batteries connected in parallel with busbars for extended runtime.

Originally intended for Remote controlled aircraft or cars, these hardshell batteries are 5.2 Amp-hours each, and output between 13.2 and 14.8 volts depending on charge level. LiPo batteries are available commercially in 1, 2, 3, or 4 cell models, outputting a maximum of 3.7 volts per cell. Our highest voltage components are thrusters which operate at 12v, so we chose 4 cell batteries to allow for a design that steps down the voltage to all the levels needed and requires no boost converters. All our logic is either 12v, 5v, or 3v3, so we have three twelve-volt buck converters, two 5v buck converters, and one 3v3 buck converter to regulate the power down to the levels we need.

3.4 Thrusters

For thrusters, we chose to use brushless DC motors spinning custom 3d printed propellers. This gives us a wide variety of options to easily change thrusters as needed. For the vehicle participating in RoboSub, we chose 100W 2418 Corrosion Resistant Waterproof Brushless Motors from ApisQueen. These brushless motors have a perfect balance between affordability, size, and performance, costing only $25 each, weighing in at 49g and 24mm across, while still being 250kv and providing 2.7N of thrust with custom 3-D printed propellers, drawing only 1.5A. These brushless motors are each controlled with a 30A defiant bidirectional ESC. This allows us to control the speed of the motor with a PWM signal from the Arduino.

3.5 Processing

There are two main computers onboard the vehicle, a Raspberry pi 5 8gb and an Arduino mega. The Pi runs the standard Raspbian OS, and handles all the logic, controls, and every core system for the vehicle. The Arduino mega functions nearly exclusively as a bridge between digital logic and physical devices. We wanted a microcontroller that is common, easy to use and learn, and has plenty of pins for controlling various devices, and the Arduino mega fits that perfectly. In addition, the USB port provides easy communication from and back to the Pi via Serial.

3.6 Auxiliary/Safety systems

To protect and work with the vehicle, separate from the main power, we have a secondary circuit which has its own power and controls. Centered around a Li Poly pack and charger, an Adafruit Itsy Bitsy m0 express controls a small screen, an RFID reader, the E-Stop, and communicates with the main Pi and Arduino. The RFID reader allows communication with the outside world without breaching the pressure vessel via preprogrammed cards, allowing us to start the main power lines from outside, without draining those batteries. The display will allow the Itsy Bitsy to provide valuable information about the state of the different systems, and the Li Poly pack should keep it all charged for multiple missions.

3.7 PCB

To better manage onboard electronics, we created a custom PCB that routes power and data signals between inputs and outputs. This PCB has 3 main sections. The first section is the power input, which accepts multiple 12v, 5v, and 3v3 lines split across terminal blocks. The second section of the PCB is the area that controls the motors. Terminals allow the ESCs to receive 12v power, then connect to the ports which will connect the main PCB to the endcap with RJ45 cables. These were chosen as they are very common, and easy to remove when the endcap needs to be opened. Six of these ports will allow the wires from all eight motors to be connected. The third and final section of the PCB is for all the other ports to the endcap, as well as the internal data and power lines. For the ports to the endcap, they are wired for data lines by default, with jumpers and circuits to disable these lines when wired for power. There are headers for internal data lines connected to the Arduino, as well as a set of pins for 5v and 3v3. Finally, fan headers are wired up for all of the internal cooling.

IV. Testing Strategy

The testing strategy of our robot focuses heavily on the internal structure, as well as prototyping of all exterior components. Our club funded a 3-D printer which has been the basis for all prototypes of the robot’s structure. Since having these we have been able to create a full-scale prototype to ensure fit before milling aluminum end caps and milling a sheet of HDPE for the top and bottom of the robot.

Our team decided to forego getting thrusters with propellors and design them in house. This has accounted for many tests of different propellor types to decide upon the right shape and size for our motors. We have gained an aquarium that has proven very useful for testing, not only propellors but the ultrasonic sensors that we have installed. These will allow us to navigate clearly though the water.

We have also begun testing the IMU. This was accomplished by attaching them to a breadboard, and had it print the results, then compared it to manual movements of the breadboard. We had a heavy focus on debugging the code with it. With this IMU, we will be able to maneuver clearly and precisely.

While we are not finished with testing, we have successfully tested all individual parts. What we have left is the testing of systems which will commence soon. We look forward to the cohesive integration of the systems together.

V. Acknowledgements

The Olympic College RoboSub Rangers would like to thank all the wonderful sponsors that have helped us build this robot through both financial and intellectual contributions. Special thanks to Keyport Naval Warfare Center and McLaughlin Research Corporation for their continued financial support. And to the Olympic College Manufacturing Center for milling our aluminum endcaps. Additionally, thank you to the Olympic College Foundation and MESA for ensuring safe travel to the RoboSub competition. Lastly, we thank the O-Ring Store and USA Metal Online.