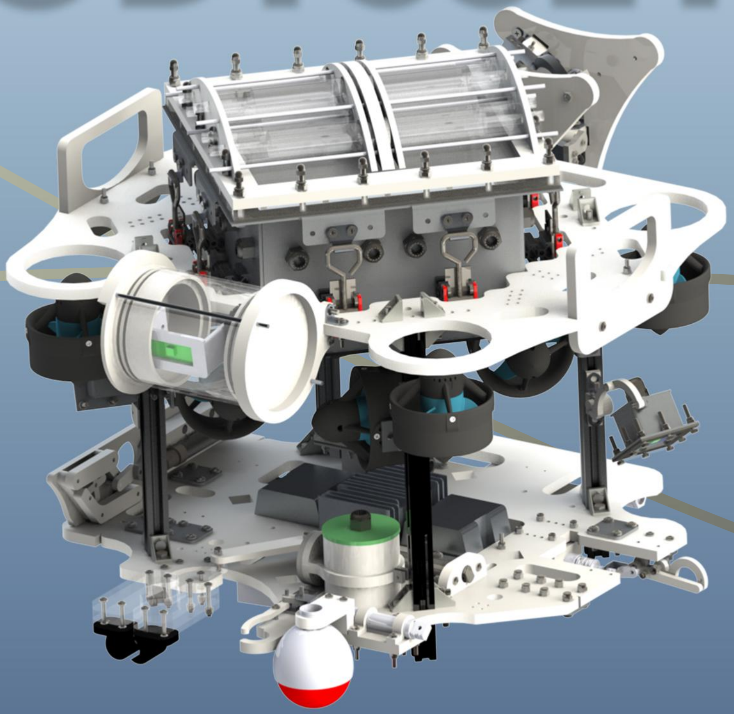
# ODYSSEY



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ALEXANDRIA, EGYPT

**Technical Documentation**

ROVS BUILT TO LAST

## Contents

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Figure 1: Acknowledgements

# 1 Introduction

## 1.1 Abstract

Aquaphoton Academy is a student-run company based in Alexandria University with a wealth of combined expertise garnered over years of endeavor in designing and manufacturing Remotely Operated Vehicles (ROV) aiming to tackle the escalating issues that the world's oceans are facing as a result of pollution and climate change.

Following last year's many successes, the team decided on pushing ***Nova***, last year's ROV iteration, to its full potential by improving the mechanical and electrical systems in terms of efficiency, ease of use and flexibility.

***Odyssey*** , our new iteration, is equipped with improved mechanical and electrical designs. Variable buoyancy is introduced, besides the unique manipulators and our own customized Electronic Speed Conrtoller's (ESC's).

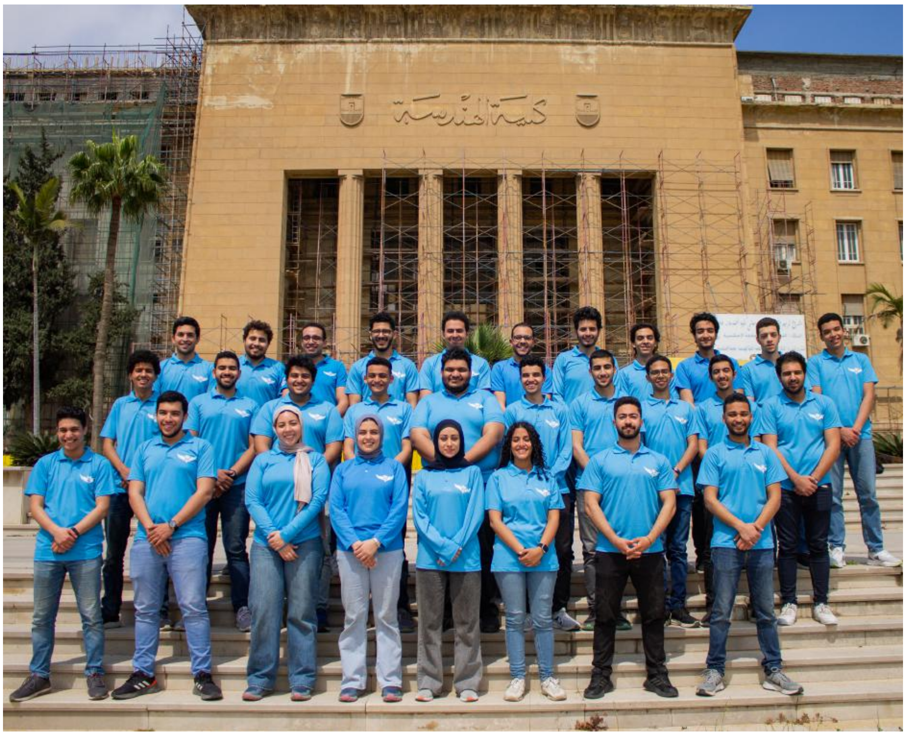


Figure 2: Aquaphoton's Team

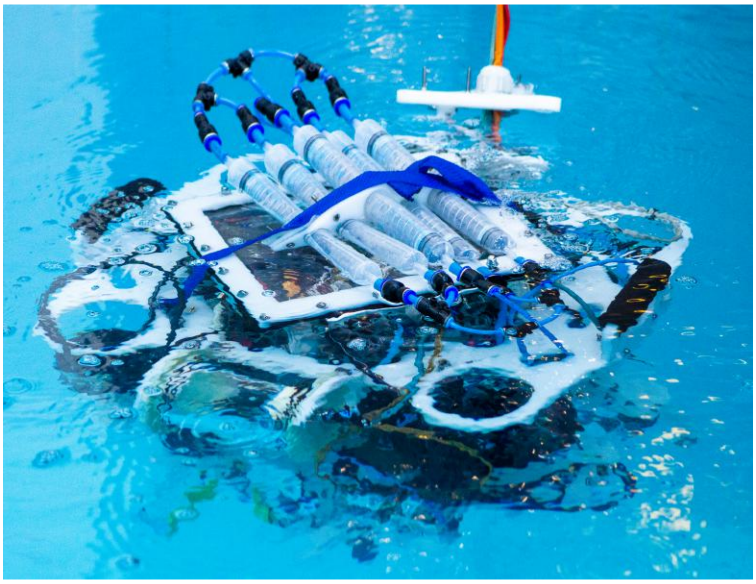


Figure 3: ***Odyssey***'s Real Life Image

This year, Aquaphoton Academy proudly presents Odyssey, embodying the spirit of extensive exploration and discovery of underwater environments. Odyssey represents our dedication to studying marine ecosystems, species, and the ocean's mysteries, addressing the complexities and challenges of the marine world to achieve significant advancements in marine science and conservation. In this year's report, we are excited to share our engineering design process that drives our consistent high-level performance. Our approach combines a continuous learning model, effective lifecycle management, and a safety-centric mindset, all of which contribute to creating a competition-ready ROV. Odyssey is the result of rigorous innovation, iteration, and testing, emphasizing consistent performance, simplicity, and safe operation. Its modular design, focused on continuous improvement, ensures precise movement, versatile manipulation capabilities, and excellent vision.

# 2 Design Rationale

## 2.1 Design Evolution

Aquaphoton Academy constantly pursues innovative solutions to enhance its mechanical designs and electrical systems, aiming to improve its ROVs' overall performance. Accordingly, our ROV is designed after a year full of research and development of last year's ROV, ***Nova***. Our current proposed solution, ***Odyssey*** , has been meticulously designed, as shown in Figure 4.

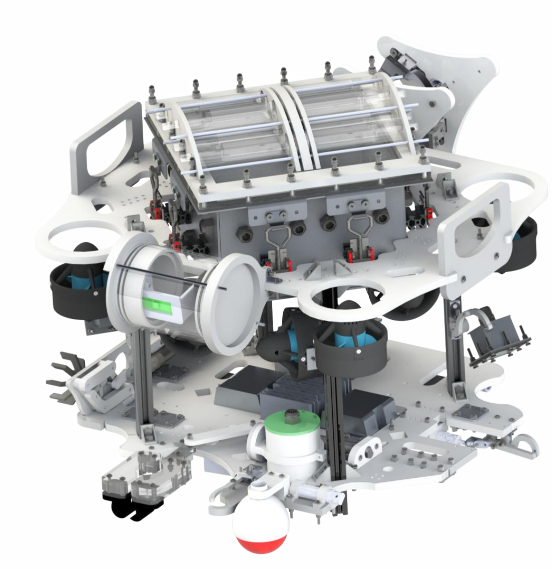


Figure 4: Rendered Finalized Model of ***Odyssey***

## 2.2 Innovations

### Hybrid Frame and Aqualock

This year's significant enhancements in the mechanical design include upgrading the main square canister (Aqualock) to improve accessibility to the electrical components. This enhancement is achieved through the implementation of an upgraded sealing technique, utilizing pull latch clamps to facilitate the process. Furthermore, we have eliminated the weak High-Density Polyethylene (HDPE) vertical plates and replaced them with Aluminum extrusion profiles measuring 20x20mm$^2$ V-slots made of a 6061 alloy. These profiles are capable of bearing excessive loads without buckling, thereby securely holding the entire system in place.

### Unique Grippers

It is worth noting that for the first time in Aquaphoton's history, we have developed our own rotating mechanism and vacuum manipulator, both of which significantly contributed to the success of this year's specialized missions.

### USB Cameras

Replacing the IP and analog cameras with the new smaller USB ones has freed up space for additional features and reduced the weight of the cases, resulting in a lighter and more compact ROV.

In addition, using USB cameras reduces troubleshooting, noise, and delay. Furthermore, the USB cameras enhanced our overall underwater vision with minimal delay. To adapt to the new approach of using USB cameras, our hardware sub-team has successfully designed our USB hub to efficiently receive all camera feeds simultaneously with a high data rate.

### ESCs

Another aspect of this year's enhancements is our ESC modifications. Last year we designed our own customized ESCs that have proven to work efficiently through intensive testing. This year, the hardware subteam improved the ESC's design and added more functions for controlling the thrusters by using more reliable components. This improved the power ratings of the ESC, providing more resilience in its performance. It also made way for novice features such as current sensing.

### Customized GUI

Many enhancements and features have been added to our previous year's Graphical User Interface (GUI) which was responsible for controlling the thrusters, Directional Control Valve (DCVs), and overall motion. An example of the features that have been added this year is allowing us to open and close a TCP/IP socket we programmed, the socket connects between the control application which serves continuously and the missions application which connects to the socket when we need to control the ROV autonomously during a mission. Another feature that has been added to the GUI is displaying the feed coming from all 4 USB cameras instead of the IP cameras only. Adding this feature made it easier to process the feed coming from USB cameras, unlike analog and IP cameras which had problems with latency and noise immunity.

## 2.3 Design and Manufacturing Process

### 2.3.1 Design Process

#### Conceptual Design

Some of the most urgent problems of last year's design was the significant size, as ***Nova*** was fit into an 815 mm diameter circle that affected its portability. Moreover, the electrical components in last year's square canister were difficult to access quickly because of the sealing technique used, which led to the loss of material and time. After a significant effort was poured into our brainstorming meetings, we were able to overcome these problems by implementing several features. For example, upgrading our sealing technique of the square canister's cover, using two lower plates on different levels, and making a designated slot for the buck converters and the DCVs to save room for the implementation of other components such as more camera cases and the new vacuum manipulator, as shown below in our hand sketches in Figure 5. During the brainstorming phase, we discussed a few more issues such as the buckling that the vertical plates encountered last year due to the excessive loads and the inadequate support and rotating the ECO-Mooring 720 degree with ***Nova***. For the buckling, we went through a few directions whether using aluminium rods or 20x20mm$^2$ V-slots. Among the choices for the rotating mechanism were using mechanical links and a piston or installing a DC motor. Simultaneously, several design ideas for the rest of the frame and manipulators were being formulated along with the camera cases due to the update of using USB cameras instead of IP and analog so we needed smaller cases than before. Moreover, we developed a concise plan detailing the design goals and required features for the electrical system.

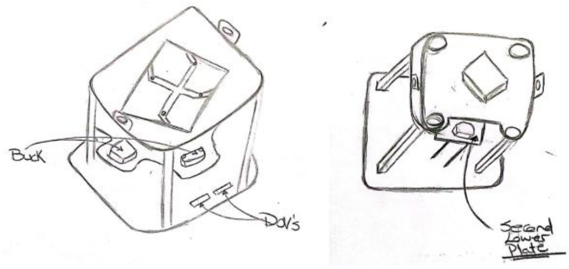


Figure 5: ***Odyssey***'s Two Hand Sketches Designs of the Two Proposed Solutions

#### Preliminary Design

After conducting a lot of simulations, and stress analysis on 3D models of the proposed frame designs, we found that the two-levelled lower plates will constrain the thrusters' flow and adjustment. The same process was conducted on the designated area for the buck converters and DCVs plate and it gave optimistically favorable results. Moreover, after reconsidering putting Aluminium rods as vertical plates it was found they will add a lot of unneeded weight for ***Odyssey*** where we can obtain the same strength and flexibility in adjusting components from the V-slots and saving up costs as well. Aquaphoton has decided to proceed with the one lower plate with a designated slot for the bucks and DCVs, the Aluminum extrusion profile, and the mechanical links for a rotating mechanism, as the DC motor case will take up space and volume necessary for other components, including the new USB camera cases. Prototype boards were also made during this phase to rigorously test new Integrated Circuits(ICs) and modules in our design, such as the motor driver and buck converter, to ensure their viability and eliminate potential errors when the finalized printed circuit boards are manufactured. We have made some improvements to our GUI, including adding new features. The most significant change is the ability to modify thruster configurations directly from the GUI, rather than having to modify them within the firmware code. This has reduced the time and effort required to make configuration changes and created a more user-friendly interface that offers greater flexibility. Moreover, in the last year, we've used analog cameras to utilize their speed and IP cameras to utilize their quality. This year we've used USB cameras combining analog and IP camera advantages.

