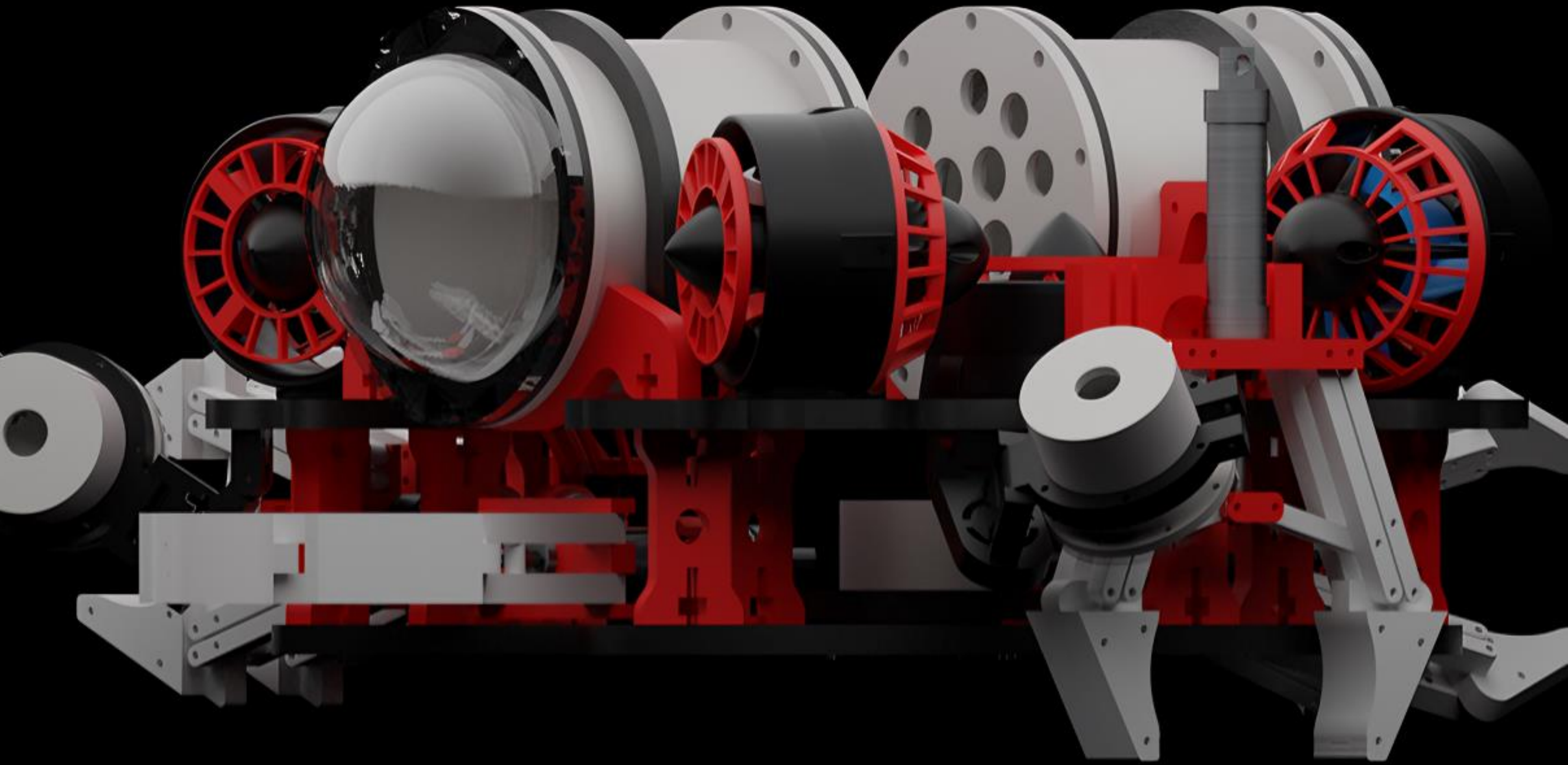
Overflow Robotics Co.

Alexandria, Egypt est.2021



POSEIDON 2.0

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Abstract 1.0

Overflow Robotics Company proudly presents ***Poseidon 2.0***, the latest innovation tailored for the Marine Advanced Technology Education’s (MATE) 2023-2024 season. Building upon the triumph of its predecessor, Poseidon, which secured the inaugural championship in Egypt, ***Poseidon 2.0*** aims to elevate our standing in the field of underwater robotics. With three years of expertise in robotics, our team of 14 skilled members, including ROV specialists, collaborated passionately to bring this remarkable ROV to life. ***Poseidon 2.0*** stands out with its emphasis on high underwater maneuverability, facilitated by its compact size and distinctive black and red color scheme. Despite its lightweight design, ***Poseidon 2.0*** packs a punch with features such as two isolation boxes, 3D-printed components, specially crafted HDPE parts, eight cameras, four grippers, an Inertial Measurement Unit (IMU), a Temperature sensor, and Six T200 Thrusters.

ne of ***Poseidon 2.0***'s most impressive attributes is its adaptability for diverse underwater tasks, owing to its multiple grippers and compact size. The development journey of ***Poseidon 2.0*** involved meticulous stages, starting with brainstorming sessions and a comprehensive review of past issues encountered with Poseidon. Subsequently, both our mechanical and electrical teams engaged in the design and fabrication phases, consuming a significant portion of our timeline. The testing phase, spanning from dry tests to pool tests, presented challenges but was ultimately the most gratifying stage in the development process. ***Poseidon 2.0*** image processing system is capable of creating a 3d model of the coral restoration area.

Figure 1 Overflow Robotics 2024 Team

Design Rational 2.0

This season, our primary focus was on enhancing ***Poseidon 2.0*** compared to the previous year. We aimed for precision in the installation of various components like thrusters, valves, manipulators, cameras and housings. In the case of camera installation in ***Poseidon 2.0***, we innovatively utilized 3D printing to create a structure akin to a universal joint. Expanding the camera setup, we efficiently installed an increased number of cameras using magnetic mechanisms in over 12 locations within ***Poseidon 2.0***, accomplishing this task swiftly.

Figure 2 Left: Final Render Right: Poseidon 2.0

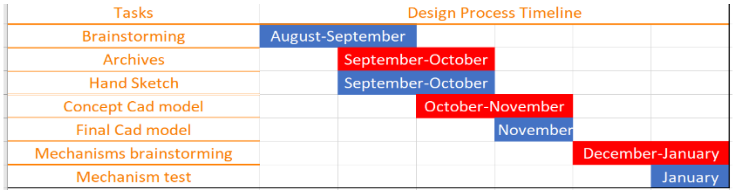
The manufacturing process of ***Poseidon 2.0*** involved the use of simple machines, including a CNC router machine for the frame and grippers, and 3D printing for the universal joint and other parts. The design of ***Poseidon 2.0*** primarily centered on a straightforward frame consisting of two upper plates, a lower plate, and 10 HDPE rods. The compact dimensions of ***Poseidon 2.0***, measuring 45cm * 35cm * 20cm, were carefully considered to minimize drag force in water, ensuring optimal performance. Overflow Robotics meticulously selected the locations to fix ***Poseidon 2.0*** components. Thrusters were strategically positioned on the upper frame to ensure unobstructed water flow, promoting optimal performance. To enhance visibility, five cameras utilized a magnet-like mechanism, providing flexibility to change their positions for a comprehensive view of tasks and the surroundings. Sealing boxes were secured on the upper plate, adhering to the buoyancy principle, where the buoyancy center positioned above the center of mass contributes to the vehicle's stability underwater. Manipulators found their designated spaces based on their tasks according to the underwater plan. Magnetic mechanisms were also strategically placed, each serving its unique function. For instance, hooks utilized for the irrigation system and ADCP were affixed to the back of the vehicle's side. The magnetic mechanisms were designed for easy removal, allowing us to interchange all the mechanisms based on our specific needs, providing adaptability and versatility to ***Poseidon 2.0***.

Design process 2.1

At the onset of the season, we conducted a comprehensive review of Poseidon's past significant issues, identifying speed and design as key areas for improvement. While Poseidon exhibited no major speed problems, it fell short of meeting our expectations. Additionally, the design did not align with our desired standards. Seeking to address these challenges and enhance various aspects of Poseidon in its new iteration, ***Poseidon 2.0*** emerged. ***Poseidon 2.0*** successfully tackled the two main issues by introducing a more modular, functional, and compact design. Modularity became a crucial factor in developing a highly professional vehicle capable of solving diverse tasks requiring different mechanisms. To enhance speed, we minimized the frame to reduce drag force and added domes to the sealing boxes, significantly reducing drag points and increasing overall speed. Following the identification of Poseidon's challenges, our team embarked on brainstorming sessions to create an advanced vehicle design capable of performing all tasks in the 2024 competition while overcoming previous issues.

Figure 3 Design Evolution

Poseidon 2.0 materialized from the synthesis of our brainstormed ideas into a cohesive design. Utilizing SolidWorks, we designed all the necessary parts. As tasks were unveiled, our design team brainstormed mechanisms needed to address them. Hooks were identified as crucial for tasks such as the irrigation system and brain coral transplant. With the design ready, we conducted Computational Fluid Dynamics (CFD) analysis and stress tests to finalize the vehicle design. Concurrently, our vehicle underwent fabrication using CNC and 3D printing machines. Manipulator fabrication was delayed until our mechanism engineers determined the optimal approach for solving underwater tasks. The assembly phase proved to be the most enjoyable, utilizing screws and nuts made of stainless steel to prevent rust problems associated with iron. This meticulous process ensured ***Poseidon 2.0***'s readiness for the challenges ahead (See figure 4).



Tasks	Design Process Timeline
Brainstorming	August-September
Archives	September-October
Hand Sketch	September-October
Concept Cad model	October-November
Final Cad model	November
Mechanisms brainstorming	December-January
Mechanism test	January

Figure 4 Design Process timeline

Frame 2.2

Material Selection: The frame of ***Poseidon 2.0*** was crafted from HDPE (High-Density Polyethylene) following a comprehensive analysis comparing HDPE, Acrylic, and Aluminum alloy 1060. Overflow Robotics assessed various factors, including cost, fabrication, availability, density, and toughness. Aluminum proved to be expensive and outside Overflows' budget constraints. While both acrylic and HDPE were cost-effective and readily available, acrylic lacked the required toughness for passing stress analysis, making HDPE the optimal choice for ***Poseidon 2.0*** (As shown in figure 5).

Material	Toughness	Availability	Cost	Density
Aluminum Alloy 1060	68935600 NM	Available	22.8 USD/KG	2700
HDPE	2210000 NM	Available	10 USD/KG	952
Acrylic	730000 NM	Available	12 USD/KG	1200
Total Price of Aluminum : 22.8 x 14 Kgs = 319.2				
Total Price of HDPE : 10 x 14 Kgs = 140				
Total Price of Acrylic : 12 x 14 Kgs = 168				

Figure 5 Material Selection

Components: The ***Poseidon 2.0*** frame comprises two upper plates connected to a lower plate through ten HDPE rods. Four housing holders are affixed to the upper plate, along with two upper handles (As shown in figure 6). Horizontal thrusters are mounted on the upper plates, and two HDPE parts connected to the upper plates support the vertical thrusters. The frame features camera slots strategically placed in 12 different positions, with eight on the upper plates and four on the lower plate.

