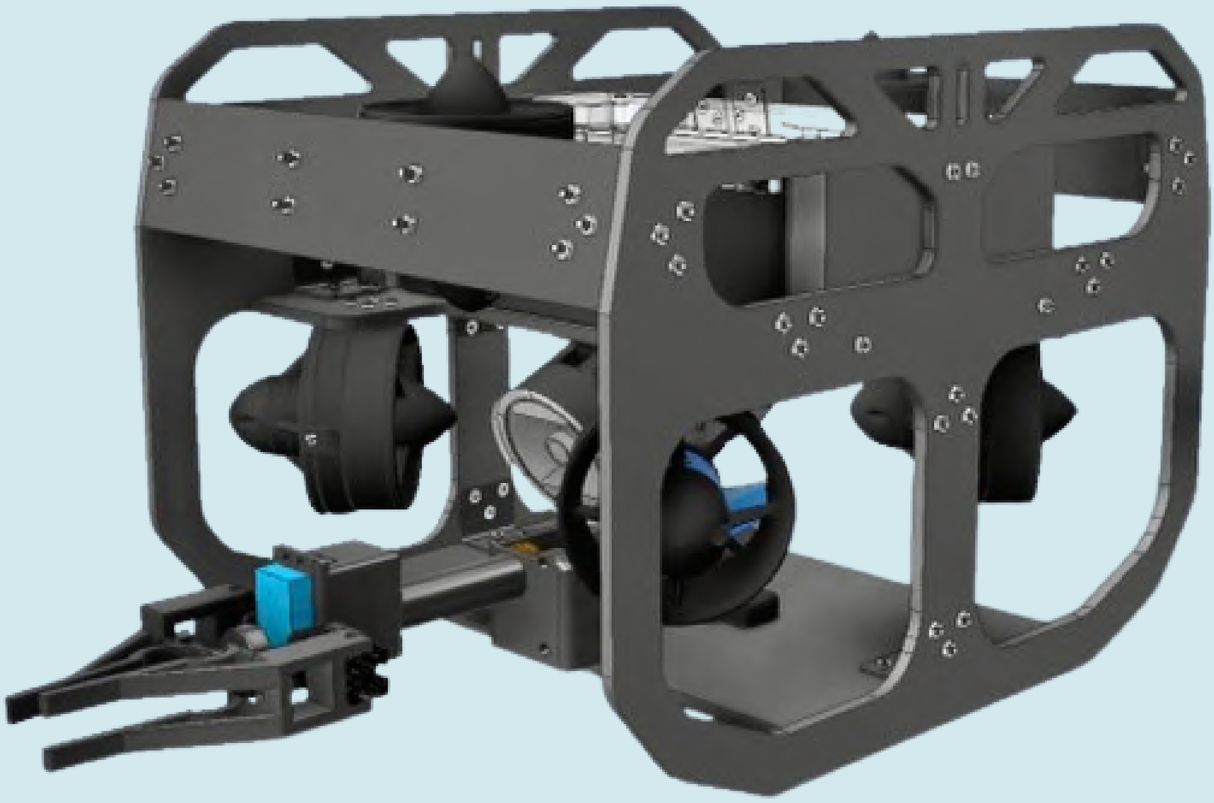
WARRIORTIDES

VALLEY CHRISTIAN HIGH SCHOOL
SAN JOSE, CALIFORNIA, USA



Members:

Robert Reese | Mentor

David Bai | CEO (12)

Ryan Chiou | President (12)

Connor Stone | Mechanical lead (12)

Zachary Martino | Mechanical (11)

Nathan Weng | Electrical lead (11)

Rhea Virk | Electrical (12)

Brayden Tam | Software lead (12)

Joshua Upputuri | Software (10)

Ållison Yen | Software (11)

Ananya Maheshwari | Business lead (12)

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ABSTRACT

WarriorTides is an entirely **student-run corporation** specializing in underwater technology—specifically Remotely Operated Vehicle (ROV) design and deployment. Our company aims to engineer **innovative ROVs** capable of addressing many of today's oceanic issues, including **facilitating** marine renewable energy, **analyzing** levels of blue carbon, and **supporting** healthy ecosystems across the mountains and the seas. This year, we have also challenged ourselves to improve water column data collection by designing a **Gatling float** capable of vertical profiling and wireless transmission.

This year, we proudly present our 4th ROV, **Triggerfish**. With **6 T200 thrusters** that command 5 degrees of freedom, a **claw manipulator** with two points of rotation, a **low-latency digital vision** system, a custom power distribution **PCB**, and a **modular frame** design, Triggerfish is ready to address all client needs. From using its claw to remove biofouling and an add-on fry container to transport endangered fish, Triggerfish was designed with **ubiquitous functionality** in mind.

Fig 1. Triggerfish

Fig 2.WarriorTides Team

WarriorTides prioritizes a learning environment alongside technical development and maintains a sense of **corporate responsibility**. We are blessed to mentor our sister Navigator team, invite the community to learn about ROVs and attend local creek cleanups to educate ourselves and those around us.

This year has been an extraordinary experience for Warrior Tides. Changes in design philosophy, team composition, and management approach have made this year's ROV the most different and, more importantly, **most innovative** out of past models. WarriorTides is confident that Triggerfish will be **invaluable** in preserving our oceans for the next generation.