#### Detailed Design

The design of the entire ROV, shown in Figure 6, was finalized in SOLIDWORKS, including the manipulators, camera cases, and the square canister. Accurate flow simulations and stress analysis were done on the entire ROV using SOLIDWORKS simulations to determine any points of weakness and finalize the design for the manufacturing phase.

A trade-off matrix, shown in Table 1, was constructed to quantitatively evaluate the chosen materials based on size, weight, and cost metrics.

The electrical system boards' design was finalized in Altium Designer. The Gerber files were sent for manufacturing while the Bill Of Materials (BOM) was sent to the components supplier. The firmware team uses this period to test new ideas using development boards.

| | Criteria | Weight | | | | | | Material Options | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Frame | Manipu-lator | Gland's Plate | Casing | Brackets | Guides, Screws and Nuts | Score | | | |
| | | | | | | | | HDPE | Acrylic | Aluminum | Stainless Steel |
| 1 | Cost Effectiveness and Availability | 0.2 | 0.1 | 0.1 | 0.1 | 0.4 | 0.2 | 9 | 7 | 5 | 3 |
| 2 | Machinability | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0 | 9 | 5 | 9 | 1 |
| 3 | Specific Gravity | 0.2 | 0.1 | 0.1 | 0.2 | 0.1 | 0 | 9 | 9 | 7 | 1 |
| 4 | Strength | 0.2 | 0.3 | 0.6 | 0.1 | 0.2 | 0.8 | 6 | 7 | 8 | 9 |
| 5 | Ductility | 0.3 | 0 | 0 | 0.1 | 0 | 0 | 7 | 1 | 2 | 3 |
| 6 | Transparency | 0 | 0.4 | 0 | 0.2 | 0 | 0 | 0 | 9 | 0 | 0 |
| Total Score Formula | | $\sum_{criteria=1}^{n}(weighting\ of\ component)_{criteria} \times (material\ score)_{criteria}$ | | | | | | | | | |
| Total Score | | Frame | | | | | | 7.8 | 5.4 | 5.5 | 3.6 |
| | | Manipulator | | | | | | 4.5 | 7.8 | 4.5 | 3.2 |
| | | Cable Glands' Plate | | | | | | 7.2 | 6.8 | 7.8 | 6 |
| | | Casings | | | | | | 6.7 | 6.6 | 5.6 | 2 |
| | | Brackets | | | | | | 8.4 | 6.6 | 7 | 3.4 |
| | | Guides Screws and Nuts | | | | | | 6.6 | 7 | 7.4 | 7.8 |

Table 1: Material Trade off matrix

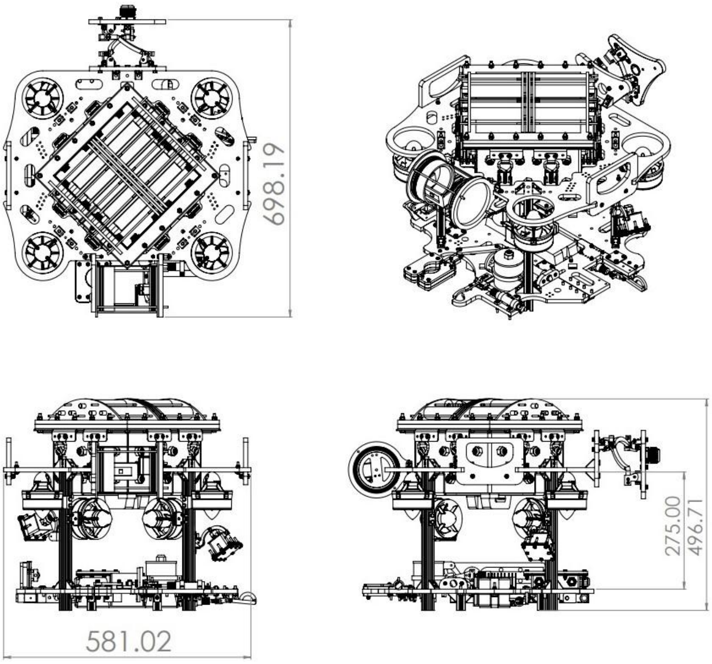


Figure 6: ***Odyssey***'s Detailed Drawing and Dimensions Extracted from the 3D Model

## 2.3.2 Manufacturing Process

The manufacturing process guarantees dimensional accuracy and building integrity while being cost-effective. Cylindrical parts were manufactured using lathing, while Acrylic, HDPE, and Aluminum plates were laser-cut and routed by a CNC machine. The Aluminum plates were then welded together to be air-tight sealed. 2D CAD drawings were prepared for CNC cutting, taking into account optimizing the usage of the material sheets to reduce wasted material. During assembly of the mechanical parts, the Printed Circuit Boards (PCBs) were fabricated, and both were ready to be tested.

During this phase, the PCBs were delivered from the manufacturer and the assembly process started. Each section in every PCB was soldered and tested separately to narrow the possibilities of fault for easier debugging and troubleshooting.

## 2.4 Vehicle Core Systems

### 2.4.1 Mechanical

- **Frame**

***Odyssey***'s frame combines HDPE and Aluminium to take advantage of each material's properties as HDPE is ductile, machinable, available, and cost-effective. Moreover, it allows ***Odyssey*** to be naturally buoyant as its density is approximately equal to fresh water's density. Aluminium is lightweight, ductile, and malleable and it has a high strength-to-weight ratio. A more clear comparison between all material options is illustrated in the trade-off matrix in Table 1. The frame, shown in Figure 7 is 5.3 kg and dimensions 698.18x581.02x496.71 mm$^3$

Figure 7: ***Odyssey***'s Rendered Hybrid Frame

The main structure of the frame consists of three sections: the upper plate, the lower plate and the four vertical plates made from 6061 Aluminum alloy extruded Aluminum profiles 20x20 $mm^2$ V-slots. The V-slots assemble and unify the two other plates, as well as support the upper plate.They are mounted at a 45° angle to comply with the thrusters' configuration and are extended to the ground so that the lower plate maintains a safe distance from the ground, safeguarding the components. The Aluminum extruded profiles feature a variable fixation to accommodate any unexpected changes so that ***Odyssey*** adapts to the required tasks.

The upper plate consists of the canister, an Aluminium cross that provides support to the plate and reduces bending, a small buck, two HDPE handles, the main camera, and the strain relief which makes sure that the tether moves freely without restricting ***Odyssey***'s movement. Moreover, the strain relief prevents the canister's cables from getting damaged due to tension on the tether

The lower plate consists of five manipulators, three of which are connected using variable plates making it easier to change the manipulators as tasks vary. It also includes four buck converters carried by an Aluminium part and six DCVs

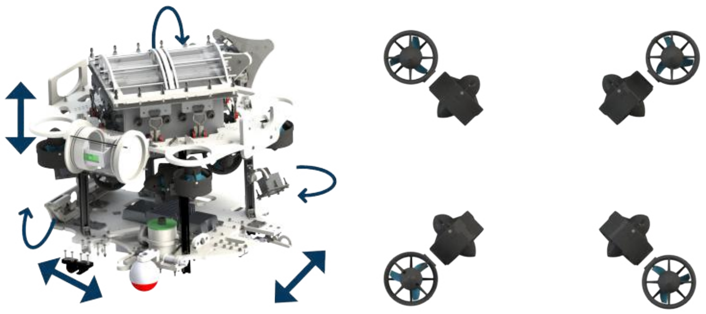
## Propulsion

***Odyssey*** is equipped with eight BlueRobotics thrusters; five of which were reused and three were newly purchased. A rigorous evaluation test was conducted on each thruster to evaluate its performance and decide whether it was fit for redeployment or not. This test verified that all the selected reused thrusters are still as adequate and reliable as they were when used in the previous year, allowing our design to be as cost-efficient as possible.

This configuration, shown in Figure 8b, was chosen to maintain symmetry in the frame while providing the best stability during motion. A T200 thruster has a maximum forward thrust of 36.4 N. Accordingly, the horizontal T200 thrusters in an X-shaped configuration will produce 76.48 N of thrust in the forward direction and give a combined maximum thrust force of 145.58 N in the upward direction.

Despite the T200's higher cost and maximum power consumption we managed to use 108 Watts to reduce the consumption, it offers us a multitude of advantages: its higher force generation, which provides faster motion for ***Odyssey*** , as well as allowing for more degrees of freedom, all of which made its usage an imperative choice in our design.

***Odyssey***'s thrusters' configuration provides six degrees of freedom as shown in Figure 8a. The three degrees of freedom: surge, sway, and yaw, are attained using four T200 thrusters that are mounted horizontally at 45°. This allows ***Odyssey*** to move in forward, lateral, and rotational motion. Four T200 thrusters are also installed on the upper plate's edges to grant the three degrees of freedom, heave, pitch, and roll. Not only do they provide sufficient force to counteract drag during vertical motion within our power limit range, but they also simplify the picking up of objects from lower levels, taking advantage of both pitch and roll degrees of freedom.



(a) Six Degrees of Freedom

(b) Thrusters Configuration

Figure 8: ***Odyssey***'s Propulsion

Several flow simulations were made to validate that ***Odyssey*** can withstand the drag force and to calculate its maximum speed. The maximum coefficient of drag at surge speed was determined to be 0.011 from the simulation shown in Figure 9, where 63.381 N drag at 1 $m\,s^{-1}$ speed and 0.1765 $m^2$ projected area were calculated according to equation 1.

$$F_D = C_D * A * \rho * V^2/2 \tag{1}$$

where $F_D$: drag force, $C_D$: coefficient of drag, $A$: projected area, $\rho$: density of the fluid, and $V$: flow velocity relative to the object.

## Buoyancy and Stability

During the design phase, simulations were made to determine the shift of the center of buoyancy ($C_b$) relative to the center of gravity ($C_g$). It was concluded to be 3 mm to ***Odyssey***'s left and 11 mm

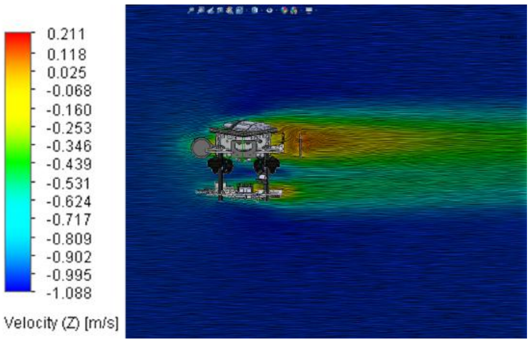


Figure 9: ***Odyssey***'s Flow Simulation in SOLIDWORKS

to ***Odyssey***'s back, some external weights were added to correct the shift.

### ► Variable Buoyancy

We had to update our buoyancy system to be variable to adapt to any possible level ***Odyssey*** needs to be underwater, which replaces the less accurate Foam we used before. The variable buoyancy consists of ten syringes distributed on the top of the main square canister on the Acrylic lens held by two HDPE parts. This new system has enhanced our ROV's lifting capabilities and adjusted the buoyancy force to be increased by 5.88 N when the syringes are empty and 5.88 N added to the ***Odyssey***'s weight when filled with water.

Taking the center of the lower plate's back end as a reference, ***Odyssey***'s $C_g$ coordinates are (-109.84, -73.8, 12.73), and its $C_b$ is located at (-106.48, 21.44, 21.55). While both centers lie on the same vertical axis, to achieve stability, the $C_b$ needs to be above the $C_g$ to create a proper restoring moment. This is achieved by the addition of lead weights, which also contribute to achieving neutral buoyancy.

***Odyssey***'s weight is 230.424 N, and the displaced volume is 22549318.077 mm$^3$. Archimedes' principle was then applied to calculate ***Odyssey***'s buoyancy, as shown in equation 2.

$$F_b = \rho * V * g \tag{2}$$

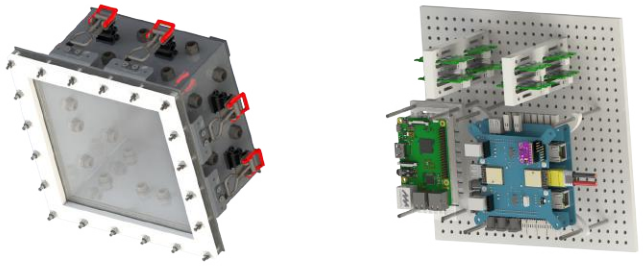
where $\rho$: fluid density, $V$: fluid volume, $g$: acceleration due to gravity, and $F_b$: buoyancy force. $F_b$ equals 225.49 N which is slightly less than ***Odyssey***'s weight.

## • Main Canister

Aqualock is our promoted square canister, shown in Figure 10a, which houses and protects the electrical system. It is inspired by last year's square Aluminum canister but with some significant improvements in its sealing technique. This year's enclosure volume is 250x250x175 mm$^3$ with a top cover Acrylic lens 10 mm thick accompanied with eight pull latch clamps along its lateral area where each face has two, to securely lock the cover and ease its opening and closing.

The inspection mechanism of the electrical components is inspired by the classical breadboard's shape, and is composed of a variable plate, shown in Figure 10b, that provides the system brackets with multiple fixations, enabling the orientation of the system to be altered as needed. In addition, it allows for better and more convenient access to the components inside, which are securely held in place.

HDPE was the selected material for the brackets due to its strength and ductility needed to carry all our electrical components. The brackets are connected to the main variable plate using sliding stainless steel rods that have high rigidity and strength.