Figure 6 Frame Render

Figure 7 Side view

Figure 8 Front view

Figure 9 Bottom view

Shape: ***Poseidon 2.0*** draws inspiration from the octopus, incorporating manipulators in all directions. The design allows for holding up to six mechanisms through magnetic slots, resulting in an overall appearance resembling an octopus shape.

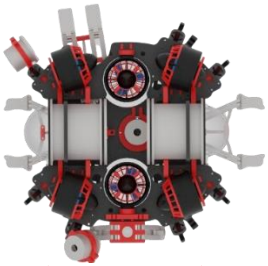


Figure 10 Upper view

Stress Analysis 2.3

Overflow Robotics engaged in a comprehensive drag force analysis using SolidWorks Simulation to delve into the drag points affecting their vehicle initially, concerns arose about potential high drag due to the numerous components integrated into the vehicle. However, the simulation results provided valuable insights. At a speed of 1 m/s, the overall drag force was found to be 6.8 N in the forward direction. This unexpected finding prompted a closer examination of the design's symmetry, which contributed to a consistent drag force across various movements. Identifying the key drag points as the vertical rods and manipulators, Overflow Robotics took proactive measures. Manipulators were strategically edited, fixing some at specific angles to minimize drag force. Simultaneously, adjustments were made to the vertical rods, fixing them at different angles to further reduce drag. In essence, this drag force study using SolidWorks Simulation not only addressed initial concerns but also paved the way for targeted modifications to enhance the aerodynamic performance of ***Poseidon 2.0***.

Housing 2.4

Figure 11 sealing box layout

Overflow Robotics, in its pursuit of advancing ***Poseidon 2.0***, made the decision this year to design two electronic enclosures positioned in a tandem arrangement (As shown in figure 11). Each enclosure, fashioned from HDPE in a cylindrical form, features an inner HDPE plate at one end, accommodating cable glands. At the outer ends, transparent Acrylic Domes are installed on both housings to facilitate clear camera vision and minimize drag force. Acrylic Domes are installed on both housings to facilitate clear camera vision and minimize drag force (As shown in figure 12).

Figure 12 Electric Housing

Manipulators 2.5

Poseidon 2.0 is equipped with four manipulators, each assigned specific tasks.

Horizontal Manipulators: Two horizontal manipulators are fixed in ***Poseidon 2.0***, positioned in tandem at the front and back. Serving as the primary manipulators, these are pneumatically operated and constructed using HDPE and 3D parts to connect the links. With an opening capacity of up to 82 mm, these manipulators are tailored for Mate 2024 tasks. They are utilized for releasing the multi-function node, recovering an acoustic receiver, transplanting branching coral, and addressing Probiotics 2. (Manipulator shown in figure 13)

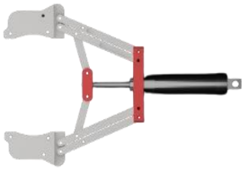


Figure 13 Horizontal Manipulator

Figure 14 Manipulator layout

Clamp Manipulator: This innovative manipulator results from merging two vertical manipulators into a single unit. Achieved by extending 3D connectors to hold all HDPE links, the clamp manipulator is located at the right front side of the vehicle (As shown in figures 15 & 16). Designed to open up to 78 mm, it is ideal for holding the Smart cable repeater and the AUV power connector, both constructed from horizontal PVC pipes.

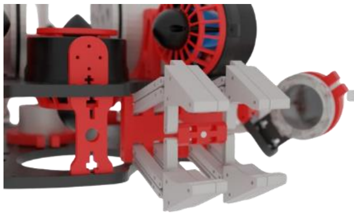


Figure 15 Clamp Manipulator layout

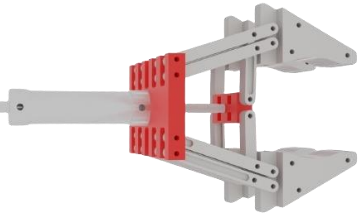


Figure 16 Clamp Manipulator

Down Manipulator: Similar in design to the horizontal manipulators, the down manipulator is fixed at the left side of the vehicle, facing downward. This manipulator is specifically designed for collecting sediment samples. To facilitate this, a hook-like rod mechanism is installed, enabling the activation of the irrigation system through the vehicle and manipulator motion.

Figure 17 down Manipulator

Pneumatics 2.6

Utilizing pneumatics this year was not a new venture for Overflow, as we had employed this technology twice in the past and we were well-acquainted with all its components. However, this year presented a unique challenge as we aimed to reduce the size of the vehicle. Opting for the traditional large pistons was deemed impractical due to their size, which would have been too cumbersome for the frame. Consequently, we embarked on a search for smaller pneumatic pistons. After careful consideration of the competition tasks, it became evident that our manipulators needed to achieve an average opening of over 7 cm. determining the required stroke for the pistons to meet this criterion, we settled on 23 mm. selecting a 15x25 mm piston proved to be an optimal choice, delivering the desired performance (As shown in figure 19). This decision allowed us to achieve a maximum manipulator opening of 82 mm, perfectly aligned with the competition requirements. Having finalized our choice of pistons, we opted to repurpose existing solenoids after thorough testing to ensure they were in good condition. The solenoids underwent testing by connecting them to the air compressor and linking them to a pressure gauge at one end and a piston at the other. Stability in pressure gauge readings during the switching of air paths were a crucial criterion. Fortunately, most of our solenoids performed impeccably. However, one solenoid that did not meet the required standards was promptly replaced with a new one. All solenoids used were of the 5/2 type, specifically designed to work with double-acting pistons. The decision to reuse our existing air compressor, which was already in good condition, was a strategic one. Adhering to stringent pneumatic safety regulations was of paramount importance. Compliance with safety standards was meticulously followed to ensure the well-being of all individuals in the vicinity of pneumatic operations (refer to section 14.0).


Figure 18 5/2 Valve

Figure 19 double acting Piston

Sealing 2.7

Designing and sealing six camera casings and two electrical housings initially presented a challenge, but our team's experience proved invaluable in ensuring the watertight integrity of these components. To achieve effective sealing, we opted for gaskets made of rubber as the primary choice for all our components. Stainless steel glands were employed to secure the cables, and the gaskets were strategically tightened using screws in a star pattern to evenly distribute pressure across the gasket. However, we encountered a significant issue with the unavailability of cable glands, leading to a conflict between standard dimensions and the glands we had on hand. After the installation of the glands, it became apparent that the O-rings were not perfectly tightened, resulting in a leak. To address this issue, we decided to modify the glands using a center lathe machine. This modification allowed us to precisely adjust the dimensions, ensuring a perfect fit for the O-rings and effectively stopping any further leakage (Exploded view in figure 20).


Figure 20 Sealing Box

Buoyancy and ballast 2.8

Buoyancy is the tendency or capacity to remain afloat in a liquid. The buoyancy will define if your object will sink or float while it is the combination of the ratio of your objects mass to surface area in contact with the fluid. Also, when an object floats, it has displaced the exact same weight of the fluid as the object which means if an object that is put in a air into the more than the weight of the fluid it displaces, it will sink. Buoyancy is then directly related to the weight or density of the fluid, so denser or heavier fluids will be able to float heavier objects. In a column of fluid, pressure increases with depth as a result of the weight of the overlying fluid. Thus, the pressure at the bottom of a column of fluid is greater than at the top of the column. Similarly, the pressure at the bottom of an object submerged in a fluid is greater than at the top of the object. An excel sheet was created to identify each object volume, buoyant force and weight in water (As shown in figure 21). We concluded the total needed foam for our vehicle from that spreadsheet, we found out that Poseidon was slightly negative so it needed extra foam to float. Making the frame neutrally buoyant was one of the main design considerations that went into its creation. As a result of the removal of extra material, Poseidon weight was reduced to

9.7 N and its displacement volume to 10890 cm3. The following is how Archimedes' principle was used to produce neutral buoyancy: F Buoyancy = Vg, where the buoyancy force is 8.7 N, which is less than the weight of ***Poseidon 2.0***. As a result, 1 Kg of negative buoyant force affected Poseidon which meant we needed to add floating foam.

Object	Volume	Buoyant force	Mass
Frame	**3200**	**3 Kgs**	**3.2 Kgs**
Enclosures	**700**	**3 Kgs**	**1.7 Kgs**
Manipulators	**2800**	**2.65 KGs**	**2.8 Kgs**
Thrusters	**2064**	**0.936 Kgs**	**2.064 Kgs**

Figure 21 Buoyancy Calculations

Thrusters 2.9

Figure 22 T-200 Thruster

At the onset of the season, we confronted the choice between upgrading to T500 thrusters or sticking with our existing T200 thrusters. After extensive research and a comprehensive comparison of both options within the Mate amperage and voltage limits, it became evident that opting for T500 thrusters would only yield a 14.9% increase in thrust force but would entail a substantial 232.6% surge in cost. Consequently, the decision was straightforward, and we chose to retain the T200 thrusters. The well-maintained condition of our thrusters from the previous season also played a pivotal role in efficiently managing our budget. The T200 supports variable speed control, enabling precise adjustments for nuanced maneuvering. Employing a communication protocol, often PWM, facilitates seamless integration with the control system for regulating thrust and direction. The T200 thruster aligns with Overflow Robotics' requirements for reliable and adaptable electrical performance in their 12-volt setup. Overflow Robotics opted to repurpose a previously used Extreme 3D Pro joystick from past years to govern thruster movements. The team at Overflow Robotics undertook the development of custom code to supply power to the thrusters and manage all essential movements. Building upon power calculations from the preceding year, adjustments were made to align with the demands of a six-thruster ROV. In order to guarantee synchronous activation of all thrusters and the delivery of precise power levels, the team rigorously tested thruster calibration. This process aimed to identify the most accurate range for pulse-width modulation values, ensuring optimal and coordinated performance across all thrusters. **Power Consumption** played a curtail role while choosing our thrusters so both the T-200 and Johnson pilge pump were tested at same current to specify the best option. (See figure 23).

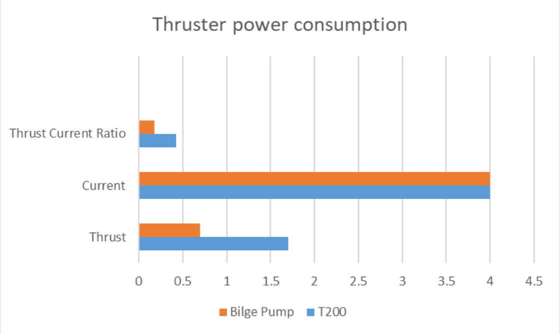


Figure 23 Power consumption diagram

Propulsion 2.10

Figure 24 Thruster layout

Poseidon 2.0 is equipped with a sophisticated propulsion system consisting of six thrusters strategically allocated for optimal maneuverability. Among these, four thrusters are dedicated to horizontal motion, while the remaining two facilitate vertical motion. The four thrusters dedicated to horizontal motion are fixed at a specific orientation ranging from 15 to 75 degrees (As shown in figure 24). This arrangement allows for precise control and navigation in various directions. This orientation was chosen based on insights gained from our previous two seasons, where we observed that lateral movements were prioritized by our pilots and used infrequently. To optimize for our specific needs, we fixed the thrusters in a more productive configuration. For vertical motion, two thrusters are fixed on both sides of the vehicle. Contributing to stability and controlled ascents or descents. See figure 25 for thrust calculation.