PROJECT MANAGEMENT

Company Description

Warrior Tides is a company of **10 engineers.** We have a CEO, President, and four subteams all working together towards creating a **mobile** and **versatile** ROV. The CEO oversees the entire team, while the President helps the CEO make crucial decisions. Both leaders are responsible for **recruiting** talent, **mentoring** employees, and **assigning** tasks.

The four subteams are **Mechanical**, **Software**, **Electrical**, and **Business**. Each department has a team leader that keeps members organized and delegates tasks. We meet **twice a week** to collaborate and fabricate our ROV. Our advisor supervises all our meetings and is freely available for consultation. All team-wide decisions related to the MATE competition and the design of the ROV are made during group meetings with **all** team members present.

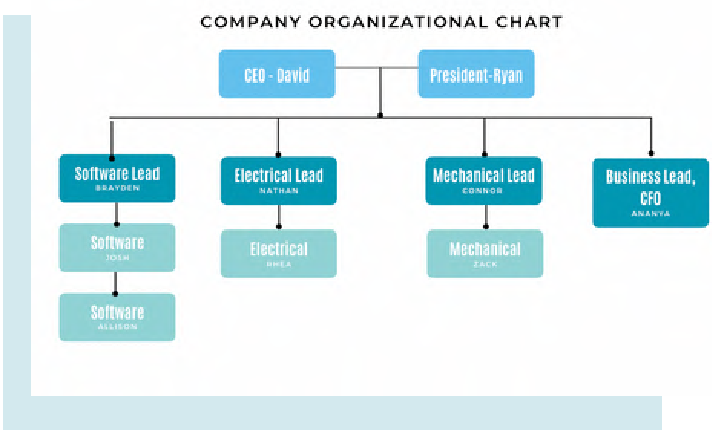


Fig 3. Organizational Chart

Scheduling

The overall plan for the season was to spend the first semester building a new frame, PCB, and control system. The second semester was spent working on competition-specific manipulators, computer vision algorithms, and drive practice. We also created a Gantt chart. **Unfortunately, due to extended time spent on frame design and tether issues, we fell behind schedule. However, we were able to overcome this challenge by approaching the rest of the season with adaptability and flexibility.**

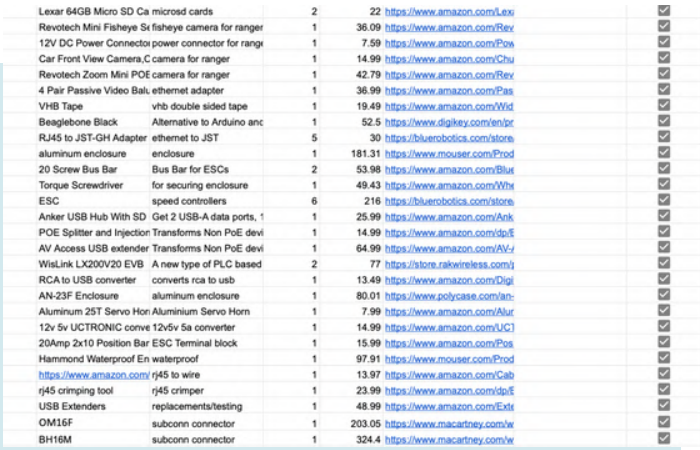
Decision Making

Though each specific process differed, we made overall decisions through **team discussions** and took a **holistic** approach to the vehicle's systems. We encouraged **all** engineers from various technical backgrounds to propose their ideas and utilized **decision matrices** to reach our final decisions. We made decisions by setting criteria and then talking through each option until we reached a gradual consensus. One example was when we were deciding whether to have a 4, 6, or 8-thruster configuration. We considered the **criteria** of feasibility, **ease** of programming, **compatibility** with the PCB, **speed**, and **weight**. After discussing each configuration, we agreed to use the six-thruster configuration.

Day-to-Day Operations

For most of the season, WarriorTides meets on Mondays and Wednesdays from 2:45 - 5:45 for a total of **six hours per week**. As we approach the competition, we meet **daily**, focusing on the subteams that need the most time. Each work session begins with an **all-hands meeting** where we discuss updates and provide announcements.

To **manage the budget**, we organize all purchase requests in a **Google sheet**. We keep track of the remaining budget after every purchase. We use **Microsoft Teams** as our primary platform for **communication** as it provides an organized environment for company announcements and discussions.