(a) Assembled View of AquaLock with the Pull Latches Clamps

(b) Electrical Components Assembly on the Breadboard

Figure 10: ***Odyssey***'s Main Canister: Aqualock

## • Sealing

### ► Main Canister Sealing

Aqualock's cover sealing, shown in the figure 11 is composed of two sections, first, a squared Aluminum flange with a maximum area of 280x280 mm$^2$ welded to the main body. This flange seals using a custom-shaped gasket compressed to the 10mm-thick Acrylic lens. Another gasket is compressed to the lens and an Aluminum flange using bolts. Moreover, we are featuring a new sealing technique this year to utilize the opening and closing of the canister saving time of screwing and unscrewing twenty bolts every time. We have implemented new pull latch clamps, two on each side ,each applies a force of 1961.33 N, eight in total, they are installed tightly to seal the canister and to distribute the normal pressure force equals to 6.27 bar on all sides of the flange which were calculated according to equation 3

$$P = \frac{F}{A} \tag{3}$$

where $P$: Pressure, $F$: Total force, $A$: Area.
The flange's total area: $280^2 - 230^2 = 25500$mm$^2$.
Total force: $m \cdot g = 10 \times (200 \times 8) = 16000$N.

The 3mm thick Aluminum sheet was chosen after conducting tests and proving its ability to maintain its strength even at small thicknesses without posing any leakage risks on ***Odyssey*** . Twenty nine AGRO glands are held on the sheet, each mounted on a groove 15mm in diameter.

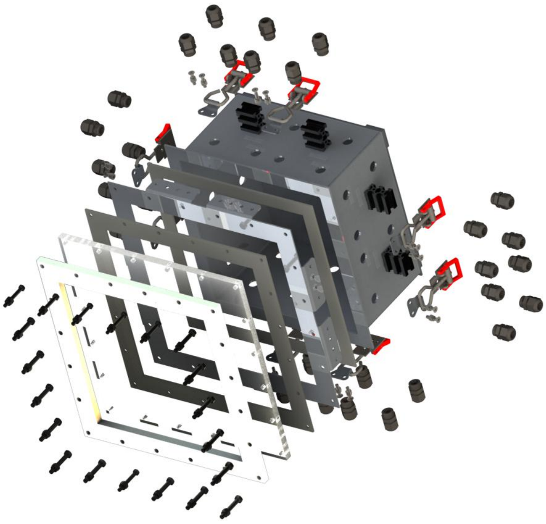


Figure 11: Main Canister: Aqualock - Exploded View

### Main Camera Case

The main camera case, shown in Figure 12, is utilized and mounted above the end effector on the upper plate of ***Odyssey*** to hold the main front camera that overlooks the scissors and the hook manipulators. Since it is connected to the shaft of a servo motor using a 3D printed Polylactic Acid (PLA) part, the camera inside can rotate 180 degrees and provide ***Odyssey*** with an even wider, unobstructed view compared to a normal fixed setting. This camera case was utilized last year as it proved to be reliable in sealing and in providing the pilot with a better view. It is sealed via two flanges using two radial O-rings. Together, they hold a 4-inch Acrylic cylinder whose length is 140 mm. A pair of Stainless Steel guides are also used to keep it intact. The back flange is mainly responsible for sealing the camera's cable using an AGRO gland, while the front flange is specially designed to mount a servo motor on it.

(a) Assembled View (b) Exploded View

Figure 12: Main Camera Case Overlooking the Main Manipulator

### Manipulators Camera Case

This camera case, shown in the Figure 13, which is mounted to overlook the rotating manipulator, is composed of a rectangular Aluminum container with an area of 44x40 mm$^2$ and a height of 35 mm. A rectangular flange with an area of 65x60 mm$^2$ is welded to it. The case is covered by a rectangular 5 mm thick Acrylic lens to provide a clear view and it is sealed by a custom-made rectangular gasket that is bolted to the flange by the Acrylic lens. The camera itself is fixed by a PLA 3D-printed part and its cables are sealed by an AGRO gland added to the side of the case.

(a) Assembled View (b) Exploded View

Figure 13: Manipulators Camera Case Overlooking the Rotating Mechanism

### Bottom View Camera

The main idea behind this case, shown in Figure 14, is that the threaded part of the casing was adapted to be used as the source of compression on the O-ring. This sealing technique provided us with a more compact and lighter design, as it was sealed without using a single bolt. It consists of three parts: the outer front case, the camera fixation part, and the back-end cap. The outer front case comprises a face O-ring along with an internal thread, while the camera fixation part contains the camera along with an external thread. These two are then fixed together, compressing an Acrylic lens between them using the O-ring. The back-end cap holds the AGRO gland that seals the camera's power cable.

(a) Assembled View (b) Exploded View

Figure 14: Bottom Viewed Camera used to Monitor the Way Points

## Manipulators

### Scissors Manipulator

The scissors manipulator, shown in Figure 15, can hold objects with a gripping force of 45.5 N. To amplify the piston's stroke, a scissors mechanism proved to be the most suitable for the design of this manipulator, as it doubled the 50 mm piston's stroke. Since we now only need to use one pneumatic cylinder, the size is significantly more compact.

It is mounted on the lower plate of ***Odyssey*** and is used in carrying the vertical profiling float, it is used to recover the acoustic receivers from the water and place an Acoustic Doppler Current Profiler (ADCP) in the designated location at the potential spawning site.

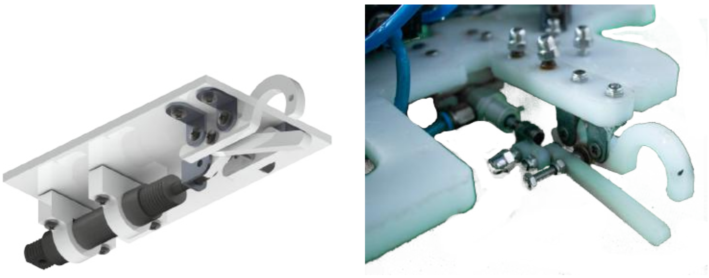
To convert this manipulator into a multi-functional one, two 3D parts will be fixed on both static and dynamic end effectors. This modification will allow us to retrieve objects from different planes. Consequently, we can pick the multi-function node with the acoustic release pin, holding the recovery float in place that accomplishes tasks (1.1 , 2.1 , 3.1 , 3.2 , 3.4 , 4).

(a) Render (b) Real Life

Figure 15: Scissors Manipulator

### Hook Manipulator

The hook manipulator, shown in Figure 16, is simply composed of a moving link connected to a 1 cm stroke piston and a static hook-shaped one fixed to the lower plate. It is mounted twice on the lower plate vertically and horizontally allowing ***Odyssey*** to place the SMART repeater in the designated area, grab the float pin, and carry the brain coral to the coral restoration area that accomplishes tasks (1.1 , 2.2 , 3.1).



(a) Render (b) Real Life

Figure 16: Hook Manipulator

### Vacuum Manipulator

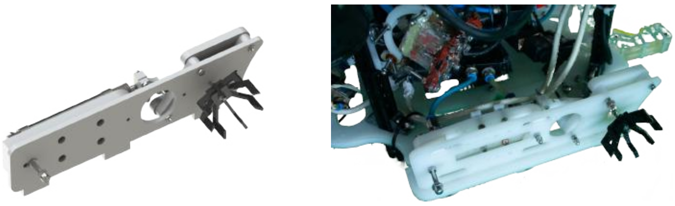
The vacuum manipulator's concept is to make a complete vacuum in a balloon filled with a sticky material when pressed such as Flour. It collects the sediment sample at the potential spawning sites when force is applied on the sediment to define its shape then by applying the vacuum the balloon holds the object tightly, restricting its volume and motion using a Polyvinyl Chloride (PVC) cone, as shown in the Figure 17.

### Rotating Manipulator

The rotating manipulator, shown in Figure 18, serves the function of translating linear piston motion into rotational motion, enabling the end effector to rotate a full 360 degrees. This mechanism offers a seamless solution for rotational motion without needing any additional motors, relying only on a single pneumatic piston and a few static links to restrict the rotating link. The rotating

Figure 17: Vacuum Manipulator of Irregular Shapes

manipulator is used to revolve the stop valve 360 degrees clockwise to activate the irrigation system. Installing a 3D printed end effector made from Thermoplastic Polyurethane (TPU) that is the same size as the valve to easily hold and tightly rotate that accomplishes the very specific task (3.1).

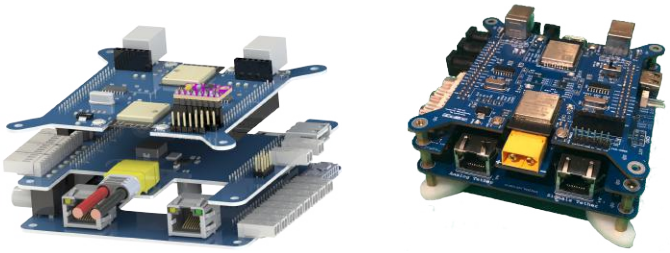


(a) Render (b) Real Life

Figure 18: Unique Rotating manipulator

### 2.4.2 Electrical

***Odyssey***'s underwater electrical system is composed of a total of three PCBs: a control unit, a tether signal unit, and a power unit. Each was designed with Surface Mount Device (SMD) Technology to reduce size and cost. This year we tried to make our new system compatible with last year's system with a few adjustments to enhance our ROV's features as shown in Figure 19.

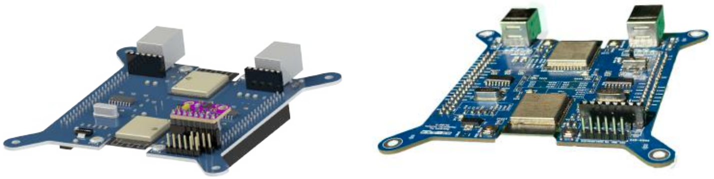


(a) Render of the Multi-Board System (b) Real Life photo of the Multi-Board System

Figure 19: ***Odyssey***'s Underwater Electrical System

- **Control Unit**

Sitting atop the boards in the multi-board fixation, the control unit is a four-layer PCB that plays an important role in managing all control and communication signals within ***Odyssey*** . The board, shown in Figure 20, hosts two ESP32s, with one dedicated to the motion system and the other responsible for the auxiliary system.



(a) Render (b) Real Life

Figure 20: Control Unit PCB

The motion system node not only maps all motion commands to each of ***Odyssey***'s thrusters for better control and precise movement, but it also incorporates proportional, integral, and derivative (PID) control into the system. This integration significantly improves the maneuverability and stability of the ROV, ensuring resistance against turbulent or calm changes in the water flow. The necessary readings of depth and orientation are continuously gathered from the pressure and IMU sensors present on the board. The PID system deploys a feedback loop principle that takes a desired orientation and a measured orientation to calculate an error value. The correction is based on proportional, integral, and derivative terms of the error, each multiplied by a coefficient. The resultant terms from all the degrees of freedom are applied to the kinematic mapping algorithm, which generates the appropriate thruster values.

The auxiliary system is responsible for managing all commands related to DCVs, the servo, and the variable buoyancy within ***Odyssey*** . It also communicates with the pressure and temperature sensors and continuously receives their readings.

- **Power Unit**

At the center of the multi-board fixation lies the Power Unit board shown in Figure 21. Its primary function is to regulate, distribute, and maintain a stable power supply to the entire electrical system for the entire ROV. This year's system utilizes the same buck converter as the previous year's system. This decision was made because of its high power efficiency, and it had been tested in the 2023 system under a high load to monitor its noise and ripple voltages, proving its compatibility with this year's system.

The power unit supplies power for various connected devices as shown in the following:

- DCVs and USB Hub- **12V** supply.
- Servo motors - **6V** supply.
- Raspberry Pi and the Control Unit - **5V** supply.
- ESP32 microcontrollers - **3.3V** supply.


(a) Render (b) Real Life

Figure 21: Power Unit PCB

Initially, there was an idea to directly connect 48 V from the station to the system without using isolated buck converters outside the canister. However, this idea was ultimately abandoned due to challenges in component placement on the board as well as wiring issues within the canister. The concept will be revisited and considered for the 2025 system.

As shown in Table 2, The maximum power consumption of ***Odyssey*** is approximately 931.936 W, drawing nearly 19.434 A of current from the 48 V power supply. The peak current is then multiplied by a 1.5 factor of safety, resulting in a maximum current of 29.151 A, for which a 30 A fuse is installed. It is important to note that the thrusters are not operated at full power to stay within our power limit.

| Component | Input Voltage (V) | Max. Current (A) | Quantity | Consumed Power (W) |
|---|---|---|---|---|
| **Thrusters (T200)** | 12V | 9A | 8 | 864W |
| **USB Hub (Powers 4 Cameras)** | 12V | 2A | 1 | 24W |
| **DCV** | 12V | 0.33A | 7 | 27.72W |
| **Servo Motor** | 6V | 0.9A | 1 | 5.4W |
| **Raspberry Pi** | 5V | 2A | 1 | 10W |
| **ESP32** | 3.3V | 0.26A | 2 | 1.716W |
| **Total** | ________ | ___________ | ____ | 932.836W |

Table 2: Power Calculations

## Tether Signal Unit

The Tether Signal Unit shown in Figure 22 serves as the base of the underwater electrical system. It carries all control signals from the Control Unit to the ESCs, DCVs, and servo motors that are connected to the ROV. The features added in this year's board fall under the category of better signal integrity; for example, better routing and layout.