Direction	Degree	Single thruster thrust	Total Thrust
Forward	**15**	**1.71**	**6.606 KGF**
Backward	**15**	**1.56**	**6.02 KGF**
Slide right	**75**	**1.71**	**1.77 KGF**
Slide left	**75**	**1.56**	**1.61 KGF**
Upward	**0**	**1.56**	**3.12 KGF**
Downward	**0**	**1.71**	**3.42 KGF**

Figure 25 Thrust Calculation

Innovation 2.11

After the competition manual was released, our company realized the necessity of thinking innovatively to overcome numerous obstacles. Overflow's primary objective was to maximize the underwater product demonstration score, aiming for the full 350 points. This required us to explore numerous creative solutions to enhance our performance. Initially, our company devised a dual sealing box system, streamlining our electrical setup to reduce repair time and lower the chances of system failure. Additionally, we brainstormed ways to tackle multiple tasks concurrently. As a result, we outfitted our vehicle with four manipulators, significantly reducing task durations. Furthermore, we identified certain tasks—like installing the irrigation system, placing the smart repeater, and positioning the ADCP—that didn't require an active manipulator. For these, we engineered passive mechanisms, such as creating a magnetic hook for the irrigation system that securely attaches to our vehicle at specified locations. Our company discovered that each task required a distinct type and shape of mechanism. To address this, we developed a magnetic locking mechanism, named "magnetic locks," consisting of two components. The first part, affixed to our frame, housed two magnets, while the other part contained the specifically designed mechanism along with another two magnets (As shown in figures 26 & 27).

This innovation enabled our team to interchange mechanisms swiftly, reducing product demonstration run time and enhancing overall efficiency. Furthermore, in an effort to minimize costs, our employees were encouraged to creatively tackle the challenges faced by ***Poseidon 2.0***. As a cost-saving measure, our company opted to utilize a total of 8 cameras, necessitating 2 display monitors. To accommodate these monitors economically, we devised a custom touch case. Instead of purchasing one at an estimated cost of $120, we manufactured the touch case ourselves using wood and bolts, resulting in a production cost of only $35. This approach allowed us to tailor the case to our specified dimensions. Moreover, upon realizing that using 5 or 6 manipulators would be cost-prohibitive, we strategically designed a clamp gripper that acted as a dual vertical gripper and was designed specifically for the smart cable repeater and the AUV docking station power connector.

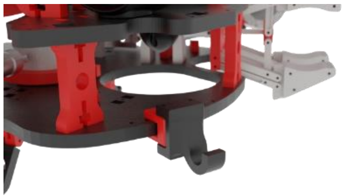


Figure 26 Magnet Mechanism attached

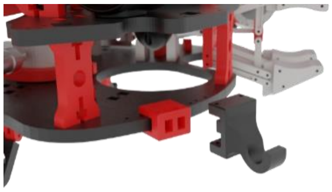


Figure 27 Magnet Mechanism De-attached

Cameras 2.12

Upon reviewing the competition tasks, Overflow Robotics identified the need for multiple manipulators—four, to be exact. Additionally, for optimal visibility, ten cameras were deemed necessary. However, the electrical team faced a constraint, accommodating only eight cameras due to the limited number of available pairs in the signal tether. Responding to this challenge, the mechanical team showcased creativity by devising magnet-lock mechanisms (As shown in figure 28). This innovation enabled the interchange of positions for five cameras, providing a total of twelve different vision spots—an ingenious solution to

Figure 28 Camera magnet mechanism

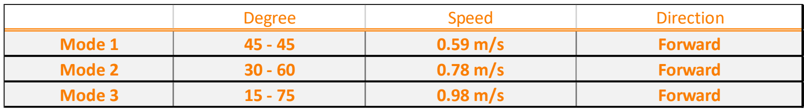
overcome the initial limitation. For the camera system, Overflow Robotics opted for CCTV cameras due to their affordability and ready availability in Egypt (As shown in figure 30). To facilitate data transmission, video balloons were soldered to each camera, amplifying the camera signal (As shown in figure 29). These video balloons were then connected to USBs, which, in turn, were linked to the PCB. The eight USB connections were consolidated into two Ethernet cables, organized in twisted pairs, and connected to the tether. At the other end of the tether, two Ethernet cables were attached to the top-side station PCB, ultimately connecting to the DVR through video balloons. The utilization of video balloons played a crucial role in providing a robust signal for the cameras, ensuring a stable feed underwater at all times. However, the thrusters were found to draw a significant amount of current, resulting in an overall voltage drop that adversely affected the camera system. To address this issue, Overflow Robotics made the decision to install sixteen capacitors and a boost converter. This setup ensures that even during high-current usage, the capacitors supply the cameras with the necessary power to operate effectively, mitigating the impact of voltage fluctuations.

Figure 29 Video Ballon

Figure 30 CCTV Camera

Design Critical decisions 2.13

We opted for HDPE over aluminum due to its cost-effectiveness, lighter weight, and flexibility to shape it according to our requirements. The HDPE frame weighed approximately 3200 grams, whereas the same design in aluminum exceeded 5700 grams. SolidWorks was employed to measure the mass in both cases, confirming that HDPE was significantly lighter and better suited to our needs. To optimize forward and backward speeds, we strategically fixed the thrusters at angles ranging from 15 to 75 degrees based on our requirements. Lateral speed wasn't a primary consideration underwater, so the 75 to 15-degree fixation increased our forward and backward speed by 30% (As shown in figure 31).



	Degree	Speed	Direction
Mode 1	**45 - 45**	**0.59 m/s**	**Forward**
Mode 2	**30 - 60**	**0.78 m/s**	**Forward**
Mode 3	**15 - 75**	**0.98 m/s**	**Forward**

Figure 31 Propulsion variations

In our design process, multiple manipulators and mechanisms necessitated a considerable number of cameras. However, our electrical team determined that our system could accommodate no more than eight cameras. As a solution, we fixed 3 cameras at main positions (front, rear, and down views) and made the other 5 movable across our frame. The three fixed cameras provided essential perspectives, while the remaining five, equipped with magnetic locks, offered flexibility to change their positions as needed for various views.

Figure 32 Camera Slots

Buy Vs Build & New Vs Used 3.0

Overflow Robotics Team maximizes efficiency and organization in its operations, employing a strategic approach when deciding between buy vs. build and new vs. used options. Our primary focus lies in crafting customized solutions to precisely meet the specific requirements of our customers. For instance, we engineered a tailor-made smart cable roller device, aligning with our preference for custom-built solutions whenever feasible. When opting to purchase components, our team diligently researches and evaluates products to ensure optimal utilization of resources. Thorough internet research guides us in identifying the most suitable parts, factoring in cost-effectiveness and shipping times. Alternatively, our in-house building process involves utilizing appropriate tools, materials, and design software to construct bespoke items. Our software and manufacturing tools facilitate the customization of both newly created and reused parts.

Reused components are selectively incorporated, mainly focusing on high-cost, sophisticated items. Thrusters, cameras, and tether represent some of the reused elements, ensuring efficiency without compromising performance.

Mission tasks mechanisms 4.0

The installation of the ADCP proved challenging to manage with our manipulator. To address this, we devised a hook-like mechanism that was 3D printed and connected to our magnetic mechanism slots this innovative solution securely held the ADCP in place until the pilot initiated a roll to the right or left, at which point the ADCP would be effortlessly released. Despite unsuccessful attempts to collect a sediment sample using our gripper in water tests, we devised an alternative solution. A sphere-like hollow mechanism was created (See figure 33), divided into two halves. Each half was installed on one side of our manipulator through designated mechanism slots. The inner face of the sphere was chamfered, facilitating the easy collection of sediment samples (As shown in figure 33). Installing the sprinkler over the coral proved to be time-consuming with our manipulator. To streamline this process, we opted to 3D print a holder designed to secure the loop between four forks under pressure. Once successfully installed, the pilot could move away from the coral head, and the sprinkler would be released by force, simplifying the installation process.

Figure 33 Sediment sample mechanism

ROV Tools 4.1:

Overflow Robotics has been steadfastly pursuing the objective of achieving a total score of 340 points in underwater product demonstrations since its inception. To reach this target, a variety of tools have been developed to facilitate our vehicle's performance:

For attaching a recovery line to the bale of the multi-function node, we experimented with different tools. Initially, we devised a passive rack and pinion mechanism with a stopper that engaged when pressure was applied to close the hooks (see figure 34). Although this concept showed promise, it proved to be time-consuming underwater, taking 2-3 minutes and causing delays in other tasks. Consequently, we pivoted to our second idea, which involved a detachable manipulator equipped with a pneumatic piston operated by air (See figure 35). This innovation significantly reduced the time required to less than one minute, ensuring smoother operation.

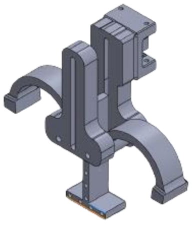


Figure 34 the passive idea

Figure 35 De-attachable manipulator

When it came to positioning a GO-BGC Float, such as our team's creation "Batta 1.0," beyond 2.5 meters from the pool's edge, our vehicle initially struggled to grasp the float. To address this challenge, we designed an acrylic tool enabling our manipulator to securely hold the float in place (Refer to figure 36 for mechanism).

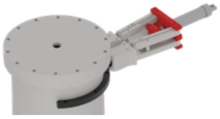


Figure 36 Float attachment

Our float employs a power screw mechanism to operate the buoyancy engine. We incorporated six syringes, each capable of displacing 20 ml of water into the float body, which is made of cylindrical HDPE. This design adheres to all safety regulations set by MATE, ensuring maximum safety and reliability. The float communicates with the station using an NRF module, transmitting depth data every 5 seconds during its profiling process. This consistent and reliable data transmission ensures accurate and timely data collection for effective monitoring and analysis of underwater conditions.

Electrical 5.0

The ***Poseidon 2.0*** electrical system is designed to establish seamless connectivity among its components and ensure reliable operation while submerged. The system comprises two main components: the underwater housing and the control system on top. The underwater housing consists of two sealed boxes, each containing two PCBs, with each PCB having a specified job. On the surface, the control system at the top includes two PCBs housed within our top-side station. The two bottom-side housings are linked to the tether, supplying power and data to all our PCBs. Power distribution is managed by two power cables within the housings, while an Ethernet cable handles data distribution. For vehicle operation, two Arduino Nanos are employed—one situated at the thrusters housing and the other at the topside control system (As shown in figure 37). The dual Nano configuration enables connectivity to RS-485, facilitating data transmission through the tether.