Lexar 64GB Micro SD Ca	microsd cards	2	22	https://www.amazon.com/Lex	☑
Revotech Mini Fisheye S	fisheye camera for ranger	1	36.09	https://www.amazon.com/Rev	☑
12V DC Power Connecto	power connector for range	1	7.59	https://www.amazon.com/Pow	☑
Car Front View Camera,C	camera for ranger	1	14.99	https://www.amazon.com/Chu	☑
Revotech Zoom Mini POE	camera for ranger	1	42.79	https://www.amazon.com/Rev	☑
4 Pair Passive Video Balu	ethernet adapter	1	36.99	https://www.amazon.com/Pas	☑
VHB Tape	vhb double sided tape	1	19.49	https://www.amazon.com/Wid	☑
Beaglebone Black	Alternative to Arduino anc	1	52.5	https://www.digikey.com/en/pr	☑
RJ45 to JST-GH Adapter	ethernet to JST	5	30	https://bluerobotics.com/store	☑
aluminum enclosure	enclosure	1	181.31	https://www.mouser.com/Prod	☑
20 Screw Bus Bar	Bus Bar for ESCs	2	53.98	https://www.amazon.com/Blue	☑
Torque Screwdriver	for securing enclosure	1	49.43	https://www.amazon.com/Whe	☑
ESC	speed controllers	6	216	https://bluerobotics.com/store	☑
Anker USB Hub With SD	Get 2 USB-A data ports, 1	1	25.99	https://www.amazon.com/Ank	☑
POE Splitter and Injection	Transforms Non PoE devi	1	14.99	https://www.amazon.com/dp/E	☑
AV Access USB extender	Transforms Non PoE devi	1	64.99	https://www.amazon.com/AV-	☑
WisLink LX200V20 EVB	A new type of PLC based	2	77	https://store.rakwireless.com/	☑
RCA to USB converter	converts rca to usb	1	13.49	https://www.amazon.com/Digi	☑
AN-23F Enclosure	aluminum enclosure	1	80.01	https://www.polycase.com/an-	☑
Aluminum 25T Servo Hor	Aluminium Servo Horn	1	7.99	https://www.amazon.com/Alur	☑
12v 5v UCTRONIC conve	12v5v 5a converter	1	14.99	https://www.amazon.com/UCT	☑
20Amp 2x10 Position Bar	ESC Terminal block	1	15.99	https://www.amazon.com/Pos	☑
Hammond Waterproof En	waterproof	1	97.91	https://www.mouser.com/Prod	☑
https://www.amazon.com/	rj45 to wire	1	13.97	https://www.amazon.com/Cab	☑
rj45 crimping tool	rj45 crimper	1	23.99	https://www.amazon.com/dp/E	☑
USB Extenders	replacements/testing	1	48.99	https://www.amazon.com/Exte	☑
OM16F	subconn connector	1	203.05	https://www.macartney.com/w	☑
BH16M	subconn connector	1	324.4	https://www.macartney.com/w	☑

Fig 4. WarriorTides Order Form

Fig 5. Karaoke during MATEsgiving

While WarriorTides takes pride in our professionalism and technical excellence, we also prioritize **creating** an open company atmosphere and promote a **sense of community**. In order to boost team morale, we created a snack schedule where team members were assigned to bring food on certain days. This gave the team a chance to mingle as a community and build friendships during our four o'clock break time.

WarriorTides has additionally held multiple **team bonding events** that have not only created a fun way to interact with other employees but have also established the communicative atmosphere we strive for - such as "MATEsGiving" and a Creek Cleanup. We truly believe that a **good team dynamic** between all members helps us build a company that enables **learning** and **collaboration** in the process of developing a product.

Fig 6. Christmas Party

Fig 7. Team Bonding

ROV OVERVIEW

Vehicle Overview

Entering this year's competition season, our team first identified the critical issues with our previous ROV to brainstorm **potential improvements** to **optimize** Triggerfish's **performance** in completing mission tasks. Based on results from last year's international competition and reading the competition manual, the mechanical team decided to **redesign** the frame, enclosure, and claw, straying entirely away from past year's designs. A **new simplified PCB** design, as well as a redesigned tether, were tasked to the electrical team. Our software team chose to focus on developing a **revamped control system** that handled multidirectional driving and power optimization, as well as **improvements** to the mission task workflow.

Taking a more conventional approach to the ROV's design, we utilized a rectangular **aluminum enclosure** and **laser-cut Delrin** plates to function as a central hub for the electronics and be **focal mounting points** for different manipulators, respectively. The claw was also redesigned to use aluminum extrusions as rails to allow for **linear motion** to open and close the pincer, avoiding issues with gears slipping in previous designs. These new changes stemmed from the concerns of overcomplicating the design from last year's ROV, which led to time-costly maintenance repairs when one system failed. The decisions made by all team members' inputs and opinions benefited the design process and produced a **far simpler ROV** design that **effectively optimizes** the essential components, allowing Triggerfish to move swiftly underwater when completing mission tasks.

This year's **topside control station** is built to store **two 22" monitors** in a Pelican case, where the control computer is housed alongside the power supply for the ROV.

Triggerfish's onboard electronic system consists of a **two-layer power PCB**, allowing for reliable power distribution and simplicity. Triggerfish also utilizes a USB extender to **enable communication** to the topside station via Ethernet and USB cameras, allowing for **adjustable video streams that can prioritize quality or framerate.**.

Triggerfish's control code consists of **Python** and **Arduino** to transfer data between the ROV and topside station.

Fig 8. TriggerFish

Fig 9. Brainstorming thruster configuration

BRAINSTORMING

Our brainstorming process consisted of evaluating the strengths and weaknesses of last year's ROV design to **develop** new ideas as **solutions** to previous issues. Some ideas were also generated based on existing designs observed in other ROVs during the last year's international competition. As our team began discussion, we **combined aspects of multiple ideas** while setting up an effective decision matrix to determine which ideas would be prototyped.