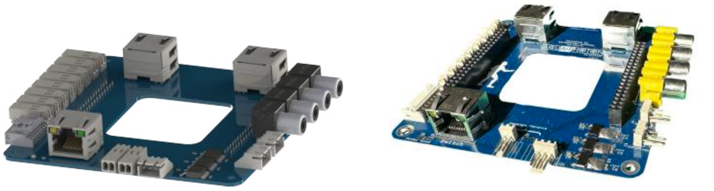

(a) Render (b) Real Life

Figure 22: Signal Unit PCB

The previous ROV included a combination of IP cameras and analog cameras to leverage the advantage of both types in terms of resolution and latency. We have decided this year to choose a new solution that integrates both speed and resolution, ***Odyssey*** uses only USB cameras which provide better vision underwater with minimal delay. The USB cameras have made it easier to perform the software missions on the GUI by processing the data sent from cameras using ETHERNET Cat 6 to ensure the highest reliability and resolution with the least amount of delay.

A more detailed illustration of ***Odyssey***'s vision system can be seen in Figure 23 and Figure 24.

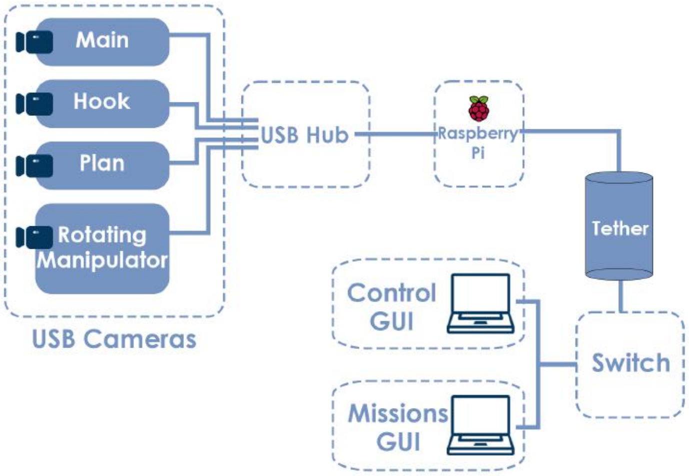


Figure 23: ***Odyssey***'s Vision System Schematic

## Tether

***Odyssey***'s tether, shown in Figure 25, is composed of a power cable, a pneumatic hose, and one Ethernet cable that communicates with the ***Odyssey***'s control station.

The tether was made neutrally buoyant by periodically adding short rubber sheaths along the tether, preventing it from obstructing ***Odyssey***'s

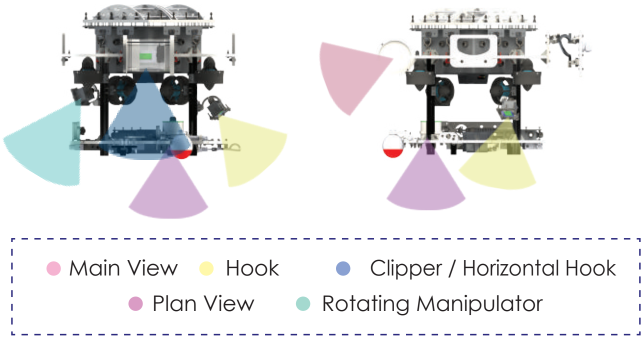
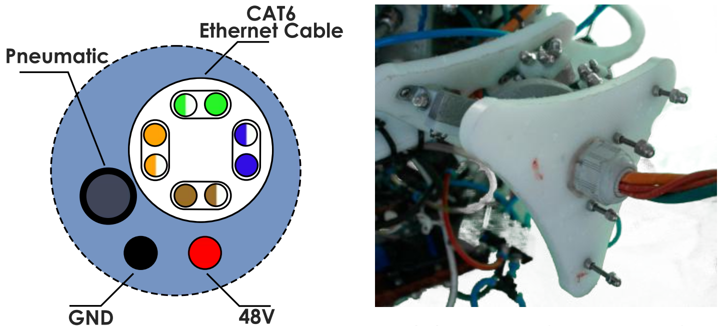


Figure 24: ***Odyssey***'s Fields of View for Exploring the Ocean

path unintentionally. The tether is 20 m long and is encased in a protective sheath for enhanced durability. The tether's ends are connected with strain relief, shown in Figure 25b, which is needed to protect the tether from excessive tension and accidental strong tugs.



(a) Cross Section View

(b) Real Life Photo of ***Odyssey***'s Strain Relief

Figure 25: ***Odyssey***'s Braided Tether

High-quality Copper wires are utilized to minimize power loss and withstand ***Odyssey***'s power consumption. Shielded and twisted pairs are used in transmitting video signals to neutralize external noise and ensure optimal image quality

A tether management protocol is implemented to ensure the safety of the ROV as well as the employees, in which a tether man is responsible for the proper deployment and handling of the tether during operation. The protocol is achieved as follows:

1. Before deployment, the tether-man, who is the only one near the poolside, unrolls the tether and lays it on deck.
2. The tether is carefully connected to the topside control station and the strain relief is secured to it to prevent accidental tugging damage.
3. After deployment, the tether-man holds the tether carefully at all times to ensure it doesn't block or hinder ***Odyssey***'s movement.
4. Once the ROV is retrieved from the water and powered down, the tetherman disconnects it from the topside control station.
5. The tether is rolled up again to eliminate any tripping hazards or damage to it.

By carefully following this protocol, along with the added protection of strain relief, we were able to reuse last year's tether, resulting in a significant cost reduction and minimizing the time of the pre-deployment phase.

### Topside Control Station

Aquaphoton's custom-made control box, shown in Figure 26, is constructed from Wood by our team. It comprises a 400x540 mm$^2$ case containing our Topside Control Station's wires, cables, and connectors, as well as a specific place for the joystick. Furthermore, it is designed with a 300x450 mm$^2$ sliding part that serves as a holder for the co-pilot's laptop. The control box is equipped with a 21-inch LED screen that displays the camera's view to the pilot. This control box was reused from one of the previous years due to its versatile design, portability, and overall convenience for our station.

Figure 26: Control Box

## 2.4.3 Software

### Communication System

The communication system, shown in Figure 27, is a star topology composed of ROS2 communication which connects both the microcontrollers and the laptop by utilizing the Raspberry Pi as the hub or the center of the network.

***Odyssey***'s main method of communication is ROS2. A Raspberry Pi acts as the bridge

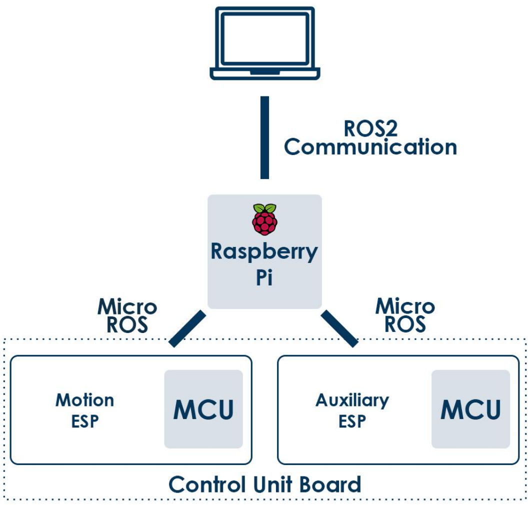


Figure 27: Communication System Diagram

between the topside control station and the underwater system, connecting to the underwater system via micro-ros. All joystick commands are neatly organized into multiple topics that the station publishes, which the underwater system subscribes to and then executes the commands accordingly.

Starting from the top, the topside control station initializes the ROS2 control node that begins publishing all commands to their corresponding topics, e.g. motion topic, servo control topic, etc...

Then, the Raspberry Pi initiates and acts as a server for all the ROS2 nodes, at the topside control station and the underwater control unit, allowing communication among them.

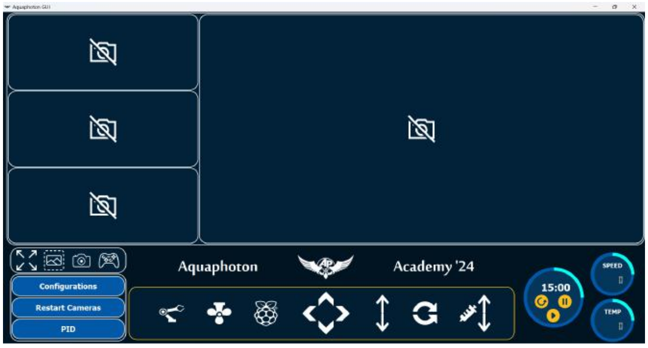
The motion system node receives motion control commands to both directly move ***Odyssey*** and to pass the set-points along to the PID system that in turn performs the calculations and calibrations needed for maintaining smooth and stable motion. Moreover, it also publishes temperature, pressure, current, and voltage readings to the topside control station, giving the co-pilots a complete status report of ***Odyssey*** that is invaluable for both safety and mission completion tasks.

Meanwhile, the auxiliary system node receives all commands concerning the DCV's change of state and servo movement. Since the two nodes are separated, swift execution of the commands is guaranteed and wouldn't be affected by the PID calculations.

## Graphical User Interface

Designing an intuitive, easy-to-use, and configurable GUI is one of, if not the most important aspect of any ROV, as it is what allows the pilot to maneuver and monitor it in the final stage of deployment. With that in mind, ***Odyssey***'s split GUIs architecture was created to ensure maximum optimization and the best capabilities for both the pilot and the co-pilots. All GUIs are developed in Python and the Qt application framework.

In total, we have two main GUIs, shown in Figure 28: the Control GUI and the Missions GUI. The Control GUI is made primarily to be used by ***Odyssey***'s pilot while the Missions GUI aids both copilots and the pilot in performing image processing missions, autonomous missions, and missions that rely on manual calculations.



(a) Control GUI showing all camera feeds, current motion and sensor's readings

(b) Missions GUI enabling us to do software tasks

Figure 28: GUIs

### Control GUI

The Control GUI has more debugging and configuration options than it would usually provide to allow making any changes as easily and fast as possible. It is divided into two main sections:

1. A configuration window, that can dynamically configure the thrusters' orientation (clockwise

or anticlockwise) and test each thruster separately. It also allows us to send new PID coefficients during the initial calibration phase.

2. A control window, shown in Figure 28a that initiates the ROS2 control node and displays the video feed of all cameras in parallel and synchronized real-time, as well as various sensors' readings that indicate ***Odyssey***'s current state. Moreover, this window features connectivity indicators for the Raspberry Pi, motion node, auxiliary node, and variable buoyancy state for easier and swifter monitoring.

► **Missions GUI**

The Missions GUI, shown in Figure 28b, allows the copilots to switch between certain camera feeds specific to each mission, along with any relevant sensor readings needed. Each mission has a special interface and customized widgets that aid in successfully performing it. Since there are two separate GUIs, the pilot can monitor and maneuver ***Odyssey*** in parallel with the co-pilots who oversee autonomous missions and complete any calculations needed.

### • TCP/IP Socket

Since ROS2 is the backbone of our system, we were encouraged using the Linux operating system for controlling the ROV.

To increase the usability of the missions application and make it cross-platform, we programmed a socket that connects between the process running the control application and the process running the mission application since the control application already operates on Linux.

The mission application acts as a client that connects to the port and sends a message , on the other side, the control application acts as a server that binds to the port and keeps listening to the messages sent from the client.

The socket uses the Transmission Control Protocol(TCP) for reliability and to ensure that all the messages are sent successfully. The communication between the processes is transient asynchronous communication, both client and server have to be active at the time of communication. In addition, the client sends the message and blocks until it receives a reply.

The socket can be used to send any other messages, such as the vertical profiling float's depth over time, or any other data.

This new feature allows us to:

1. Limit the requirements for the missions application.
2. Implement a cross-platform application.
3. Get the benefit of packages and tools supported by any platform.
4. Establish a reliable connection between the two processes.

## 2.5 Mission Specific Auxiliary Tools

### 2.5.1 Vertical Profiling Float

Aquaphoton acknowledges the vital importance of collaboration in addressing the challenges posed by climate change. In support of this belief, we have chosen to support the goal of the National Science Foundation (NSF)-funded GO-BGC project. In our contribution, a prototype vertical profiling float as shown in Figure 29 was intended for real-world applications in ocean monitoring and inspections.

The float uses a combination of electrical, mechanical, and software components to function. The firmware controls a motor that changes direction based on limit switches. While the buoyancy engine is operating, the pressure sensor is used to measure the pressure, which is used to calculate the depth. The measured depth change over the time is sent to our GUI to be plotted, this is achieved using a web server that is initiated on the ESP32. The web server is accessed from our GUI by connecting to the ESP32 IP address through a Wireless Local Area Network(WLAN). Refer to the Non-ROV Devices Design document for more details.

Figure 29: ***Odyssey***'s Float

## 2.5.2 Software Algorithms

### • Coral Restoration

Autonomous missions are integral to the success of underwater operations, particularly in tasks requiring precision and care, such as transplanting brain coral for reef restoration. In such a mission, ***Odyssey*** assumes control, leveraging advanced algorithms and sensors to navigate and perform tasks with zero pilot intervention.

To transplant the brain coral autonomously, ***Odyssey*** slowly ascends until it detects the square using its red color as shown in Figure 30, ***Odyssey*** keeps centralizing the square in the frame within a certain tolerance threshold while approaching the square.

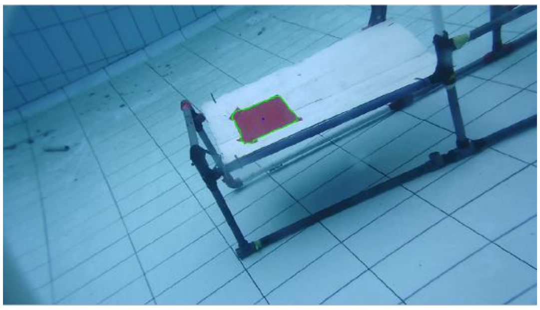


Figure 30: Detected Square

The servo motor holding the camera keeps rotating as ***Odyssey*** approaches until the camera's line of sight is perpendicular to the horizontal plane. At that exact moment, the horizontal hook manipulator is opened to drop the brain coral on the Velcro square, and the pilot regains control of the ROV.