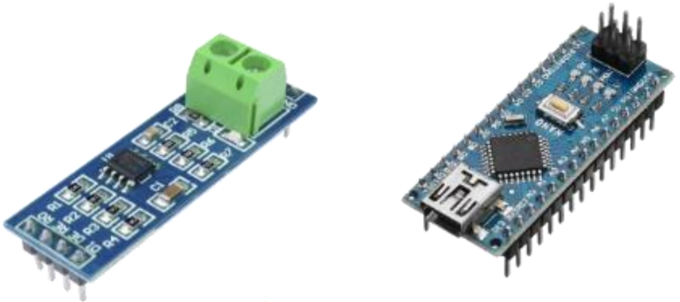


Figure 37 Left: Rs-485 Right: Arduino Nano

PCBs 5.1

The PCBs have been meticulously designed to fit into two waterproof boxes, each with an 11-cm diameter. In these boxes, the four PCBs are strategically organized, with two PCBs in each box (As shown in figure 38). The power wiring originates from the station, connects to the PCBs in box one, and then extends to box two. The electric team has carefully arranged pairs of PCBs in one box, incorporating a specific number of wires to regulate electrical voltage and ensure stability. Within box one, the PCBs cater to thrusters and cameras. To maintain image stability from the eight cameras during thruster motion, capacitors are employed to compensate for voltage drops. The camera signals are transmitted to the station through eight pairs of Ethernet cables, while four pairs of Ethernet cables carry motor signals to the Arduino in box two. In the second PCB, ESCs output 12V, and safety measures include a 10A fuse for each thruster and three 10A diodes, one for each thruster pair. These components safeguard the PCBs by breaking the circuit in the event of an increase in electricity or preventing damage from electrical returns. Box two houses the brain and electric switch for grippers, benefiting from the safety mechanisms implemented in Box 1. This box consists of straightforward components. The Arduino handles code and control in Poseidon after GUI intervention. For long-distance communication using the UART protocol, RS485 is employed due to its advantages, including longer distances (up to 1200 meters), higher data transfer rates (up to 30 Mbps), and the ability to connect multiple devices on a single network with just two wires. The L298n manages the on/off power for grippers, receiving a 1/0 signal from the Arduino. It opens 12V if the signal is 1; otherwise, the power is directed to 0V. The L7805 voltage regulator, supplied with 12V, outputs 5V, ensuring stability with 220nF capacitors. Power communication between the two PCBs utilizes copper spacer rods, while thruster signals traverse from box one to box two through Ethernet cables, completing a robust and well-organized system.

Figure 38 PCBs

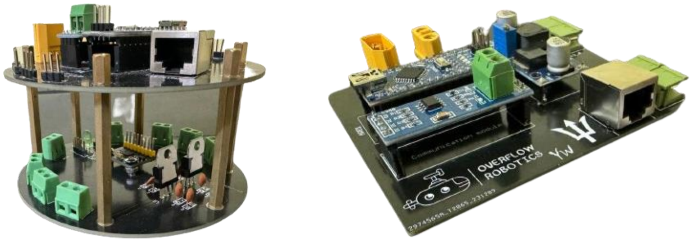


Figure 39 Left: Communication PCB Right: Station PCB

Communication Protocol 5.2

Recognizing the pivotal role of communication systems in enhancing overall vehicle performance, Overflow Robotics has prioritized the establishment of robust communication between the vehicle and the pilot. To achieve this, Overflow developed two communication systems, with the primary one being the RS-485 board. This board is strategically installed in both the top side and the electrical housing. In the housing, the RS-485 is integrated into the communication PCB and linked to the Arduino Nano, facilitating data transmission through a signal tether. The other end of the RS-485 is connected to the top-side PCB, which also interfaces with an Arduino Nano. Both RS-485 boards serve as transmitters and receivers. The top side board transmits joystick commands and receives IMU and temperature sensor readings, while the bottom one receives joystick commands and transmits IMU readings and temperature sensor data. As a backup, Overflow implemented a secondary communication system consisting of an RJ-45 connected to Ethernet at both ends, directly interfacing with the Arduino. Having these two communication systems enables the avoidance of system failures through swift switching between them in case of errors.

Figure 40 Rj-45

Tether 5.3

Overflow Robotics leverages a repurposed tether previously utilized in our older vehicles, "Poseidon & Arsenik," for ***Poseidon 2.0***. To ensure its compatibility with ***Poseidon 2.0*** components, rigorous quality tests were conducted. Initially, the power tether cables were examined by connecting them to a power supply on one end and multiple high-current thrusters on the other. Measurements of voltage drop and amperage through the tether were taken using a Clamp meter. The assessment revealed that despite being overloaded, the tether maintained a stable ampere and exhibited minimal voltage drop, prompting our decision to utilize the older power tether (Test result in figure 41).

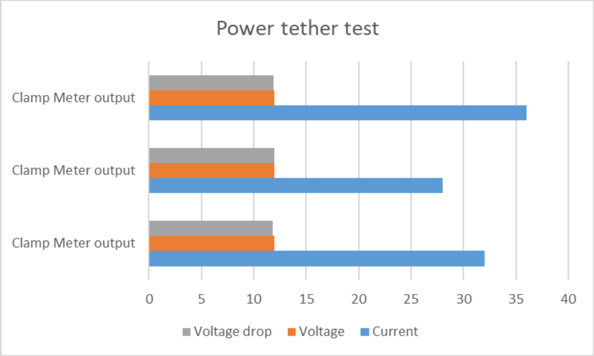


Figure 41 Power tether test

Subsequently, the signal tether underwent testing by connecting it to Ethernet ports at both ends and linking it to laptops through RJ-45s. The data transfer capabilities of all eight cables within the signal tether were assessed. While the signal tether was found to be in excellent condition, it was limited by its length of only 20 meters. To address this limitation, we extended the tether by soldering an Ethernet cable at the station side, ensuring its functionality and expanding its reach. Efficient tether management stands out as a crucial factor influencing ROV performance. Overflow Robotics explored numerous strategies to enhance tether management efficiency. Initially, recognizing the significance of tether buoyancy, we opted to attach foam at one-meter intervals along our tether, ensuring it remains buoyant. Addressing the challenge of tangles, a major hindrance to ROV movement, meticulous measures were taken during pool testing to ensure the tether remained untangled from start to end. To minimize potential disruptions, strict guidelines were enforced, restricting movement around our workspace exclusively to designated tether personnel. Our tether comes out to total of 5 wires, 2 power cables, 1 twisted pair camera signal cable, cat 6 Arduino signal and an air hose. We chose to use to separate power cables as it was already available in our company.

TCU (Tether control unit) 5.4

Figure 42 DVR

Our TCU (Tether Control Unit) served as the primary control station for our vehicle, encompassing essential components to facilitate seamless operation. The TCU featured two monitors displaying camera feeds, supported by two DVRs responsible for collecting and displaying the camera feed on the monitors. A dedicated power supply ensured the vehicle received the required power for its operation. The TCU also included two PCBs, each connecting four video balloons to an Ethernet cable sourced from our tether. To enhance practicality and accommodate all necessary components, we custom-built the TCU case from wood, measuring 85x45x35 cm. This bespoke design allowed us to efficiently house and organize the monitors, DVRs, power supply, PCBs, and other essential elements within the case. Additionally, a strain relief from our tether was thoughtfully connected to the handle of the case, contributing to the overall stability and reliability of the TCU during operation (TCU in figure 43).

Figure 43 TCU

Sensors 5.5

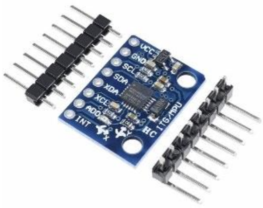


Figure 44 IMU

IMU: The ***Poseidon 2.0*** ROV incorporates an IMU (Inertial Measurement Unit) for monitoring acceleration, orientation (Yaw, Pitch, and Roll), and angular rates. This IMU comprises 3 accelerometers, 3 gyroscopes, and optionally, 3 magnetometers for heading accuracy, providing comprehensive data for maintaining the ROV's stability and inclination underwater. The IMU sensor was utilized to implement a PID (Proportional-Integral-Derivative) control system. This system's objective is to stabilize the motion of the vehicle across all axes. It accomplishes this by employing two thrusters to control the vehicle's speed and an additional two thrusters to adjust its direction if it veers off course in any direction.

Figure 45
Temperature Sensor

Temperature: To validate and ensure the accuracy of the smart cable repeater readings, we employed an independent temperature sensor. This sensor was modified by extending its length to 20 meters through cutting and welding. By comparing the readings obtained from this sensor with our own measurements, we could verify the consistency and reliability of the smart cable repeater data.

Figure 46 Depth sensor

Depth sensor: A depth sensor has been installed on our Float "Batta 1.0" to accurately measure its depth during profiling activities. This depth information is then transmitted to the top-side station where it is graphed for analysis and monitoring purposes.

Software 5.6

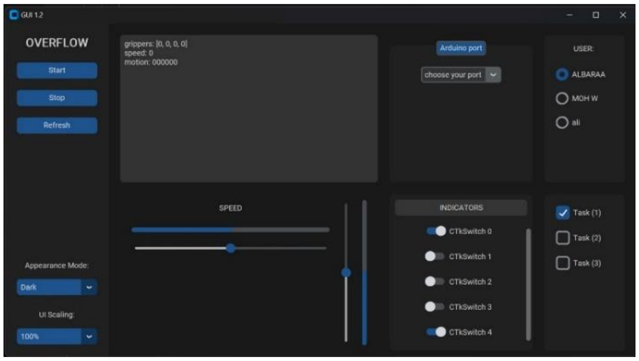
Poseidon 2.0's software team convened to assess its strengths and weaknesses, identify any shortcomings from the previous year's software, and establish a roadmap for software development. An initial training phase was scheduled early in the year to enhance software development skills and pass on knowledge from previous projects to new team members. Following the previous year's strategy, the team opted for a simple yet effective software architecture, comprising two layers: the Topside and Bottom-side. The Top-side layer, known as the Control Unit (TCU), utilizes a Graphical User Interface (GUI) developed using Microsoft Visual Studio and coded entirely in Python. Conversely, the Bottom-side relies on primary communication via the HC-12 for float missions and RS-485, implemented in C++ using Arduino Boards. The choice of C++ was driven by its speed and efficiency, while the Arduino Nano Chip (Microcontroller) was selected for its compact size, reducing the volume within the tube and facilitating board design. Image processing tasks are handled using OpenCV, Numpy, and Turtle libraries, chosen for their extensive documentation and readily available online resources. Beyond its visual appeal, the GUI serves multiple functions: facilitating interface between the joystick and vanguard, controlling thruster speeds to enhance user experience, organizing different widgets for each mission, and featuring a pilot Head-up Display (HUD) for displaying sensor readings such as the IMU Sensor. A notable feature is the integration of a 3-Dimensional model within the application, replicating all ROV movements. The control system's overarching aim is to oversee all electrical components on the ROV, providing the pilot and co-pilot with an intuitive interface for vehicle operation (GUI in figure 47).

Driving modes: 3 different driving modes was created to ensure the easiness of accomplishing the tasks:

Up mode: When activating this mode from the (Graphical User Interface), it ensures that the vehicle maintains stability at the water's surface. This is achieved by utilizing IMU readings to stabilize the vehicle at the highest positive value of the y-axis. This functionality allows our vehicle to maneuver effectively while carrying multiple components such as the irrigation system, the ADCP, the float, and the smart cable repeater, as seen in run 1.

Down mode: Activating this mode from the GUI ensures that the vehicle maintains stability at the bottom of the water. This is accomplished by utilizing IMU readings to stabilize the vehicle at the lowest value of the y-axis. This functionality enables our vehicle to maneuver effectively during tasks such as installing the AUV power connector and triggering the pin of the multi-function node.