Design Philosophy

One accomplishment of our team this year that we would like to highlight is the **success** of our **new design philosophy**. Over the last few seasons, we noticed that our team prioritized coming up with creative ideas which resulted in convoluted designs rather than streamlined ones. This cost us time in maintenance repairs when one system failed. After realizing this fault, we implemented tenets as foundational principles in our design philosophy to emphasize creating a high-performance ROV.

Our team's tenet is **"Unity and Performance."** It speaks to our ultimate goal of being a competent, specialized group of individuals who can demonstrate competitive excellence and create powerful technical legacy and training systems.

- **"Keep it Simple"** is the backbone of the electrical team. The tenet emphasizes the need to ensure the systems designed are only complex enough to complete everything it needs, avoiding the problem of introducing additional points of failure from an overcomplicated design.
- The mechanical team developed the principle, "**When Times Get Rough, Duct Tape and Zip-Ties,"** which focuses on our goal of simplifying solutions instead of overcomplicating them without logical reason, hence the reason for prototyping.
- Finally, our software team introduced **"Divide and Conquer,"** pointing to the fact that the coding division is highly efficient when it comes to actual development, though it is still essential to collaborate on big-picture architecture when envisioning a complete system.

The decisions made by all team members' inputs and opinions benefited the design process and produced a far simpler ROV design that effectively optimizes the essential components, allowing Triggerfish to move swiftly underwater when completing mission tasks.

VEHICLE DESIGN

FRAME

The frame is constructed out of **Delrin**, featuring notable qualities of **high rigidity** and easy **machinability** for its relatively **lightweight**. Sheets of Delrin were laser cut into plates with added weight reduction holes and mounting holes for additional flexibility when it comes to the attaching manipulators, such as the rotating claw and external cameras. **316** stainless steel L-brackets, nuts, and bolts connect the different frame pieces and **prevent corrosion**.

Triggerfish's composition of high-density materials such as Delrin and aluminum have caused it to be negatively buoyant. We calculated how much buoyancy foam we would need to counteract the weight of the ROV in water and make Triggerfish **neutrally buoyant** and designed various attachments for foam to the frame.

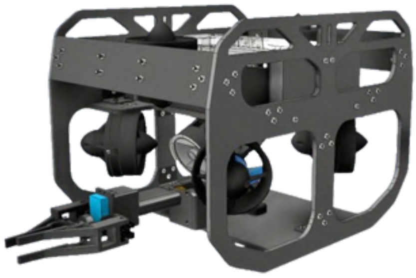


Fig 10. CAD of ROV frame

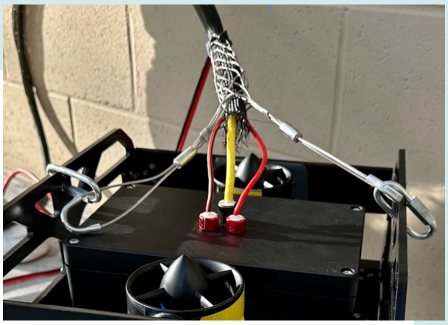


Fig 11. Strain Relief

The frame is also **symmetrical**, keeping the center of gravity below the center of buoyancy–approximately in the center of the vehicle. The Delrin frame is coupled with a CNC-milled aluminum enclosure that **houses all electrical components**. Additionally, there is a **strain relief** mechanism utilizing aluminum mesh to **alleviate tension** within the tether.

Last year, we had eight thrusters vectored aiming toward the corners of the ROV. This orientation was not only crowded but also displayed just three kilograms of force in all directions. This season, we opted to use **six thrusters**. Four thrusters are in a vectored orientation to **surge forward, backward, and yaw**. During surge, the vectored thrusters generate roughly 3.252 Kg F (kilograms force) combined; in yaw, they generate approximately 4.6 Kg F. The last two are oriented vertically in the front and back to **heave up, down, and pitch**. Pitch and heave generate 2.3 Kg F of thrust. This system allows two thrusters to act in any of the **six degrees of freedom**, guaranteeing speed and precision in all propulsion.

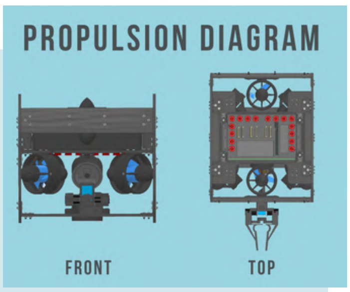


Fig 12. Propulsion Diagram

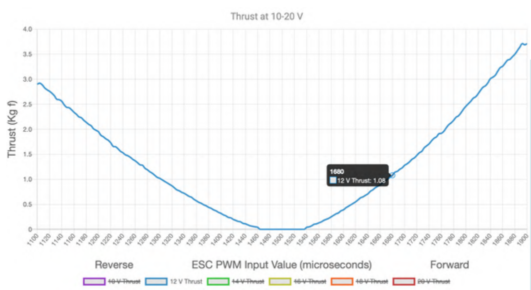


Fig 13. Thruster current performance

CONTROL SYSTEM

ONBOARD ELECTRONICS

Our **two-layered power PCB**, mounted on the side of our electronics enclosure, serves as the backbone of our ROV's electronics system, providing a **reliable power distribution** source.
Designed with simplicity, our power PCB features two Anderson connections for power input from the tether and power output. Our ESC board module, which consists of two screw terminal blocks, delivers the necessary amperage to power our six onboard ESCs, ensuring our thrusters are able to operate properly.