For more details about the detection technique and the tracking algorithm, please refer to the Autonomous Control document.

### • 3D Coral Modelling

ROVs prove to be very useful for analyzing and working out the restoration methods of a coral reef as they can autonomously maneuver through dangerous and vast areas and then report back with the sizes of the coral reefs.

To construct the 3D model of the coral restoration area autonomously, ***Odyssey*** rotates around the coral restoration area and captures frames with a rate of 5 FPS using the main camera. The captured frames are aligned to get the tie points between the images where they are then used to build a mesh showing the 3D model of the coral restoration area as shown in Figure 31.

Figure 31: Coral 3D Model Created Using Photogrammetry

To get the required dimensions, the plan view shown in Figure 32a is built from the 3D model and the length is measured using the known width of 36 cm. To measure the height, the front view shown in Figure 32b is built which allows the height to be measured easily as the 3D model is scaled using the true length provided by the judge.

(a) Plan View (b) Front View

Figure 32: Plan & Front Views of the 3D Model

After testing the discussed approach, it resulted in a measured length of 151.7 cm and a measured height of 96.4 cm where the height is the distance between the branching coral and the ground. The true length is 150 cm, while the true height is 95 cm. The relative mean error of this approach is ±1.3%.

### • Sturgeon Localization

Sturgeon fish faces population decline due to habitat loss, pollution, and overfishing. To reintroduce the sturgeon fish again in native water, researchers aim to understand Lake Sturgeon habitat preferences, by implanting sonic tags in the fish and deploying acoustic receivers, the fish movements are tracked to identify potential spawning sites by detecting sturgeon spawning sounds known as ”Sturgeon Thunder”.

***Odyssey*** can recover the acoustic receiver and a Python script is developed to plot a graph of the number of sturgeons in each location over the course of fifteen days, as shown in Figure 33 using Matplotlib and Seaborn libraries.

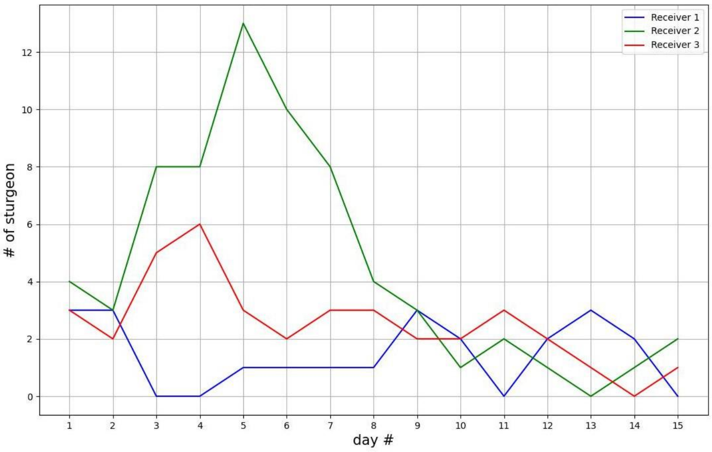


Figure 33: Number of Sturgeons Detected at Each Receiver Over Time

### 2.5.3 SMART Repeater Temperature Sensor

Aquaphoton realizes the importance of monitoring the ocean's health and seismic activity. We have integrated a temperature sensor to ***Odyssey*** which allows us to monitor and study the ocean's condition, that's to cope with the objective of the Science Monitoring And Reliable Telecommunications (SMART) cables project, which collects and transmits temperature, pressure and seismic acceleration data.

A DS18B205 external water proof temperature sensor was integrated to our electrical system. The sensor's readings are continuously updated in our GUI.

## 3 Safety

Aquaphoton prioritizes safety in all stages of their ROV development, resulting in a safe work environment with minimal injuries for the past twelve years.Aquaphoton adapts their safety protocols as the company grows. This includes new rules for new equipment and more training for the bigger workforce. New employees are well-trained on safety rules before working with mentors.

The workshop layout was reorganized to create more space to have more workstations and eliminate tripping hazards, allowing employees to confidently contribute to the projects while staying safe. All work done in the workshop is overseen by a dedicated safety director to make sure the checklist that can be found in Appendix C is being followed. This includes using safety checklists, wearing personal protective equipment (PPE) such as face guards, protective gloves, and a soldering air filter, and completing job safety analyses (JSA) before starting work to determine potential hazards during ROV operation. These regulations can be seen in the form of safety practices in Figure 34.

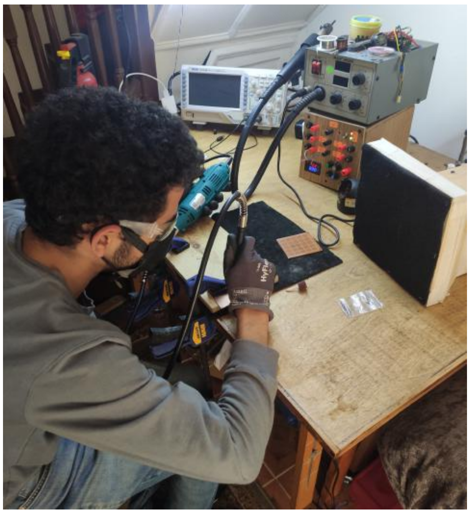


Figure 34: Safety Practices in Action

### 3.1 ROV Safety Features

Safety is Aquaphoton's top priority and thus it is always kept at the forefront during the design and manufacturing phase. The frame is carefully sanded down to remove all sharp edges and all bolts are thoroughly covered. The thrusters' propellers are all covered with shrouds that ensure the safety of our employees and anyone handling ***Odyssey*** . In addition, extra safety measures were implemented for ***Odyssey***'s vertical profiling float and manipulators. The TPU end effector of the rotating mechanism was chosen carefully as it is chemical resistant, weather resistant, and non-toxic making it a valuable material for enhancing its safety.

All the manipulators are covered with padding to ensure a soft grip that doesn't pose any risk on the vertical profiling float and any playground elements while transporting them. Finally, along with the tightly sealed enclosure of the float, (please refer to the safety review document for more details) a pressure release valve is placed on the battery container to ensure that the internal pressure never exceeds the external pressure. All these measures combined ensure that ***Odyssey*** is not a hazard to its surroundings by any means and is compliant with MATE's safety requirements. For everyone's safety, we strictly follow operational procedures not just for our members safety, it also minimize our impact on the environment, preventing harm to sensitive marine environments.

## 3.2 Safety Checklist

Aquaphoton takes safety very seriously and follows a strict protocol for all company members before, during, and after ***Odyssey*** is deployed. Inspections are conducted regularly and a complete list of operational safety guidelines can be found in Appendix B. While it is the duty of employees to thoroughly follow the safety checklist, a safety director ensures that it is followed rigorously.

# 4 Testing and Troubleshooting

## 4.1 Full System Testing

Full-system testing procedures, shown in Figure 35, are carried out on ***Odyssey*** before any operations.

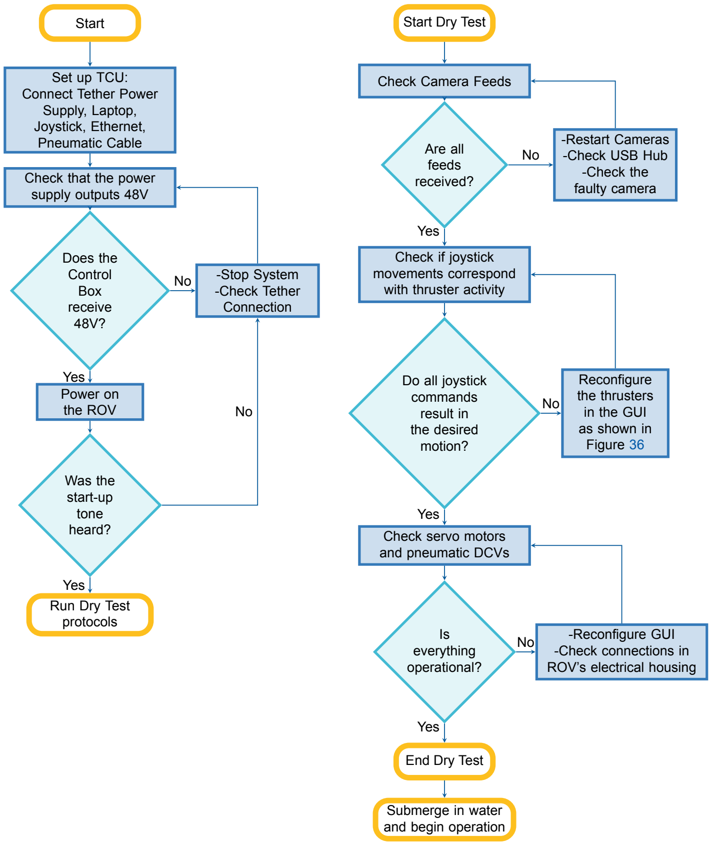
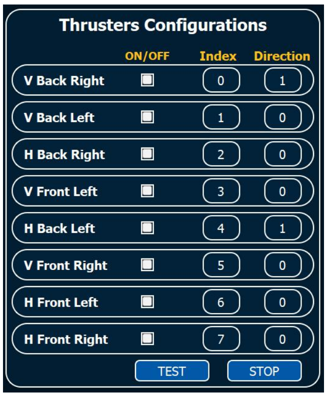


Figure 35: Full System Test Flowchart



Thrusters Configurations

| | ON/OFF | Index | Direction |
|---|---|---|---|
| V Back Right | ☐ | 0 | 1 |
| V Back Left | ☐ | 1 | 0 |
| H Back Right | ☐ | 2 | 0 |
| V Front Left | ☐ | 3 | 0 |
| H Back Left | ☐ | 4 | 1 |
| V Front Right | ☐ | 5 | 0 |
| H Front Left | ☐ | 6 | 0 |
| H Front Right | ☐ | 7 | 0 |

Figure 36: Thrusters Configurations GUI

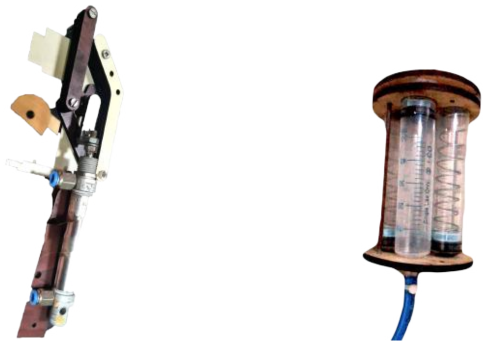
## 4.2 Mechanical Testing

Through rigorous mechanical testing, ***Odyssey***'s mechanical system was optimized to ensure its reliability, efficiency, and durability. Not only does that minimize the potential of failures and negate safety hazards in ***Odyssey*** , but it also ensures its successful operation in challenging and harsh underwater environments.

All components of the mechanical system were prototyped first to conduct safety tests and ensure the design was effective and efficient. Each prototype was thoroughly refined and tested before reaching the final design and assembly phase to avoid any complications while integrating it into ***Odyssey*** as shown in Figure 37 showing the prototype of the rotating mechanism clarifying the steps of our design. The stability of the frame was validated by loading and subjecting it to high vibrations which ensured that all fixations were secure. Moreover, the pneumatic manipulators and their DCVs underwent testing to guarantee the full mobility of the end effectors. Finally, the sealing mechanisms also underwent a validation process according to the procedure shown in Figure 38 to ensure their effectiveness.

## 4.3 Electrical Testing

Before assembling the electrical system of ***Odyssey*** , every PCB is tested individually before being integrated into the system. This approach significantly reduces the time and effort required for troubleshooting. An electrical testing and troubleshooting plan was implemented, as shown in Figure 39, to provide a structured approach to identifying and resolving any issues encountered during the testing process.



(a) Rotating Mechanism's Prototype (b) Variable Buoyancy's Prototype

Figure 37: Mechanical Prototypes

Furthermore, a comprehensive functional testing plan was performed to validate the performance of the electrical system. This involved conducting a series of tests to assess the system's ability to regulate voltage, transmit data, and control the ROV's various components.

To test and validate the stability of the ESP32 microcontroller, multiple iterations of a prototype PCB were developed. Through rigorous testing, a better and more reliable design was reached with every iteration until the most optimal one was realized and integrated into our main system.