Stabilize mode: Activating this mode from the GUI ensures that the vehicle maintains stability at the current level of the water. This is accomplished by utilizing IMU readings to stabilize the vehicle at the current value of the y-axis. This functionality enables our vehicle to maneuver effectively during most of our tasks underwater.



```
grippers: [0, 0, 0, 0]
speed: 0
motion: 000000
```

Appearance Mode: Dark

UI Scaling: 100%

Figure 47 GUI

Trade-offs 6.0

Throughout our season, we encountered several decisions that shaped our course of action:

- Thrusters: The choice between **T200s** and **T500s** was weighed carefully. Despite the T500's increased power, it came at a staggering 230% higher cost than the T200.
- Materials: Opting for HDPE proved beneficial in reducing overall machining costs. It was locally available and incurred lower fabrication expenses.
- Microcontroller: The **Arduino** versus **Raspberry Pi** dilemma involved considering functionality and cost. Although the Raspberry Pi offered more features, it fell short of meeting all our needs and came at a higher cost—approximately 210% more than the Arduino.

Figure 48 Raspberry Pi

- Manipulators: The decision to go with **in-house built** or **pre-built** manipulators hinged on the proven track record of in-house designs over the past two seasons. In-house manipulators played a crucial role in our previous vehicles, offering customization in design. Additionally, pre-built

Figure 49 (Newton subsea gripper)

manipulators, often motorized, posed potential sealing issues over time.

- Manipulator Operating System: Choosing between **hydraulics** and **pneumatics** for the manipulator operating system involved evaluating safety, cost, and efficiency. While hydraulics demanded extensive safety precautions due to their inherent risks and incurred higher costs, pneumatics proved to be a safer and more cost-effective option. After thorough brainstorming and testing on our Manipulators, pneumatics emerged as the solution that satisfied all our requirements.

Logistics 7.0

Project management 7.1

Overflow Robotics, an organization composed of high school students, is dedicated to advancing environmentally conscious technology through innovative solutions. This year marked a growth for the company, expanding its team from 13 to 14 members. Among them, 8 individuals returned, and 6 new recruits joined, all driven by a shared passion and commitment. At the start of the season, our team at Overflow Robotics strategically formed sub-teams based on members' individual interests and skills these sub-teams spearheaded the simultaneous development of various components aligned with the customer's objective. Each meeting initiated with a comprehensive discussion among the entire team regarding the goals for the session and any crucial announcements.

Subsequently, individual sub-teams convened to address their assigned tasks, with designated experienced members available to provide guidance and support. Overflow Robotics prioritizes a culture of collaboration, fostering respectful interactions and creating a supportive environment conducive to learning. These principles are fundamental to the collective success of the team and the overall progress of the company. Essential protocols, including maintaining a safe working environment and a consistent focus on completing tasks throughout the entirety of meetings, were not just enforced but also expected from every employee. Several staff members willingly took on leadership responsibilities to oversee distinct facets of the company:

- Chief Executive Officer (CEO) - Responsible for strategic leadership and decision-making.
- Chief Financial Officer (CFO) - Tasked with financial oversight.
- Mechanical, Electrical, & Software Leaders- Coordinate and oversee departmental functions.

Overflow Robotics was organized into three primary sub-teams: Mechanical, Electrical, and Software, each with distinct responsibilities (For personnel check home page). The Mechanical team oversaw tasks such as vehicle CAD design, fabrication, analysis, and sealing. The Software team was responsible for various software-related functions, including creating Arduino code, developing the GUI (Graphical User Interface), and handling image processing tasks. In the current year, there were two main autonomous tasks: generating a 3D model for the restoration area and transplanting the brain coral. To enhance output, the Software team further divided into two sub-teams—Vehicle Software Needs and Image Processing—allowing members to focus on specific tasks and improve overall performance. The Hardware team was tasked with managing cabling and electronic design for the vehicle. Their objective was to create a more stable electric system compared to Poseidon 1.0. Day-to-day problems and challenges were brought to the attention of the sub-team head. The head then took charge of overseeing the issue, engaging in brainstorming sessions with sub-team members, and collectively formulating solutions. The final idea was communicated to one of the employees for implementation. In instances where Overflow Robotics encountered major challenges, the CEO assumed the responsibility of proposing solutions to designated sub-team heads and distributing tasks among team members (Company tree in figure 50). Overflow Robotics had a primary objective of developing ***Poseidon 2.0*** to meet all Mate rules and qualify for mission objectives. The design of ***Poseidon 2.0*** was tailored to fit within a space less than 1x1 meter square, enabling smooth navigation through the launching area. Additionally, it weighed less than 20 kilograms to avoid disqualification. Safety procedures were diligently considered throughout the design and fabrication phases.

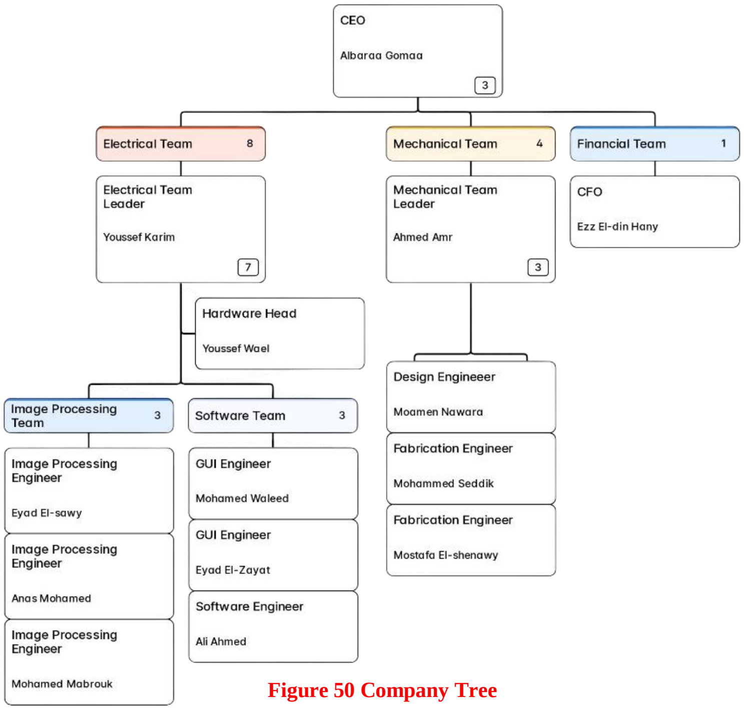
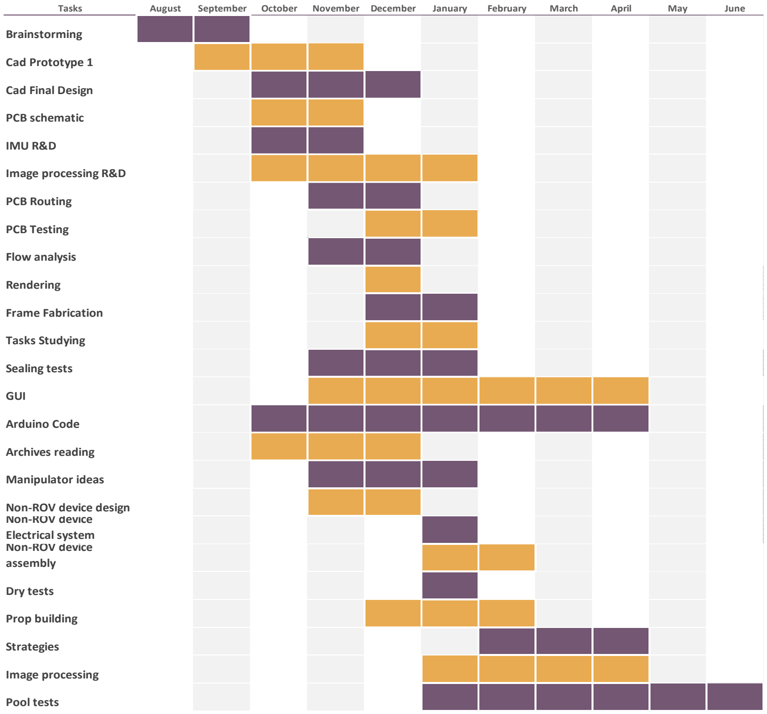


Figure 50 Company Tree

Planning and Scheduling 7.2

One of the primary hurdles faced by Overflow Robotics this year revolved around scheduling and planning. With high expectations, the team required a significant time commitment from each member. Consequently, effective communication among employees became paramount to ensuring strong attendance and productivity during meetings. To facilitate this, messages were regularly disseminated via WhatsApp, our messaging platform, and through email, encouraging active engagement and interaction among all team members. A critical organizational tool utilized by Overflow Robotics was the shared Google Drive. This centralized repository housed every document produced by the company, meticulously organized into categories like Design Documents, Photos, Competition Documents, Safety, Codes, and more. Thorough documentation of the company's work remained crucial to the success of Overflow Robotics. Early in the year, the challenge of crafting a project schedule emerged as a significant hurdle for Overflow Robotics. To address this, our CEO took the proactive step of instituting an Early Timeline (As shown in figure 51), designed to initiate the season's activities.



Tasks	August	September	October	November	December	January	February	March	April	May	June
Brainstorming	🟪	🟪									
Cad Prototype 1		🟧	🟧	🟧							
Cad Final Design			🟪	🟪	🟪						
PCB schematic			🟧	🟧							
IMU R&D			🟪	🟪							
Image processing R&D			🟧	🟧	🟧	🟧					
PCB Routing				🟪	🟪						
PCB Testing					🟧	🟧					
Flow analysis				🟪	🟪						
Rendering					🟧						
Frame Fabrication					🟪	🟪					
Tasks Studying					🟧	🟧					
Sealing tests				🟪	🟪	🟪					
GUI				🟧	🟧	🟧	🟧	🟧	🟧		
Arduino Code			🟪	🟪	🟪	🟪	🟪	🟪	🟪		
Archives reading			🟧	🟧	🟧						
Manipulator ideas				🟪	🟪	🟪					
Non-ROV device design				🟧	🟧						
Non-ROV device Electrical system						🟪					
Non-ROV device assembly						🟧	🟧				
Dry tests						🟪					
Prop building					🟧	🟧	🟧				
Strategies							🟪	🟪	🟪		
Image processing						🟧	🟧	🟧	🟧		
Pool tests						🟪	🟪	🟪	🟪	🟪	🟪

Figure 51 Gantt chart

This timeline served as a guideline for the Sub-team leaders, assigning them the crucial responsibility of following and adhering to the outlined schedule for the successful execution of tasks and milestones. At the outset, Overflow Robotics sought to integrate an electronic workspace tool and opted for the utilization of "Trello" for task assignment, accompanied by specific deadlines. All team members received comprehensive announcements and technical updates via this platform to ensure everyone remained informed and aligned with the project timelines and developments (Trello dashboard in figure 52).

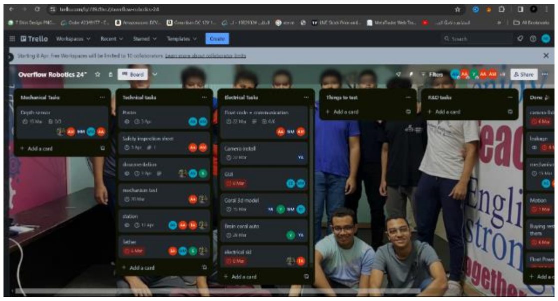


Figure 52 Trello Dashboard

Challenges Faced 7.3

Acquiring new skills stood as the primary obstacle for Overflow Robotics' ROV team. Comprising 14 employees, including 8 returning and 6 new members the newcomers faced the challenge of mastering essential engineering skills, particularly in constructing the ROV using fragmented knowledge from the previous year. Nevertheless, our team demonstrated resilience by tapping into diverse resources such as online materials, classroom teachings, and peer-to-peer learning. This collective effort proved instrumental in acquiring the necessary knowledge to successfully complete our project. Although this learning curve demanded substantial time investment, it culminated in a wealth of newfound engineering expertise and forged a strong bond among team members, fostering a collaborative environment for future endeavors. Another significant challenge arose due to the unavailability of components amidst a national economic situation. In response, Overflow Robotics employed creative solutions, opting to construct components from scratch. This initiative provided invaluable hands-on experience to team members. For instance, when faced with the absence of a solenoid actuator in local stores for creating a roller-like mechanism to manage the smart cable's movement under ROV control (As shown in figure 53), our hardware team designed a schematic and conducted rigorous testing. The resulting custom-built component proved highly effective and robust for our project needs.