The 12-5V Blue Robotics Converters and other 12-5V converter modules provide us with the flexibility to operate at two voltage levels, 5V and 12V, making our electronics system even more **versatile**. Moreover, our PCB features multiple **breakout headers** consisting of 12V, 5V, and GND to supply power to our offboard electronics, such as servos, and troubleshoot any issues.

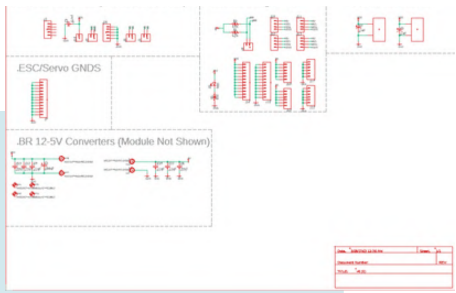


Fig 14. PCB Schematic

Our electronics enclosure is also home to various other electrical circuits, including the Arduino and the receiver side of the USB extender, which **enables communication** between the topside and ROV over Ethernet and USB. As the microcontroller on our ROV, the Arduino sends PWM signals to the ESCs and the servos.

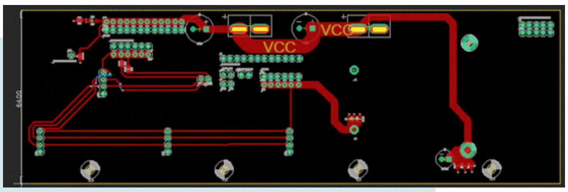


Fig 15. PCB layout

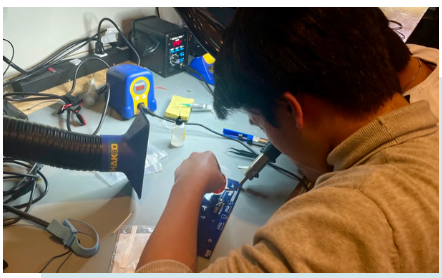


Fig 16. Electrical Lead Nathan working

Our PCB was designed using **Autodesk EAGLE**. We began the design process by creating a **SID** of the overall architecture. We then created **schematics** for both boards. We reviewed the schematics with our mentor before designing the PCB. After the design was finished, we **solicited feedback** on the PCB from a WarriorTides Alumni, currently a student at Georgia Tech. After making revisions based on our design reviews, the PCBs were ordered and **assembled in-house**, saving money and allowing members to gain valuable experience working with surface-mounted components.

In addition, our modular enclosure design improves the **serviceability** of the ROV. Triggerfish's onboard electronics can be accessed by simply removing the enclosure lid.

SENSORS

Triggerfish does not feature any sensors besides its four cameras because we have concluded that we can complete all mission tasks with solely visual data. Additionally, many of the sensors commonly deployed in other ROVs are either too expensive and impractical (sonars) or **not applicable** in the context of mission tasks (temperature/depth). While we considered using an inertial measurement unit for PID control, we decided that Triggerfish's driving was stable enough and sensor drift could act as a **potential** impediment or **point of failure**.

TETHER

COMPOSITION: This year's tether consists of a pair of silicon-insulated **power wires** and a **BlueRobotics Fathom Tether** used to relay Ethernet, all ensconced in a mesh sheath to prevent tangles and laceration that could potentially introduce shorts and damage our cable.

SUBCONN:
This year, we attempted to introduce **SubConn underwater cable connectors** between our tether and ROV. This would massively minimize the hassle of transportation, testing, and maintenance, as our ROV would no longer be perpetually linked to our topside station.
We purchased a pair of 16-pin connectors for ethernet and power, with a male bulkhead and female overmould connector. After repeated testing, we designed a custom mold for the overmould connector and cast it with the tether in a resin print filled with urethane rubber.
While the Subconns were waterproofed and conducted signal properly, we had several issues with them:

1. **Remating**
   a. The Subconns require large amounts of force and grease to mate and remate, making the process tedious, uncertain, and expensive.
2. **Curing**
   a. We had concerns about the mechanical integrity of the mold and potential deterioration over time as the top portion of the urethane rubber never fully cured.
3. **Bulk**
   a. We decided to combine our power and Ethernet cables in the same connector to reduce points of failure. This led to us selecting a large connector and designing a bulky mold. We questioned how well this would perform underwater.

Fig 17. David working with SubConn

Fig 18. SubConn Mold CAD

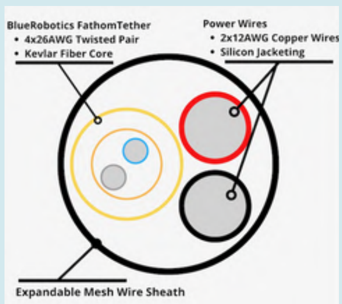


Fig 19. Tether Cross Section

Management Control: Regarding tether management, WarriorTides's policy is for one employee to stand by the poolside, taking in or letting out the tether. In addition, the driver can communicate with the poolside employee by vocal commands. We used a set of velcro straps to tie up our tether into a manageable bundle for transport.