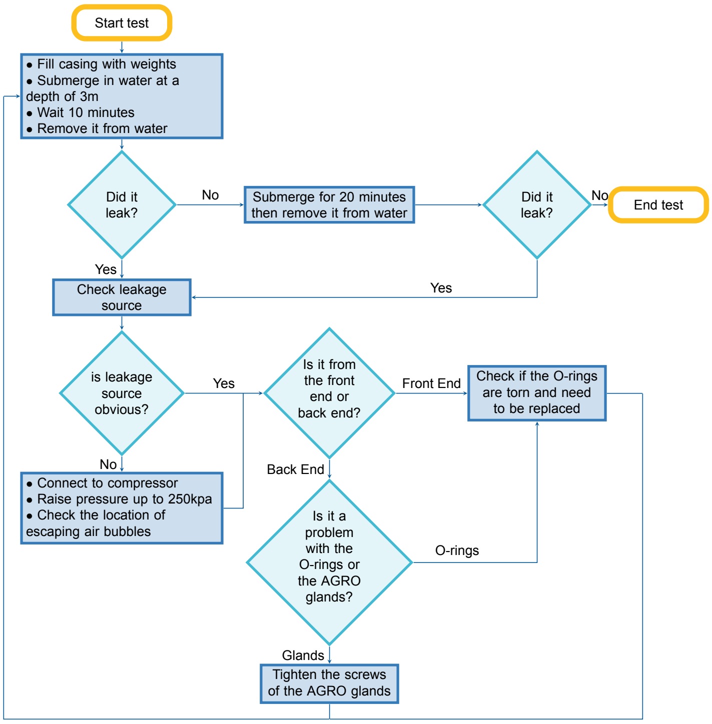


Figure 38: Sealing Test Flowchart

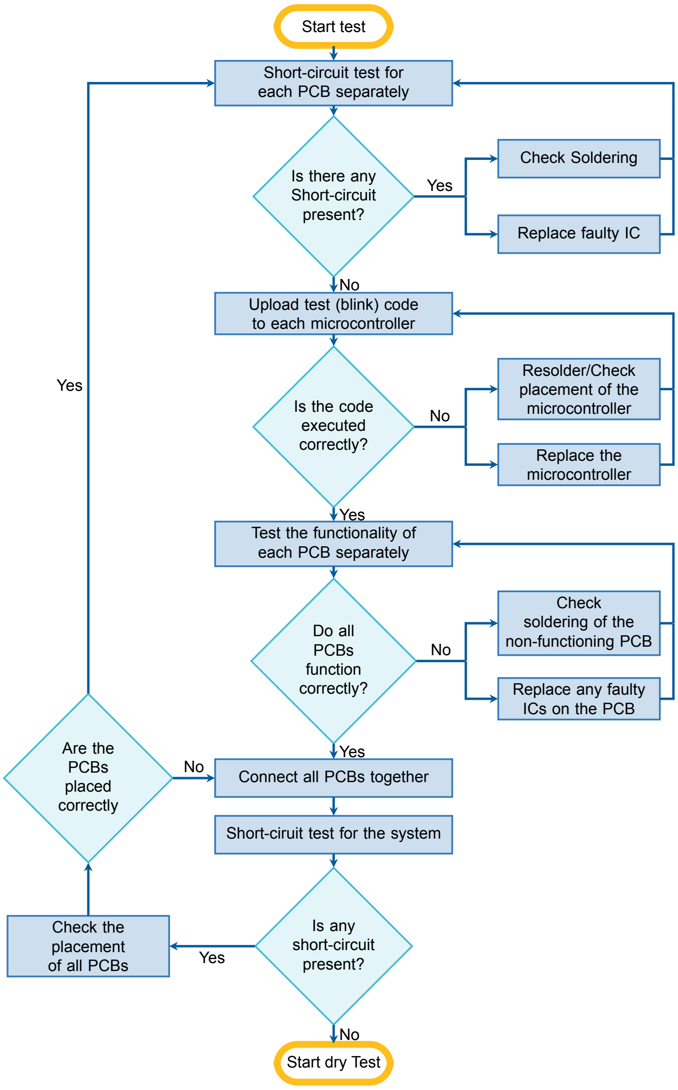


Figure 39: Electrical System Testing Flowchart

# 5 Logistics

## 5.1 Company History

Aquaphoton Academy is a student-run company from Alexandria University that has been taking part in the MATE ROV Competition for the past 12 years. Our accomplishments include but are not limited to:

1. In 2024, we placed 2nd in Egypt's Regional Competition.
2. In 2023, we placed 1st in Egypt's Regional Competition and 5th in the International MATE ROV Competition held in Colorado و USA.
3. In 2021, we ranked 2nd in Egypt's Regional Competition and 5th in the International MATE ROV Telepresence category competition.
4. In 2014, we placed 1st in Egypt's Regional Competition and 6th in the International MATE ROV Competition held in Michigan, USA.

Every year, Aquaphoton adds a new innovative ROV to its collection, with the latest one shown in Figure 40.

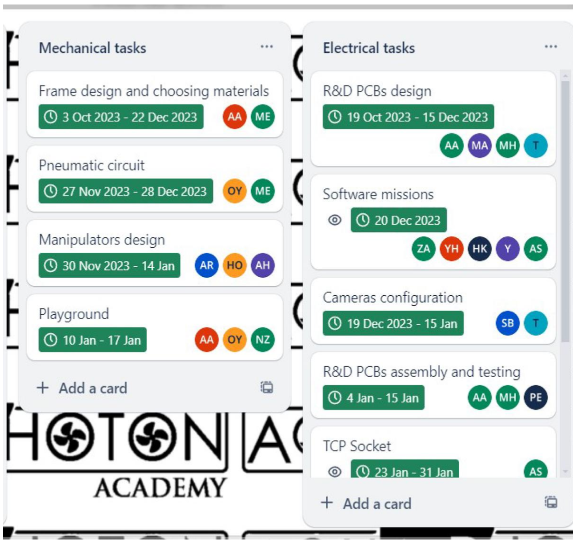
## 5.2 Company Structure

Aquaphoton Academy consists of 30 members that are split into two technical teams (Mechanical and Electrical) and four non-technical teams (Media, Documentation, Public Relations (PR), and Social Media). These teams are further broken down into project groups that take care of specific aspects of the vehicle's systems. The leader of the organization is the CEO, with two CTOs who oversee the technical teams. For more details, you can check out Appendix D for the company structure chart and job descriptions.

## 5.3 Project Management

### 5.3.1 Project Scheduling

Creating an accurate project timeline, shown in Figure 42, with realistic deadlines is crucial for the success of any project. Aquaphoton adopted a digital project management process using a Trello board, shown in Figure 41, to oversee all project groups and tasks while keeping an eye on the bigger picture. The CEO and CTOs determine the exact periods for each phase of the project and arrange meetings with non-technical department heads to ensure they are one step ahead of schedule.



Mechanical tasks

Frame design and choosing materials
3 Oct 2023 - 22 Dec 2023

Pneumatic circuit
27 Nov 2023 - 28 Dec 2023

Manipulators design
30 Nov 2023 - 14 Jan

Playground
10 Jan - 17 Jan

Electrical tasks

R&D PCBs design
19 Oct 2023 - 15 Dec 2023

Software missions
20 Dec 2023

Cameras configuration
19 Dec 2023 - 15 Jan

R&D PCBs assembly and testing
4 Jan - 15 Jan

TCP Socket
23 Jan - 31 Jan

Figure 41: A Sample of Aquaphoton's task distribution on Trello

Weekly meetings are held for each sub-team to assign tasks, discuss progress, and brainstorm new ideas. Company-wide meetings inform all members of progress, upcoming events, and decisions that need to be voted upon.

Board meetings are periodically held to make sure that the whole project timeline is being well followed. The CFO is also present to keep track of the company's budget monthly and to take note of any additional resources needed.

### 5.3.2 Workspace Management

Aquaphoton's headquarters is divided into several designated areas, including a PCB soldering station, a water testing area with a pressurized tank, a machining area, and a storage room. It's important to prepare the work area by cleaning it and ensuring that all necessary tools are available before starting any task. A workshop director is appointed to ensure that everything remains clean and organized, and he performs any repairs or improvements to maintain the workspace.

### 5.3.3 Shared Files and Libraries

Aquaphoton leverages cloud storage to promote collaboration among team members. By utilizing cloud storage, design files can be easily shared, tasks can be submitted, and corporate knowledge can be accessed from anywhere, making it easier for team members to work remotely. Overleaf is also used to streamline documentation tasks, enabling all members to read and add comments as needed. Similarly, GitHub serves as an effective platform for parallel code development, keeping all team members up-to-date with the most recent version of the code and its edit history. Additionally, shared Altium models of ***Odyssey***'s PCBs are available to ensure everyone has current and accurate 3D designs of the system boards.

## 5.4 Budget and Accounting

Aquaphoton's self-funded budget is limited and must be used carefully to avoid unnecessary expenses. Therefore, a CFO manages all of Aquaphoton's finances, including setting budgets and ensuring that the company's financial resources are utilized efficiently. A more detailed breakthrough of the budget can be found in Appendix E and Appendix F.

Figure 40: Aquaphoton Academy's ROVs over the years

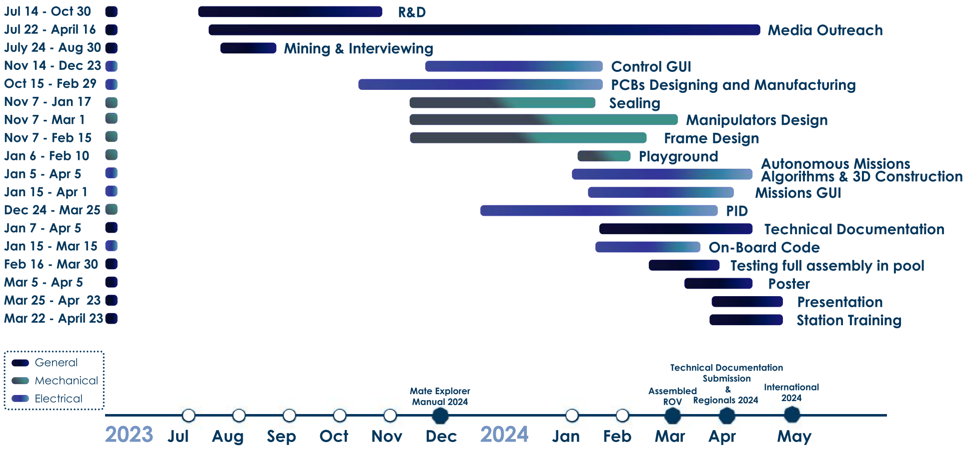


Figure 42: Project Gantt Chart

## 5.5 Build vs Buy

When developing Odyssey, we opted to build our own Electronic Speed Controllers (ESC), USB Hub board, Square Canister, and manipulators instead of purchasing commercially available products. This decision allowed us to create components specifically tailored to Odyssey's requirements, ensuring better integration, performance, and significant cost savings. Our custom ESCs and USB Hub board optimize power control and data throughout, while the Square Canister and manipulators are designed to fit perfectly within Odyssey's spatial constraints and operational needs. In contrast, commercial alternatives, though reliable, often come at a higher cost and lack the precise customization our in-house solutions provide.

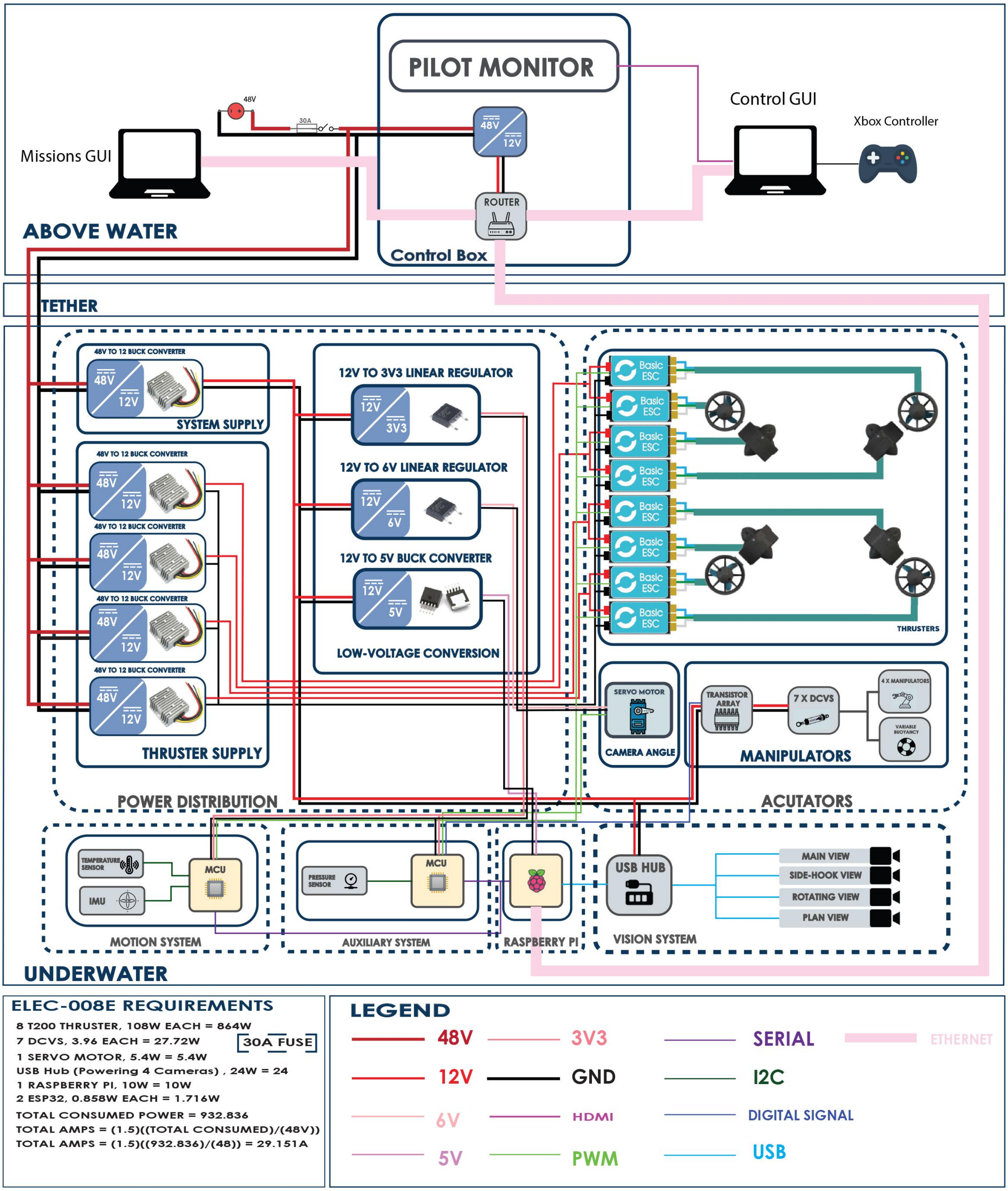
# 6 References

- MATE ROV Competition Manual 2024
- BlueRobotics' T200 Thrusters Documentation.
- Cengel, Y. and Cimbala, J. (2019). Fluid Mechanics: Fundamentals And Applications. McGraw-Hill Education.
- Parker Seal Group, O-Ring Division. (2001) ORD 5700 Parker O-ring Handbook. Parker Seal Group.
- ROS2 Humble Documentation
- micro-ROS for Arduino
- Texas Instrument TPS54561 Buck Converter
- MPU6050 IMU
- Arduino-PID-Library-V2
- JLCPCB Capabilities
- OpenCV Documentation
- Matplotlib Documentation
- HDPE Material Specifications
- Acrylic Material Specifications
- Espressif Systems ESP32 Datasheet.
- BOSCH
- PID controller.
- PyQt5 Documentation
- Python Socket Documentation