Figure 53 smart cable roller

Brainstorming 7.4

Overflow Robotics employs a systematic and collaborative approach when brainstorming potential problems for their ***Poseidon 2.0*** underwater vehicle. The process involves engaging team members from various disciplines, fostering a multidimensional perspective on potential challenges. Here's an insight into how Overflow Robotics effectively brainstorms problems for their ***Poseidon 2.0***:

- Cross-Functional Teams: Overflow assembles cross-functional teams comprising members with expertise in mechanical engineering, electrical engineering, software development, and other relevant domains. This diversity ensures a comprehensive exploration of potential challenges from different angles.
- Task-Specific Analysis: For each ***Poseidon 2.0*** mission or task, the team conducts a detailed analysis of the associated challenges. This involves considering environmental factors, operational constraints, and the specific requirements of the task at hand.
- Brainstorming Sessions: Regular brainstorming sessions are conducted, encouraging open communication and idea generation. Team members are prompted to think critically about potential failure points, technical glitches, or operational hindrances that could arise during ***Poseidon 2.0*** deployment.
- Simulations and Prototyping: Overflow utilizes simulations and prototypes to mimic real-world scenarios. This allows the team to identify issues in a controlled environment before ***Poseidon 2.0*** is deployed in actual operational settings.
- Continuous Improvement Culture: Overflow Robotics fosters a culture of continuous improvement. Team members are encouraged to share insights and lessons learned, contributing to an iterative problem-solving process.

By integrating these approaches, Overflow Robotics ensures that their ***Poseidon 2.0*** underwater vehicles are equipped to navigate a spectrum of challenges, fostering innovation and resilience in their designs. This proactive and collaborative problem-solving methodology positions Overflow Robotics as a leader in the field of underwater robotics.

Prototyping 7.5

Overflow Robotics strategically employed prototyping extensively in the development of ***Poseidon 2.0***, showcasing a commitment to efficiency and cost-effectiveness. Recognizing the potential for cost reduction, the team extensively utilized prototyping methodologies throughout the project. One notable application involved the creation of a prototype PCB (Printed Circuit Board) using Vero board. This step was crucial to validate and ensure seamless data transmission through an Ethernet cable to the other housing. By harnessing the power of prototyping, Overflow Robotics not only streamlined the overall cost of the project but also proactively addressed critical aspects of data connectivity, contributing to the success of ***Poseidon 2.0***. A significant portion of the 3D printed components underwent a thorough prototyping and testing phase before being fully fabricated. Specifically, the universal joint designed for the cameras underwent rigorous testing and prototyping using 3D printing technology. This iterative process ensured that the final design met the required standards and functionality. By prototyping these components initially, Overflow Robotics could assess and refine the designs, addressing any issues or improvements necessary for optimal performance. This strategic approach to prototyping contributed to the overall precision and reliability of the 3D printed parts utilized in their projects.

Figure 54 Left: Frame prototype Right: final frame

Testing and troubleshooting 7.6

Navigating the complexities of vehicle testing, Overflow Robotics confronts challenges with a team of adept troubleshooters. Inherent issues, from blown fuses to solder joint breaks, are met with robust analytical skills and problem-solving proficiency. The troubleshooting process is grounded in a systematic approach, keen observation, and effective testing methodologies. The systematic approach involves a comprehensive examination of the ROV's components, sensors, and connections. The goal is to identify and isolate the specific subsystem or component where the issue resides. Observation and analysis play a crucial role, as the team observes the 's behavior and gathers relevant data to analyze the problem. This includes monitoring sensor readings, error messages, or any abnormal behavior exhibited by the robot. Testing and isolation further refine the troubleshooting process. The team conducts tests to isolate the problem, running specific commands, performing component tests, or conducting experiments to reproduce the issue. This helps determine whether the problem is related to hardware, software, or environmental factors. Additionally, the "Divide and conquer" strategy is employed, breaking down the problem into smaller parts for targeted investigation and resolution. Overflow's electrical and software engineers have developed a specific troubleshooting checklist tailored to ***Poseidon 2.0***. This checklist guides the team through a structured process of identifying, isolating, and resolving issues. Our commitment to a meticulous troubleshooting methodology, honed over the years, ensures that our products, like ***Poseidon 2.0***, meet the highest standards of reliability.

Accounting 8.0

Overflow Robotics initiated the season with a proactive approach to securing funds. Two employees dedicated to spearhead the effort, reaching out to individuals and companies in pursuit of financial support. Although the initial outcomes were not overwhelming, the team successfully secured a significant sponsorship from PCB Way, covering all PCB expenses and contributing to some of the electrical components costs. Recognizing the need for financial contributions from within, Overflow Robotics implemented a strategy of employee dues. Each team member was asked to contribute a total of 230 $, reflecting their commitment to the organization and granting them access to invaluable experiences, tools, and components. In addition to these efforts, Overflow Robotics leveraged its expertise by offering multiple robotics courses throughout the season. The team effectively marketed these courses through social media channels, resulting in the collection of an additional 80 $. These diverse funding streams collectively supported Overflow Robotics in pursuing its objectives, emphasizing both external partnerships and internal contributions from its dedicated team members. (Refer to figures 57 & 60 for monthly cost tracking)

Budget 8.1

At the commencement of the season, Overflow Robotics meticulously established an estimated budget, drawing insights from the previous year's expenses and conducting on-site research at local shops to ascertain the prices of various components. Each sub-team played an integral role in this process by formulating comprehensive proposals outlining all necessary components along with their estimated costs. Upon approval from the CEO and CFO, the sub-teams proceeded with their technical work. A distinct budget section was allocated for items such as t-shirts, marketing, and social media initiatives to ensure a well-rounded financial plan. For travel expenses, a budget was outlined throughout the season, with each employee held responsible for managing their individual travel costs. This decentralized approach allowed team members to take ownership of their travel expenses, fostering a sense of accountability within the team. The structured budgeting process facilitated effective financial planning and resource allocation, contributing to the overall success and sustainability of Overflow Robotics' endeavors. (See figure 58 and 59) See figure 56 for income sources.

Cost 8.2

Due to fluctuating prices and instability in Egypt, our budget faced challenges, leading to deviations from the initial plan. However, innovative solutions helped mitigate costs, resulting in an overall savings of 30 $. The bulk of our expenses were attributed to electrical components and tools, primarily due to their international importation, which incurred higher costs. By employing efficient cost management practices, such as securing donations and carefully considering whether to purchase, manufacture, or repurpose materials, Overflow Robotics successfully maintained fiscal discipline. These strategies, coupled with the creation of custom components and the procurement of dependable materials, enabled the team to achieve a specialized and budget-conscious decisions to build the ROV. (See Figure 55), Trade-offs have played crucial role in cutting down costs (See Figure 55 for illustration).

Items	Trade-Offs Prices		Item Selected	Description
Thruster	200	690	T200	T200 or T500 Blue robotics thruster
Microcontroller	12	40	Arduino	Arduino or Raspberry Pi
Manipulators	34	640	In-home built	In-Home Built or Newton Subsea
				Gripper for manipulation system