SOFTWARE CONTROL CODE

Our control system code comprises of **Arduino control software** that runs locally on the ROV. The Arduino microcontroller communicates directly with the topside computer via Serial communication, generating PWM signals for thruster control and servo actuation. We chose to use an Arduino because it is more electronically robust and for its reliable PWM output, compared to a Raspberry Pi. As part of our control code, we developed a **power optimization code** to ensure we use the maximum amount of thrust per thruster while keeping our amperage limit in mind. This code dynamically adjusts the thruster values based on the driver inputs from the Xbox controller, using data analysis to achieve the desired movement while minimizing consumption.

To enable **multidirectional driving**, we designed a **control algorithm** that puts the thruster values in a 3x2 matrix and sends it to the Arduino for processing. This allows us to control the ROV's movement and orientation more intuitively and precisely by combining the linear directions of the X, Y, and Z axes with the angular direction of the X-axis, a **cutting-edge application** of computer science in the field of underwater robotics.

Fig 20. Software Team working

On the topside, a Python-based **communications script** handles **bidirectional communication** between the ROV and the pilot on the topside station, compiling and transmitting video to our GUI and sending joystick inputs to the Arduino for controlling the ROV.

TOPSIDE CONTROL UNIT

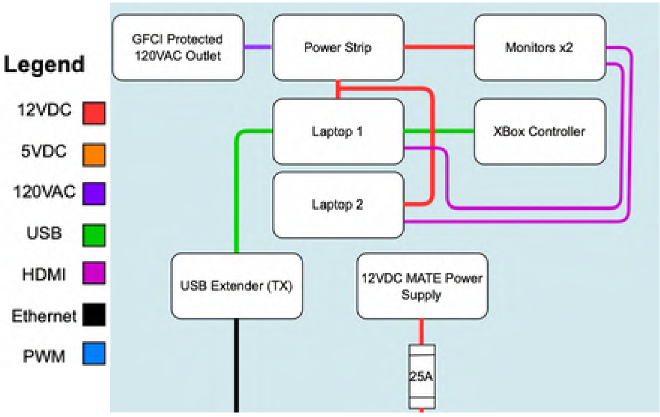


Fig 21. Topside SID

Our **topside electronics** include a **USB extender**, a windows **laptop**, an Xbox **controller**, and two 22" **LCD monitors**. The extender sends Xbox controller movement inputs from the computer to the ROV. It receives video feed and data from the ROV's cameras and manipulators, which it passes back to the laptop. The laptop then displays the central GUI between the two monitors, with the left monitor displaying the video feed gathered from all 4 cameras, while the right monitor provides an interface to complete mission tasks.

Our **topside station** is housed within a **Pelican Storm iM3220 case** with interior dimensions 44" x 14" x 8.5". It features **press and pull latches** and **in-line wheels** for easy and safe transport. We installed **brass hinges** to help support and stabilize the lid of the case when open.

CAMERA SYSTEM

CAMERA PLACEMENT

We have four cameras placed in various places on the ROV. One is placed on the **bottom plate** angled to face the claw, giving the driver a better view when attempting to complete the many mission tasks. We have a **surface** camera per the driver's request; this provides the driver with a better frame of reference when surfacing. We have a camera facing the **floor** to monitor endangered Lake Titicaca giant frogs and use eDNA to identify coral reef species. Finally, we have a camera facing **backward** on the ROV that gives the driver a better view of their surroundings.

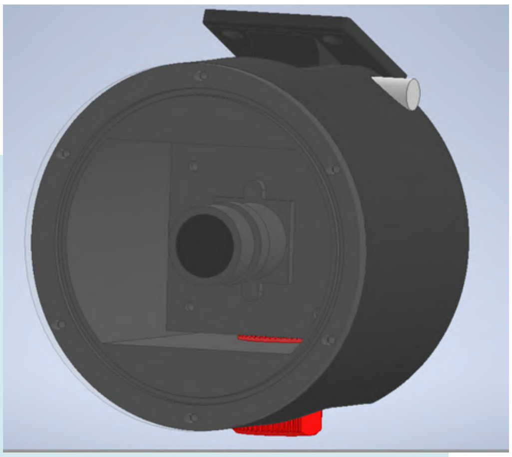


Fig 22. Camera Enclosure CAD

CAMERA ENCLOSURE

Triggerfish utilizes one camera enclosure design to house all four external cameras, with slight modifications to each based on the desired mounting location. A **3D-printed resin enclosure** houses the camera, which sits on four standoffs raised to accommodate for penetrator space underneath and provide a more **optimal viewing angle**. The resin enclosure has a built-in o-ring groove, which conveniently removes the need to source a flange from another vendor. The transparent faceplate on each enclosure is laser cut from acrylic and mechanically fastened to the frame.

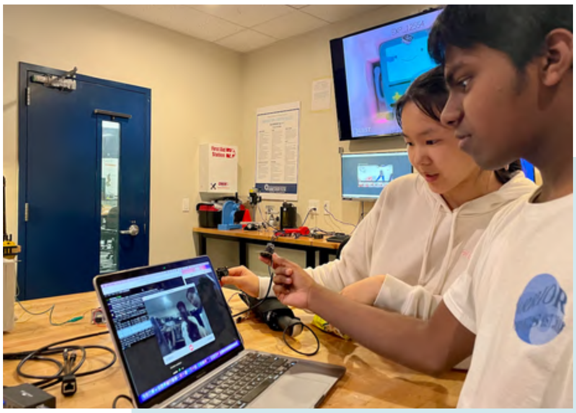


Fig 23. Testing camera feed

ELECTRICAL AND SOFTWARE

The **camera system** took a step towards simplicity this year, comprising of digital cameras built using USB-based encoders and CMOS sensors. These cameras are capable of transmitting **high-quality video footage** and have a **versatile encoding system** compatible with USB connections. This allows them to be easily integrated and installed into our ROV system. The CMOS sensors consume very little power while still giving optimal footage, making them ideal for our camera system.