# 7 Appendices

## A SIDs

- **Electrical SID**



**ELEC-008E REQUIREMENTS**

8 T200 THRUSTER, 108W EACH = 864W
7 DCVS, 3.96 EACH = 27.72W
1 SERVO MOTOR, 5.4W = 5.4W
USB Hub (Powering 4 Cameras) , 24W = 24
1 RASPBERRY PI, 10W = 10W
2 ESP32, 0.858W EACH = 1.716W
TOTAL CONSUMED POWER = 932.836
TOTAL AMPS = (1.5)((TOTAL CONSUMED)/(48V))
TOTAL AMPS = (1.5)((932.836)/(48)) = 29.151A

30A FUSE

Figure 43: Electrical SID

### Pneumatic SID

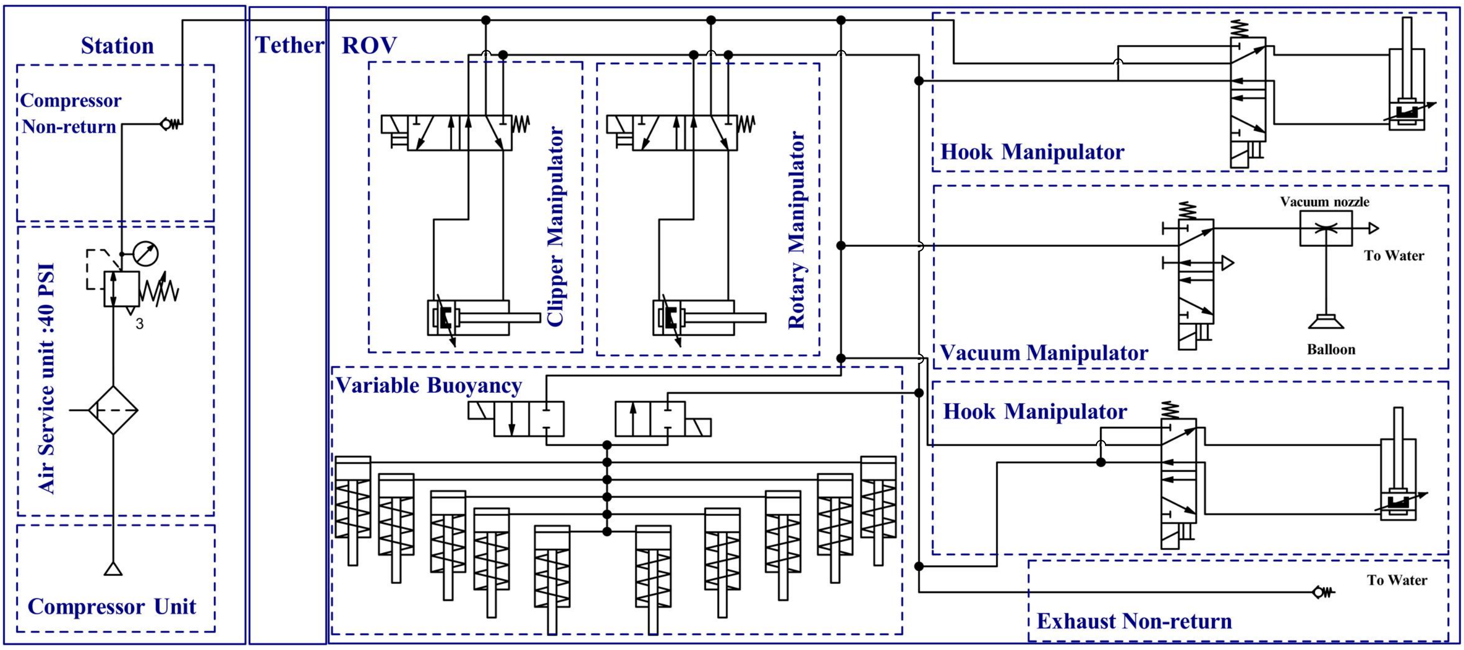


Figure 44: Pneumatic SID

## B Operational Safety Checklist

### Before Deployment

☐ Only designated crew members on deck.
☐ On-deck crew wearing proper safety attire.
☐ Power is OFF.
☐ Poolside is clear of obstructions.
☐ Tether is untangled and connected to ROV through the strain relief.
☐ Tether is connected to Control Unit.
☐ No exposed wires or loose connections.
☐ Electronics housing is sealed.
☐ Control computer is running.

### Powering Up

☐ Control Box receives 48V.
☐ Dry test of thrusters, manipulators, and payloads.
☐ Check all video feeds.

### Launching and In Water

☐ Two members are handling the ROV.
☐ Tether-man has hold of the tether.
☐ Visually inspect for leakage and check for air bubbles.
☐ Test thrusters, manipulators, and payloads.

### Loss of communication

☐ Reboot ROV
☐ Resend test package.
If no communication:
☐ Power down ROV.
☐ Retrieve ROV via tether.
☐ Check ROV is free from damage or leakage.

### Retrieval

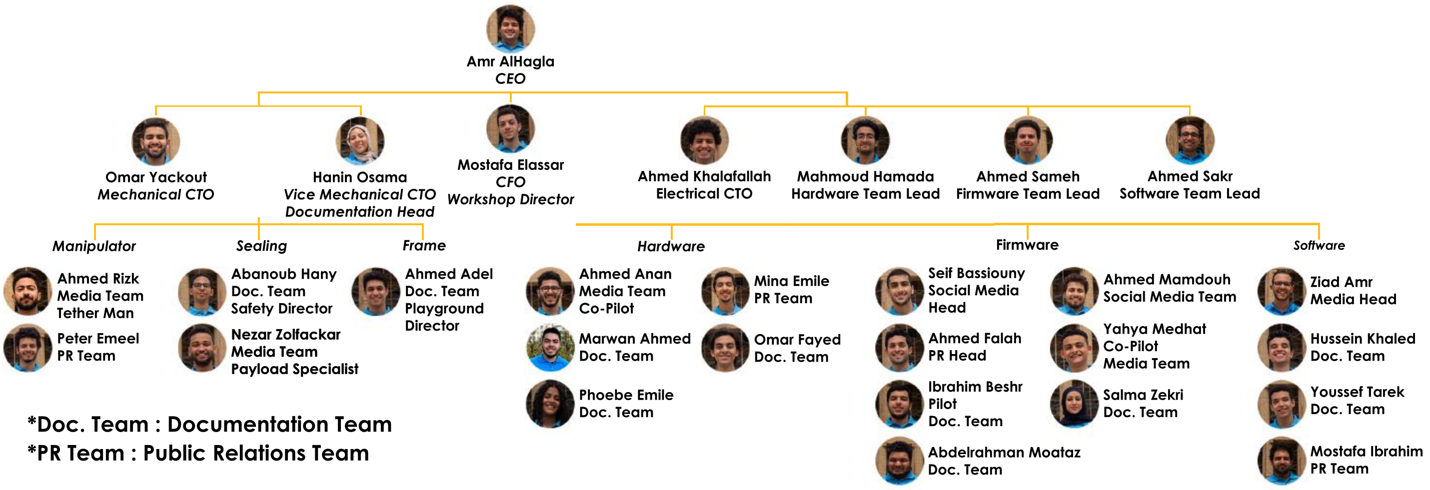
☐ Pilot surfaces the ROV and then turns off the thrusters.
☐ Designated on-deck crew members grab hold of the ROV by its handles.
☐ ROV is secured on deck.
☐ ROV and Control Unit are powered down.

## C Construction Safety Checklist

☐ Sanitized proper personal protective equipment (PPE) (e.g. gloves, goggles, and earmuffs) are worn when performing any task.
☐ Maintenance and repairs are performed proactively.
☐ Emergency kits (including fire extinguishers and first-aid kits) are checked regularly to make sure they're stocked and functional.

☐ Hazardous materials are clearly marked and stored separately to ensure they're handled carefully.
☐ Sharp tools are handled carefully, when not in use, they are stored in racks and boxes, and their sharp edges are covered with a cap -if available.
☐ Any in-water tests are performed far away from the Electrical Team's work area.
☐ The work area is well-ventilated, and additional fume extractors are used– to avoid the inhalation of harmful fumes when working with epoxy, glass fiber, etc... or soldering.

## D Company Structure and Job Description



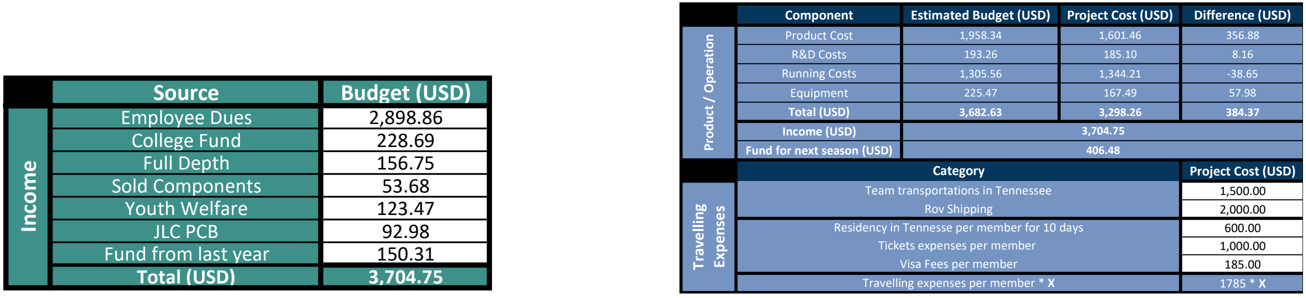
***Doc. Team : Documentation Team**
***PR Team : Public Relations Team**

**CEO** The official representative of the company, interdepartmental coordinator.
**CTO** Manages project groups and day-to-day operations.
**Vice CTO** Helps the CTO in distributing the technical tasks and managing them.
**Team Lead** Guides the sub-team members and monitors the progress of assigned tasks.
**CFO** Bookkeeper, handles the company finances and sets the budget.
**Documentation team** Led by a head, responsible for documents submission.
**Media team** Led by a head, responsible for all graphic designs and media displays.
**PR team** Led by a head, and is responsible for all the public relations affairs.
**Social Media team** Led by a head, manages all social media accounts and creates a seasonal plan.
**Workshop Director** Maintains working order of the workspace, and performs routine maintenance.
**Playground Director** Simulates the ROV's operating conditions, and coordinates the in-water testing.
**Safety Director** Ensures all safety protocols and procedures are followed.
**Pilot** Controls the movement of the vehicle from a cabin or other indoor location on the surface.
**Co-Pilot** Assists the pilot during mission tasks.
**Tether-man** Responsible for handling the tether while the ROV is underwater.
**Payload Specialist** Handles all payloads, unloading samples, and plastic debris gathered by the ROV.

Figure 45: Company Structure

## E Project Budget

The total cost of travel to the USA for X members in Figure 46b depends on who has visas. Sponsorships are being sought to help cover these costs. Details will be clear by June 10, 2024.



| | Source | Budget (USD) |
|---|---|---|
| Income | Employee Dues | 2,898.86 |
| | College Fund | 228.69 |
| | Full Depth | 156.75 |
| | Sold Components | 53.68 |
| | Youth Welfare | 123.47 |
| | JLC PCB | 92.98 |
| | Fund from last year | 150.31 |
| | **Total (USD)** | **3,704.75** |