Figure 55 Trade-Offs Cost breakdown

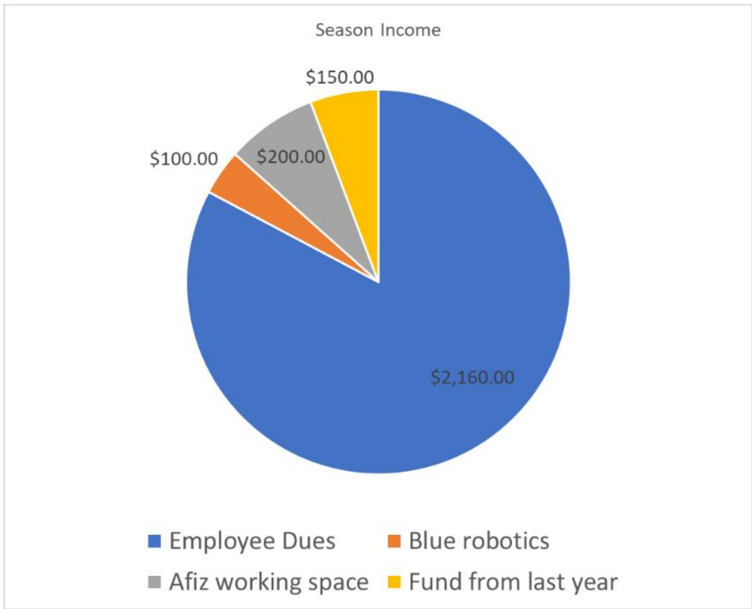


Figure 56 Season income pie chart

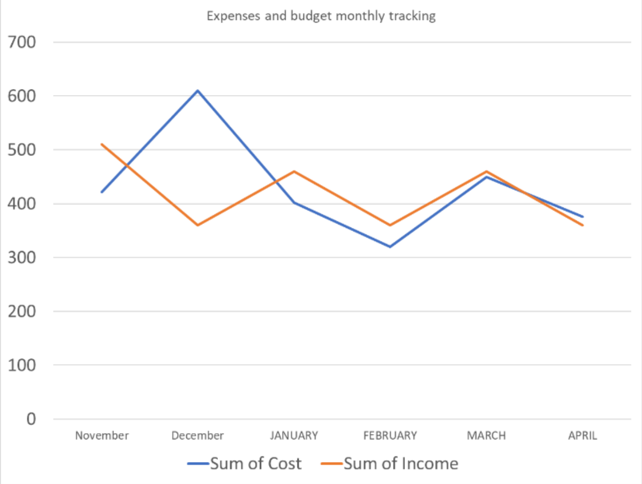
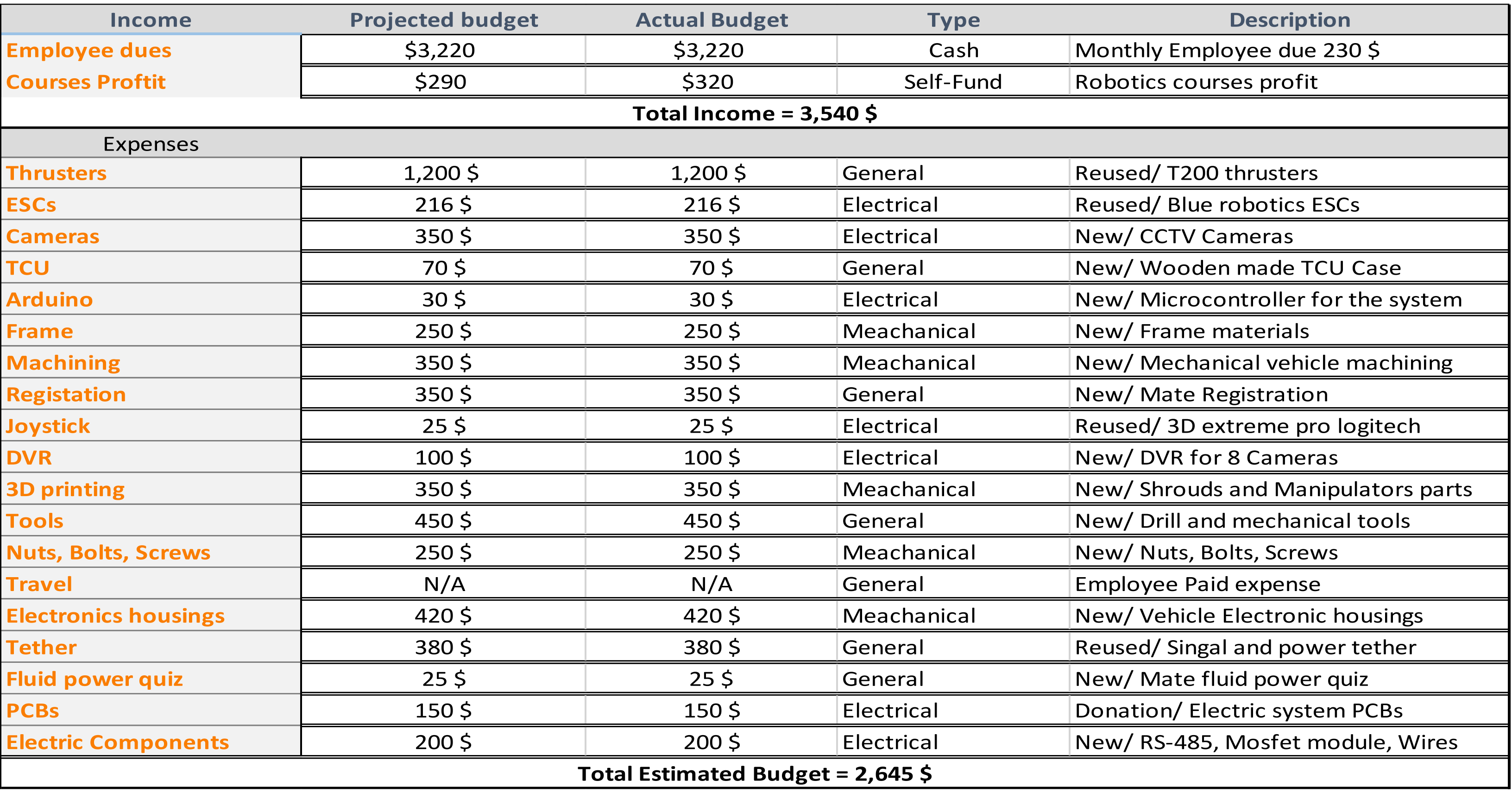
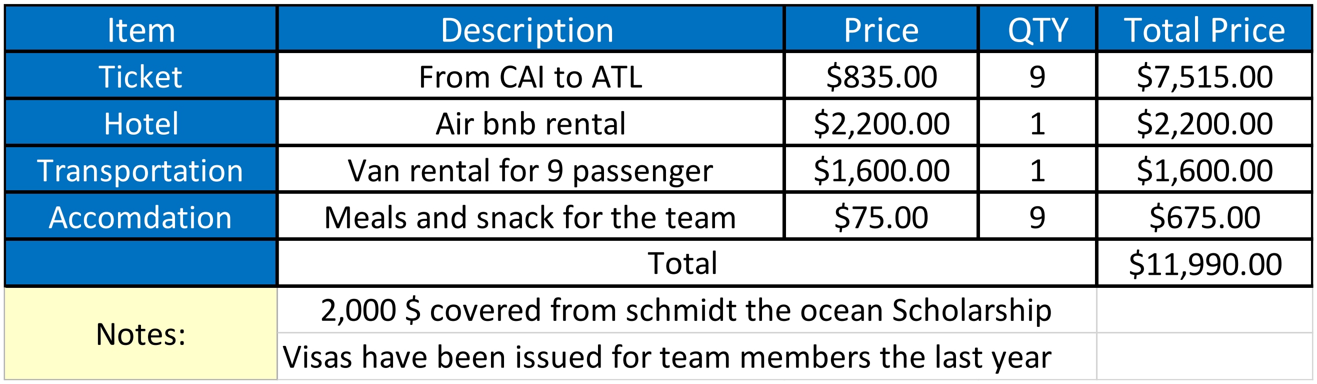


Figure 57 Season income and expenses graph



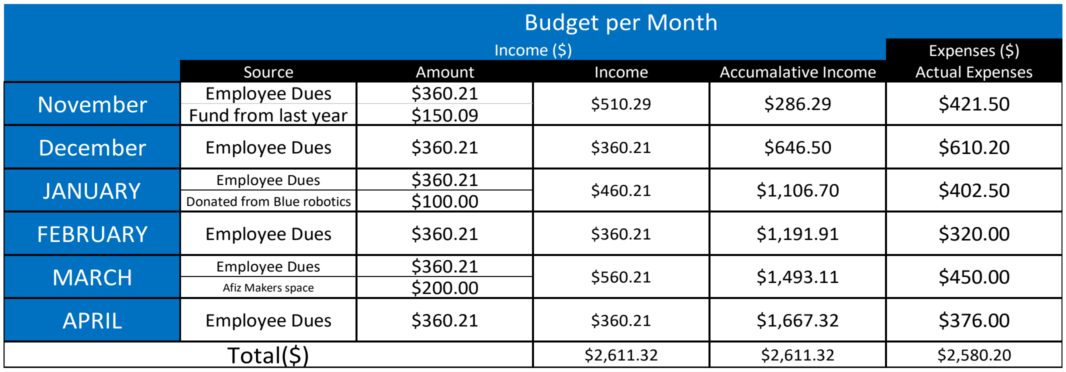
Income	Projected budget	Actual Budget	Type	Description
Employee dues	$3,220	$3,220	Cash	Monthly Employee due 230 $
Courses Proftit	$290	$320	Self-Fund	Robotics courses profit
Total Income = 3,540 $				
Expenses				
Thrusters	1,200 $	1,200 $	General	Reused/ T200 thrusters
ESCs	216 $	216 $	Electrical	Reused/ Blue robotics ESCs
Cameras	350 $	350 $	Electrical	New/ CCTV Cameras
TCU	70 $	70 $	General	New/ Wooden made TCU Case
Arduino	30 $	30 $	Electrical	New/ Microcontroller for the system
Frame	250 $	250 $	Meachanical	New/ Frame materials
Machining	350 $	350 $	Meachanical	New/ Mechanical vehicle machining
Registation	350 $	350 $	General	New/ Mate Registration
Joystick	25 $	25 $	Electrical	Reused/ 3D extreme pro logitech
DVR	100 $	100 $	Electrical	New/ DVR for 8 Cameras
3D printing	350 $	350 $	Meachanical	New/ Shrouds and Manipulators parts
Tools	450 $	450 $	General	New/ Drill and mechanical tools
Nuts, Bolts, Screws	250 $	250 $	Meachanical	New/ Nuts, Bolts, Screws
Travel	N/A	N/A	General	Employee Paid expense
Electronics housings	420 $	420 $	Meachanical	New/ Vehicle Electronic housings
Tether	380 $	380 $	General	Reused/ Singal and power tether
Fluid power quiz	25 $	25 $	General	New/ Mate fluid power quiz
PCBs	150 $	150 $	Electrical	Donation/ Electric system PCBs
Electric Components	200 $	200 $	Electrical	New/ RS-485, Mosfet module, Wires
Total Estimated Budget = 2,645 $				

Figure 58 (Estimated Budget) Re-used items are not added in the grand total*



Item	Description	Price	QTY	Total Price
Ticket	From CAI to ATL	$835.00	9	$7,515.00
Hotel	Air bnb rental	$2,200.00	1	$2,200.00
Transportation	Van rental for 9 passenger	$1,600.00	1	$1,600.00
Accomdation	Meals and snack for the team	$75.00	9	$675.00
	Total			$11,990.00
Notes:	2,000 $ covered from schmidt the ocean Scholarship			
	Visas have been issued for team members the last year			

Figure 59 Estimated Travel Budget



	Budget per Month				
	Income ($)				Expenses ($)
	Source	Amount	Income	Accumalative Income	Actual Expenses
November	Employee Dues Fund from last year	$360.21 $150.09	$510.29	$286.29	$421.50
December	Employee Dues	$360.21	$360.21	$646.50	$610.20
JANUARY	Employee Dues Donated from Blue robotics	$360.21 $100.00	$460.21	$1,106.70	$402.50
FEBRUARY	Employee Dues	$360.21	$360.21	$1,191.91	$320.00
MARCH	Employee Dues Afiz Makers space	$360.21 $200.00	$560.21	$1,493.11	$450.00
APRIL	Employee Dues	$360.21	$360.21	$1,667.32	$376.00
Total($)			$2,611.32	$2,611.32	$2,580.20

Figure 60 Monthly Accounting tracking spreadsheet

ITEM	Description	Quantity	Status	Estimated Budget (EGP)	Budgeted Value (EGP)	Difference (EGP)	Running Total
Thrusters	T200	6	Reused				
	ESC	6	Reused				
Material	HDPE	3	New	$70.00	$60.00	$10.00	$60.00
	Dome	4	New	$45.00	$40.00	$5.00	$100.00
	Rubber silicon (ROV)	1	New	$60.00	$65.00	-$5.00	$165.00
	Acrylic	1	New	$25.00	$21.00	$4.00	$186.00
	Rubber	1	New	$10.00	$10.00	$0.00	$196.00
	Rov paint	1	New	$50.00	$40.00	$10.00	$236.00
	Magnets	20	New	$60.00	$50.00	$10.00	$286.00
	Epoxy	5	New	$30.00	$30.00	$0.00	$316.00
Fabrication	Machining	1	New	$130.00	$140.00	-$10.00	$456.00
Fasteners	Screws	250	New Reused	$110.00	$120.00	-$10.00	$576.00
	Nuts	150	New Reused	$125.00	$115.00	$10.00	$691.00
Pneumatic System	pistons	7	New Reused	$90.00	$85.00	$5.00	$776.00
	Valve	7	New	$55.00	$50.00	$5.00	$826.00
	Compresor	1	Reused			$0.00	$826.00
Elecrtical System	PCBs	4	New	$190.00	$180.00	$10.00	$1,006.00
	PCB Components		New	$130.00	$120.00	$10.00	$1,126.00
	Charger	1	New	$15.00	$10.00	$5.00	$1,136.00
Vision System	Camera	8	New	$220.00	$210.00	$10.00	$1,346.00
	DVR	2	New	$75.00	$80.00	-$5.00	$1,426.00
	Camera cab	10	New	$20.00	$25.00	-$5.00	$1,451.00
	Monitor	2	New	$180.00	$150.00	$30.00	$1,601.00
Actuators	Deapth Sensor	1	New	$15.00	$8.00	$7.00	$1,609.00
	power scru	2	New	$80.00	$70.00	$10.00	$1,679.00
	Temperature sensor	2	New	$15.00	$12.00	$3.00	$1,691.00
Tether	Ethernet Cable	2	New	$105.00	$100.00	$5.00	$1,791.00
	CAT-6	1	New	$75.00	$60.00	$15.00	$1,851.00
	Pneumatic Cable	3	New	$95.00	$100.00	-$5.00	$1,951.00
	Signal Cable	2	New	$150.00	$150.00	$0.00	$2,101.00
Control Unit	Control Box	1	New	$270.00	$230.00	$40.00	$2,331.00
	Control Box Holders	2	New	$30.00	$25.00	$5.00	$2,356.00
Miscellaneous	Zipties	10	New	$35.00	$40.00	-$5.00	$2,396.00
	Heatshrink	35	New	$40.00	$35.00	$5.00	$2,431.00
	Weights	8	New	$40.00	$35.00	$5.00	$2,466.00
	Foam	20	New	$65.00	$50.00	$15.00	$2,516.00
Registration	Registration	1	New	$100.00	$100.00	$0.00	$2,616.00