MISSION TOOLS

CLAW

The claw for Triggerfish was created with **two goals for improvement** from last year.

1.The first was **removing the usage of gears.** Over the past few seasons, we attempted to use gears in the water, but they always backfired - slipping or rusting. To proactively avoid this issue, we removed gears and moved the fingers by pushing them outwards via two poles connected to a Servo motor.

2.The second goal has to do with **strengthening the grip**. Because this year's tasks require a wider variety of objects to grab, we created a 3-prong design that closes when the object within the claw is secure, along with a ½ inch PVC slot at the bottom for clearance.

This new claw was specifically built for WarriorTides to complete certain missions. It allows Triggerfish to **irradiate diseased coral** by positioning UV light sources. The unique shape of the claw grants a **greater carrying capacity** for flashlights with wide diameters. This is especially important when Triggerfish must conduct tasks like placing tents over diseased regions of coral using strings. In previous years we have had trouble dealing with lines as they tended to slip out of our manipulators. This year, however, our claw pinches at the top, leaving **no openings** for string or other objects to slip out.

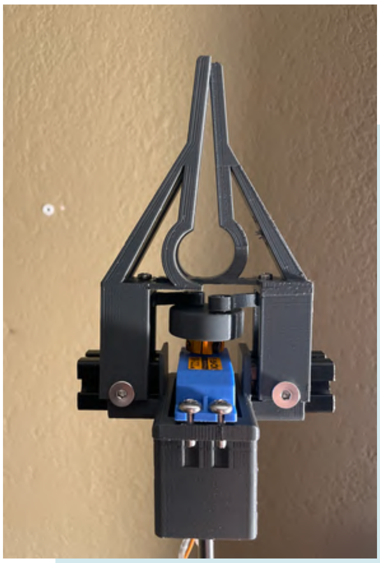


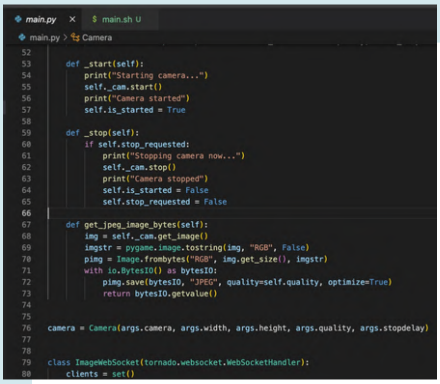
Fig 24. Assembled claw

AI TASKS

After taking multiple photos of an object or scene from different angles, our software uses sophisticated **computer vision algorithms** to stitch the images together and create an accurate 3D representation of the subject. External software can offer a range of features, including **automatic point cloud** generation, **mesh** generation, and **texture mapping**, making it possible to create highly **detailed and accurate 3D models.**

COPILOT GUI

Our co-pilot **graphical user interface (GUI)** is a React-based web application that utilizes web sockets and a Python backend server to handle requests. The co-pilot will be able to **view** the **camera feed** and **thruster data**, **adjust joystick sensitivity** (ex: high sensitivity means more abrupt and coarse movements), **run software-based mission tasks** (like autonomous or image processing tasks), and more. We created a sleek and elegant UI interface for the co-pilot to quickly assist the driver in completing mission tasks. We used ReactJS because our old solution, PyGame, was slow, inefficient, and restricting.



```
main.py × $ main.sh U
main.py > Camera

    def _start(self):
        print("Starting camera...")
        self._cam.start()
        print("Camera started")
        self.is_started = True

    def _stop(self):
        if self.stop_requested:
            print("Stopping camera now...")
            self._cam.stop()
            print("Camera stopped")
            self.is_started = False
            self.stop_requested = False

    def get_jpeg_image_bytes(self):
        img = self._cam.get_image()
        imgstr = pygame.image.tostring(img, "RGB", False)
        pimg = Image.frombytes("RGB", img.get_size(), imgstr)
        with io.BytesIO() as bytesIO:
            pimg.save(bytesIO, "JPEG", quality=self.quality, optimize=True)
            return bytesIO.getvalue()


camera = Camera(args.camera, args.width, args.height, args.quality, args.stopdelay)


class ImageWebSocket(tornado.websocket.WebSocketHandler):
    clients = set()
```

Fig 25. Excerpt of code to get camera feed

GATLING FLOAT

The float comprises of a **200ml syringe** that takes in and expels water to allow it to move up and down throughout the water. It is housed in a **3-inch acrylic tube** with two end caps on either side to keep the electronics dry from the water. Using 3-D printed pieces and a threaded rod, we can move the plunger up and down to allow the float to bring in and out the water, changing the float's density.