(a) Income

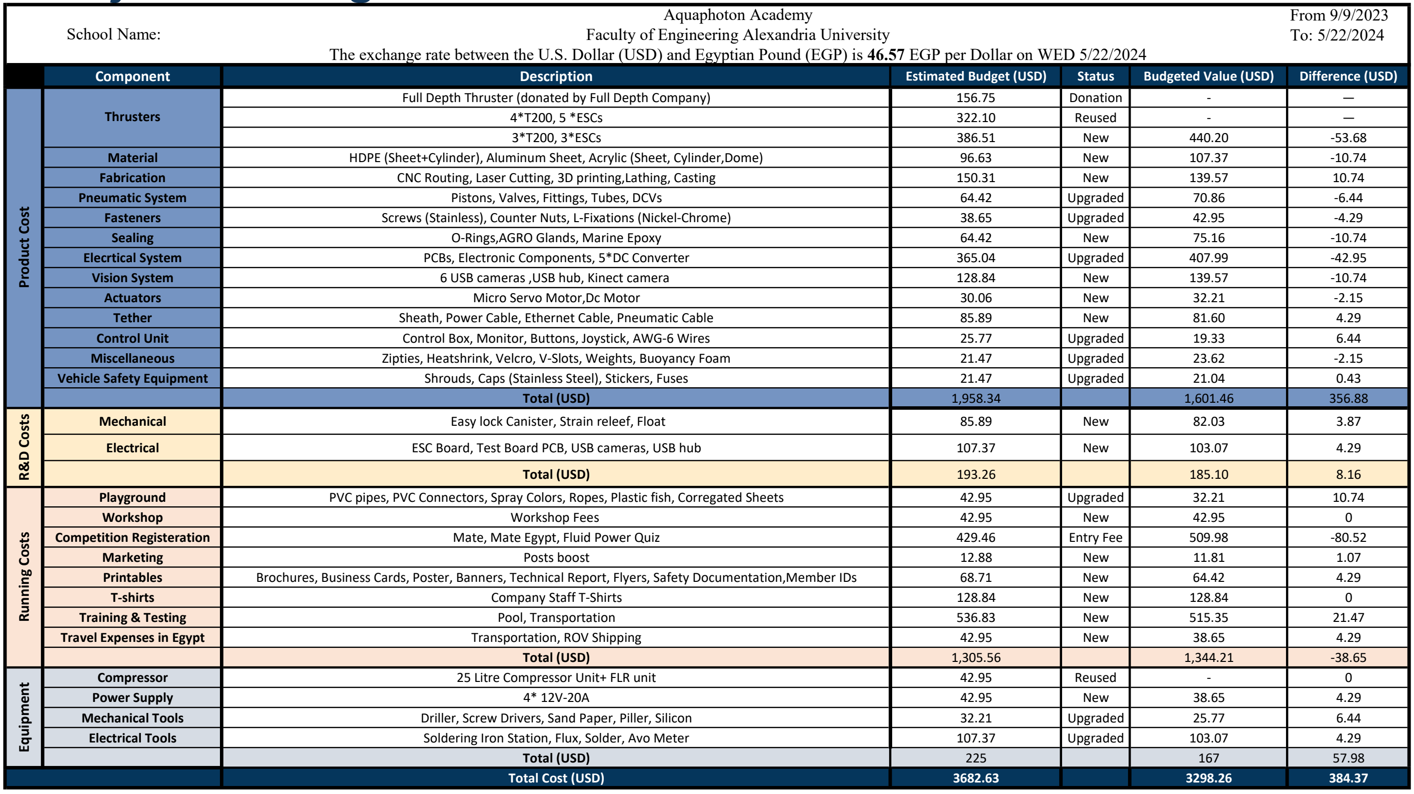
| | Component | Estimated Budget (USD) | Project Cost (USD) | Difference (USD) |
|---|---|---|---|---|
| Product / Operation | Product Cost | 1,958.34 | 1,601.46 | 356.88 |
| | R&D Costs | 193.26 | 185.10 | 8.16 |
| | Running Costs | 1,305.56 | 1,344.21 | -38.65 |
| | Equipment | 225.47 | 167.49 | 57.98 |
| | **Total (USD)** | **3,682.63** | **3,298.26** | **384.37** |
| | **Income (USD)** | **3,704.75** | | |
| | **Fund for next season (USD)** | **406.48** | | |

| | Category | Project Cost (USD) |
|---|---|---|
| Travelling Expenses | Team transportations in Tennessee | 1,500.00 |
| | Rov Shipping | 2,000.00 |
| | Residency in Tennese per member for 10 days | 600.00 |
| | Tickets expenses per member | 1,000.00 |
| | Visa Fees per member | 185.00 |
| | Travelling expenses per member * X | 1785 * X |

(b) Product/Operations

Figure 46: Projected Budget in US Dollars (USD)

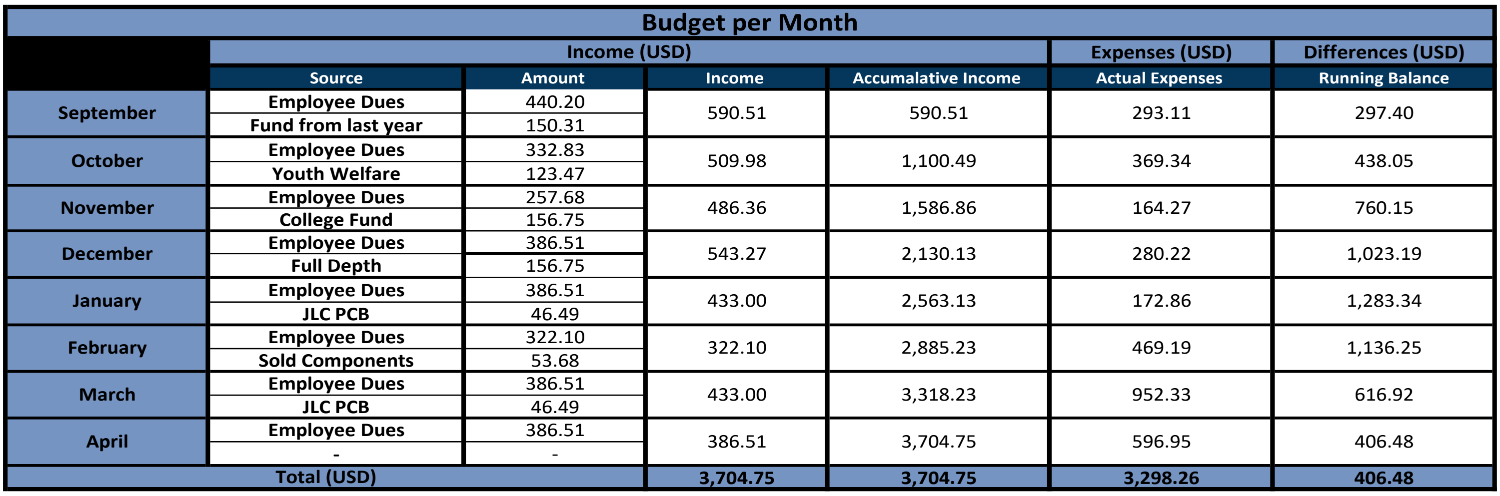
## F Project Costing



School Name: Aquaphoton Academy
Faculty of Engineering Alexandria University
The exchange rate between the U.S. Dollar (USD) and Egyptian Pound (EGP) is **46.57** EGP per Dollar on WED 5/22/2024
From 9/9/2023
To: 5/22/2024

| | Component | Description | Estimated Budget (USD) | Status | Budgeted Value (USD) | Difference (USD) |
|---|---|---|---|---|---|---|
| Product Cost | Thrusters | Full Depth Thruster (donated by Full Depth Company) | 156.75 | Donation | - | — |
| | | 4*T200, 5 *ESCs | 322.10 | Reused | - | — |
| | | 3*T200, 3*ESCs | 386.51 | New | 440.20 | -53.68 |
| | Material | HDPE (Sheet+Cylinder), Aluminum Sheet, Acrylic (Sheet, Cylinder,Dome) | 96.63 | New | 107.37 | -10.74 |
| | Fabrication | CNC Routing, Laser Cutting, 3D printing,Lathing, Casting | 150.31 | New | 139.57 | 10.74 |
| | Pneumatic System | Pistons, Valves, Fittings, Tubes, DCVs | 64.42 | Upgraded | 70.86 | -6.44 |
| | Fasteners | Screws (Stainless), Counter Nuts, L-Fixations (Nickel-Chrome) | 38.65 | Upgraded | 42.95 | -4.29 |
| | Sealing | O-Rings,AGRO Glands, Marine Epoxy | 64.42 | New | 75.16 | -10.74 |
| | Elecrtical System | PCBs, Electronic Components, 5*DC Converter | 365.04 | Upgraded | 407.99 | -42.95 |
| | Vision System | 6 USB cameras ,USB hub, Kinect camera | 128.84 | New | 139.57 | -10.74 |
| | Actuators | Micro Servo Motor,Dc Motor | 30.06 | New | 32.21 | -2.15 |
| | Tether | Sheath, Power Cable, Ethernet Cable, Pneumatic Cable | 85.89 | New | 81.60 | 4.29 |
| | Control Unit | Control Box, Monitor, Buttons, Joystick, AWG-6 Wires | 25.77 | Upgraded | 19.33 | 6.44 |
| | Miscellaneous | Zipties, Heatshrink, Velcro, V-Slots, Weights, Buoyancy Foam | 21.47 | Upgraded | 23.62 | -2.15 |
| | Vehicle Safety Equipment | Shrouds, Caps (Stainless Steel), Stickers, Fuses | 21.47 | Upgraded | 21.04 | 0.43 |
| | | **Total (USD)** | 1,958.34 | | 1,601.46 | 356.88 |
| R&D Costs | Mechanical | Easy lock Canister, Strain releef, Float | 85.89 | New | 82.03 | 3.87 |
| | Electrical | ESC Board, Test Board PCB, USB cameras, USB hub | 107.37 | New | 103.07 | 4.29 |
| | | **Total (USD)** | 193.26 | | 185.10 | 8.16 |
| Running Costs | Playground | PVC pipes, PVC Connectors, Spray Colors, Ropes, Plastic fish, Corregated Sheets | 42.95 | Upgraded | 32.21 | 10.74 |
| | Workshop | Workshop Fees | 42.95 | New | 42.95 | 0 |
| | Competition Registeration | Mate, Mate Egypt, Fluid Power Quiz | 429.46 | Entry Fee | 509.98 | -80.52 |
| | Marketing | Posts boost | 12.88 | New | 11.81 | 1.07 |
| | Printables | Brochures, Business Cards, Poster, Banners, Technical Report, Flyers, Safety Documentation,Member IDs | 68.71 | New | 64.42 | 4.29 |
| | T-shirts | Company Staff T-Shirts | 128.84 | New | 128.84 | 0 |
| | Training & Testing | Pool, Transportation | 536.83 | New | 515.35 | 21.47 |
| | Travel Expenses in Egypt | Transportation, ROV Shipping | 42.95 | New | 38.65 | 4.29 |
| | | **Total (USD)** | 1,305.56 | | 1,344.21 | -38.65 |
| Equipment | Compressor | 25 Litre Compressor Unit+ FLR unit | 42.95 | Reused | - | 0 |
| | Power Supply | 4* 12V-20A | 42.95 | New | 38.65 | 4.29 |
| | Mechanical Tools | Driller, Screw Drivers, Sand Paper, Piller, Silicon | 32.21 | Upgraded | 25.77 | 6.44 |
| | Electrical Tools | Soldering Iron Station, Flux, Solder, Avo Meter | 107.37 | Upgraded | 103.07 | 4.29 |
| | | **Total (USD)** | 225 | | 167 | 57.98 |
| | | **Total Cost (USD)** | **3682.63** | | **3298.26** | **384.37** |

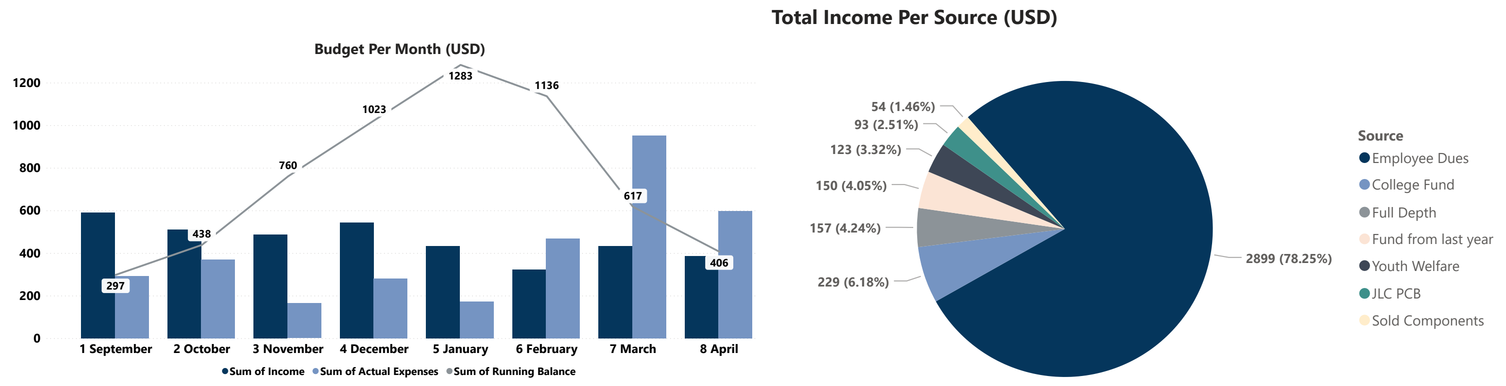
Figure 47: Expenses



**Budget per Month**

| | Income (USD) | | | | Expenses (USD) | Differences (USD) |
|---|---|---|---|---|---|---|
| | Source | Amount | Income | Accumalative Income | Actual Expenses | Running Balance |
| September | Employee Dues<br>Fund from last year | 440.20<br>150.31 | 590.51 | 590.51 | 293.11 | 297.40 |
| October | Employee Dues<br>Youth Welfare | 332.83<br>123.47 | 509.98 | 1,100.49 | 369.34 | 438.05 |
| November | Employee Dues<br>College Fund | 257.68<br>156.75 | 486.36 | 1,586.86 | 164.27 | 760.15 |
| December | Employee Dues<br>Full Depth | 386.51<br>156.75 | 543.27 | 2,130.13 | 280.22 | 1,023.19 |
| January | Employee Dues<br>JLC PCB | 386.51<br>46.49 | 433.00 | 2,563.13 | 172.86 | 1,283.34 |
| February | Employee Dues<br>Sold Components | 322.10<br>53.68 | 322.10 | 2,885.23 | 469.19 | 1,136.25 |
| March | Employee Dues<br>JLC PCB | 386.51<br>46.49 | 433.00 | 3,318.23 | 952.33 | 616.92 |
| April | Employee Dues<br>- | 386.51<br>- | 386.51 | 3,704.75 | 596.95 | 406.48 |
| **Total (USD)** | | | **3,704.75** | **3,704.75** | **3,298.26** | **406.48** |

(a) Budget per Month



(b) Month Expenses

(c) Income Expenses

Figure 48: Project Costing Spreadsheet