Figure 61 Cost Analysis

Appendix 9.0

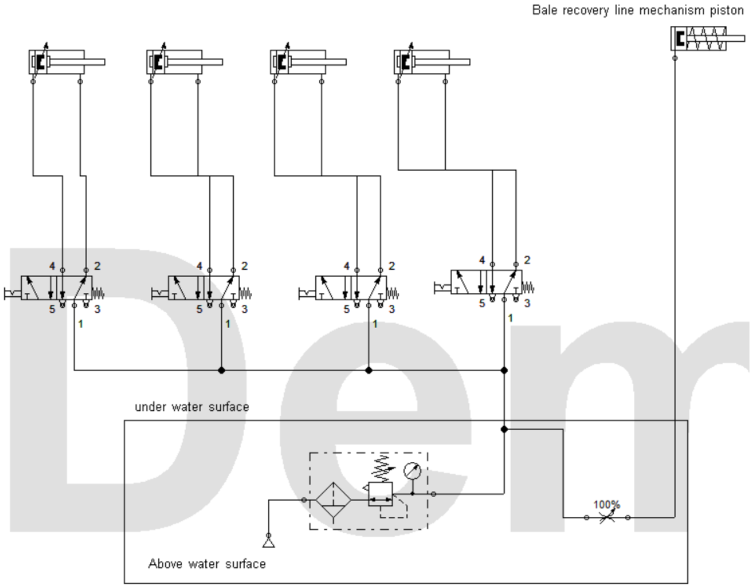
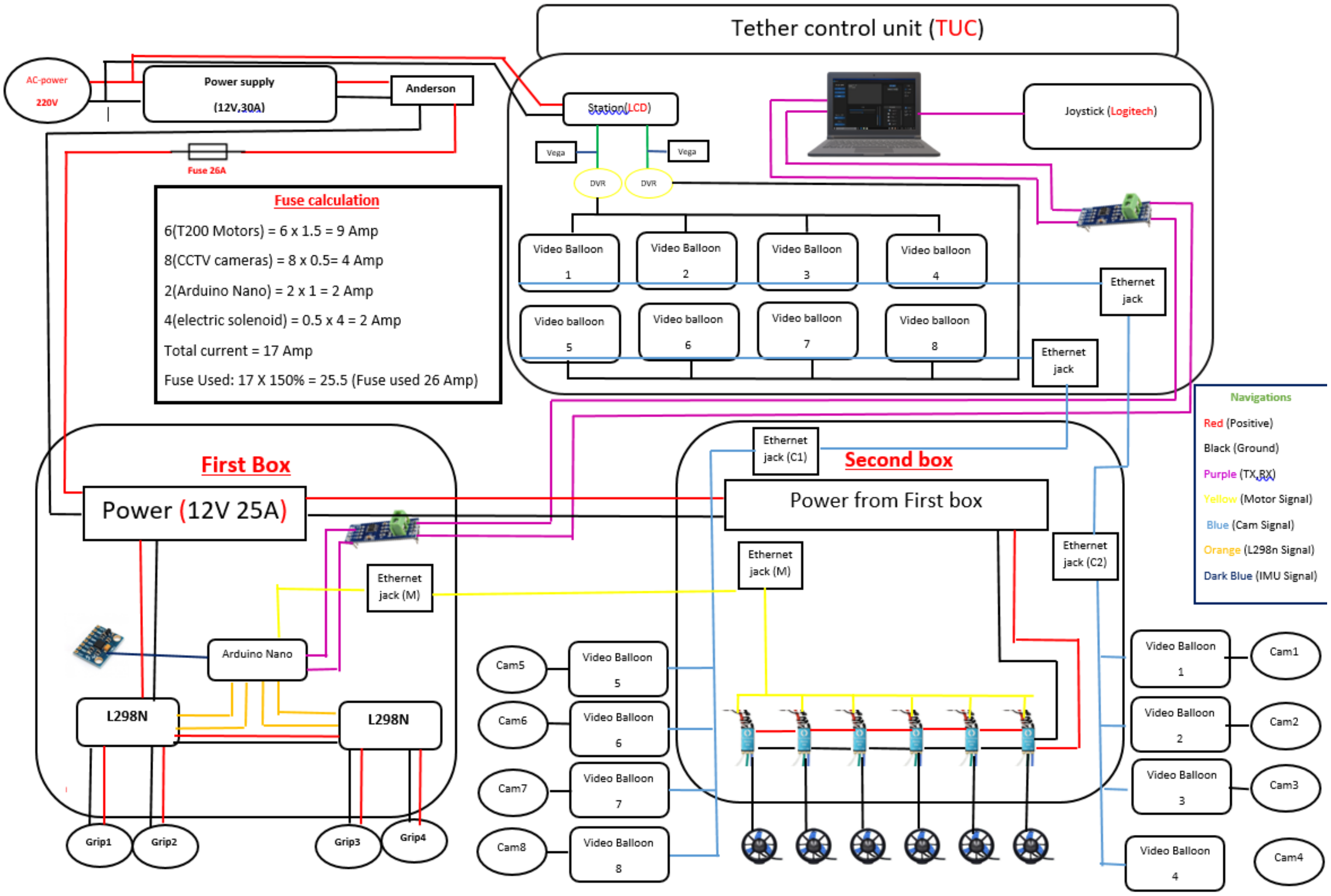


Figure 62 Fluid Power SID



Fuse calculation

6(T200 Motors) = 6 x 1.5 = 9 Amp

8(CCTV cameras) = 8 x 0.5= 4 Amp

2(Arduino Nano) = 2 x 1 = 2 Amp

4(electric solenoid) = 0.5 x 4 = 2 Amp

Total current = 17 Amp

Fuse Used: 17 X 150% = 25.5 (Fuse used 26 Amp)

Figure 63 Electrical SID

Safety 10.0:

Overflow Robotics prioritizes the safety of all team members due to the delicate and sometimes hazardous nature of our work. With many new members joining, we established an orientation to inform and remind everyone of the proper safety protocols outlined in the Environmental Health and Safety (EHS) policies and our team's Job Safety Analysis (JSA). Team member's work in pairs or small groups to ensure no one operates machinery alone. Periodic safety meetings focus on specific topics such as hand safety, eye safety, electrical safety, and power tool safety. Team members are educated on safely handling and operating the ROV to prevent accidents. If a safety protocol is violated, the team member is immediately informed of the hazard and re-taught the proper procedure. This violation is then discussed in the next safety meeting to ensure all members are fully informed of the necessary safety measures. Given that some of the payload tools pose potential dangers to divers or others working with our ROV, we have incorporated specific safety measures. Thruster shrouds cover each thruster, and we have added rounded edges and warning labels to Poseidon 2.0 to prevent harm. The tips of our claw's fingers are colored red to signal potential pinch points, and all sharp edges on the ROV have been removed or covered to eliminate cutting hazards. Thrusters are shrouded with MATE-compliant custom-fit shrouds based on MATE specification MECH006. To protect the electronics and personnel, the electronics are housed in an acrylic tube, sealed with a dome and an endcap, Additionally, a 25-amp fuse is installed between the power supply and the control box. Refer to Company Safety Review, for proof of compliance with MATE's protocol. Pool safety rules include no running on the pool deck and keeping electrical power supply lines away from water. Overflow Robotics team members use safety checklists while operating around the ROV to minimize any dangers.

General Safety Checklist 10.1:

- ✓ Establish communication with colleagues.
- ✓ Ensure all individuals have secured hair, rolled up sleeves, and stored away earphones/jewelry while handling tools.
- ✓ Confirm everyone is wearing closed-toe footwear.
- ✓ Ensure everyone is wearing safety goggles.
- ✓ Clear passageways of obstacles and cables.
- ✓ Store hazardous items and materials away from team members and the ROV when not in use.
- ✓ Keep all electronics, excluding the tether, away from water.
- ✓ Ensure thorough and effective covering of all wires.
- ✓ Connect the power source and controller before activating the control box.

Operational Checklists and Protocol 10.2:

Tether Checklist:

Setup:

- ✓ Straighten and eliminate any kinks in the tether.
- ✓ Safely plug the tether into the control box.
- ✓ Secure strain relief to prevent accidental disconnection from the control box.
- ✓ Inform other employees about the deployed tether to prevent accidental stepping.
- ✓ Attach the strain relief to the ROV.
- ✓ Connect the tether to the ROV.

Post-Run:

- ✓ Safely disconnect the tether from the control box.
- ✓ Safely disconnect the tether from the ROV.
- ✓ Neatly roll up the tether on the hose reel.

On-Deck Checklist:

- ✓ Follow the tether setup protocol.
- ✓ Connect the power supply and set it to 12v.
- ✓ Power up the ROV.
- ✓ Test the thrusters and claws.
- ✓ Verify camera views on the designated deck screens.

- ✓ Carefully lower the ROV into the water.
- ✓ Release any trapped air bubbles.
- ✓ Await the "ready" signal from deck crew.
- ✓ Initiate launch with a countdown.

Pre-Run Checklist:

- ✓ Inspect electrical power connections.
- ✓ Perform a dry run to ensure unobstructed and functional cameras.
- ✓ Confirm the security of all waterproof seals.
- ✓ Check thrusters for proper function and clearance.
- ✓ Verify proper functioning of the claw.

Post-Run Checklist:

- ✓ Power off the Control Box.
- ✓ Turn off the power supply.
- ✓ Follow the tether disconnect procedure.
- ✓ Dry the ROV and place it safely on the cart.
- ✓ Clean the work area, removing all materials, props, supplies, and debris.

Acknowledgments 11.0:

- The assistance from Mate ROV Egypt and MATE center was invaluable in addressing any issues we encountered.
- Mate ROV Egypt played a crucial role in guiding us through the entire registration procedure.
- The Mechanism Fabrication Center not only assisted us throughout the fabrication process but also provided all necessary machinery.
- Our mentors, including Moazz Mahmoud, Abdelwahab Adam, Ehab Abdel Rahman, Ahmed Amin, and Abobakr Mohamed, continuously supported and motivated us to reach new heights within our field.
- PCB Way and Blue Robotics deserve recognition for generously providing their services at discounted rates, allowing us to utilize them effectively at minimal cost.
- Additionally, the unwavering support from our friends and family members has been instrumental in our journey. They have stood by us through thick and thin, offering encouragement and understanding whenever needed. Their belief in our endeavors has fueled our determination to succeed, and we are grateful for their love and support every step of the way.

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