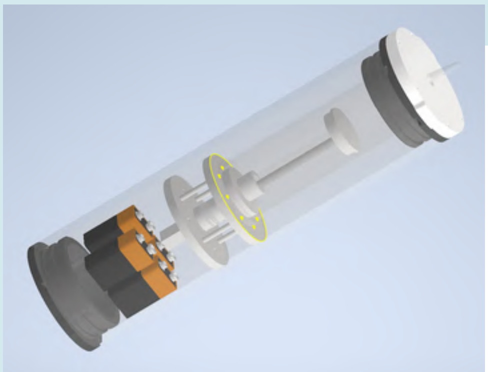


Fig 26. Gatling Float in Autodesk Inventor

9V batteries power our float converted to **5V** using 9-5V converters. The system's brain is the **ESP8266 microcontroller,** which precisely controls an **H-bridge module**. This module allows our inductive motor to operate bi-directionally while maintaining high levels of power efficiency.

We chose the **ESP8266 microcontroller** for its **WiFi connectivity** capabilities, allowing us to obtain accurate time from an NTP server. We set up the ESP8266 as a web server, which enables us to **broadcast the current time** and other important information to the server in real-time. Our clients, such as our phones or other devices, can access this webserver to view the time and other relevant data.

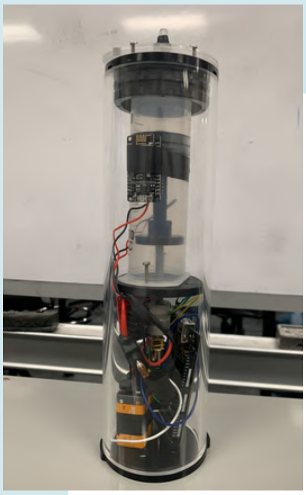
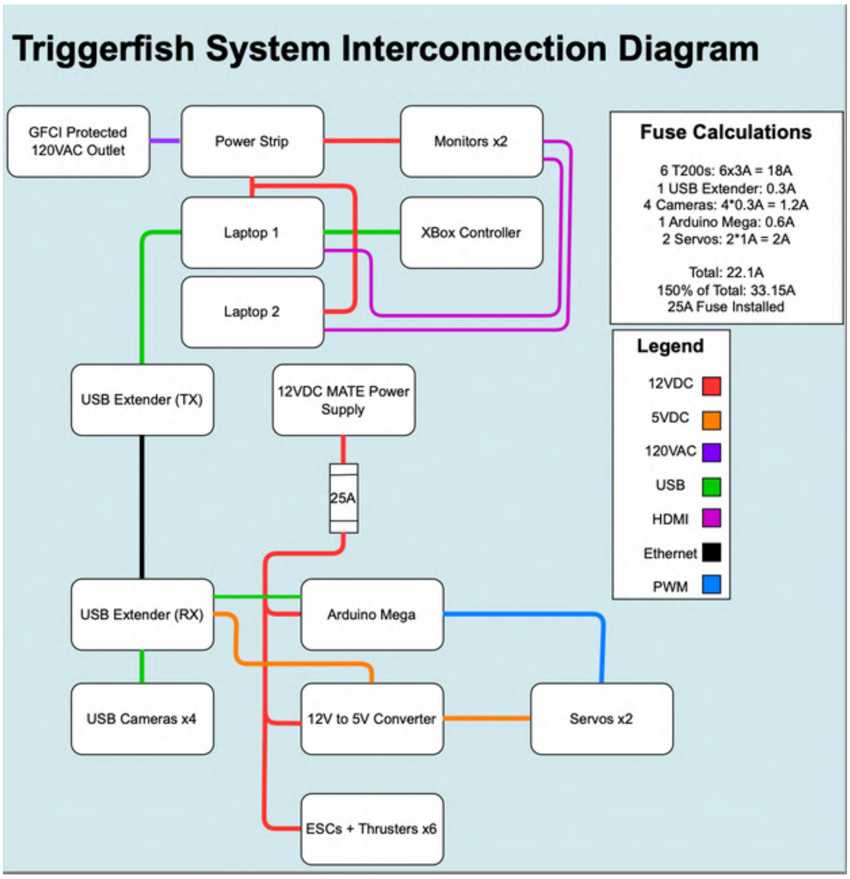
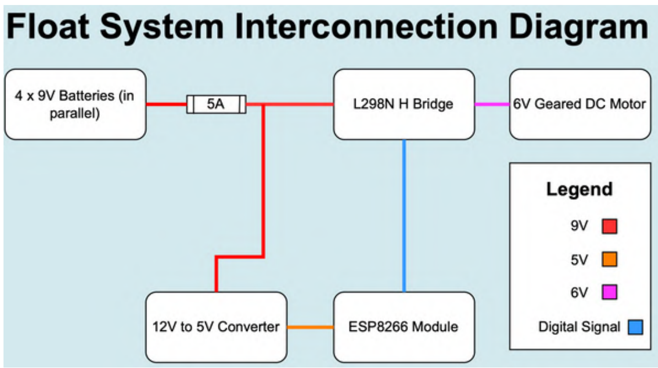


Fig 27. Gatling Float

SID





PROCESS AND ANALYSIS

BUILD VS. BUY

WarriorTides believes building is the **best way** to learn engineering skills and customize systems for mission tasks. However, we understand that sometimes items may not be possible to build because they are costly, dangerous, or impractical to fabricate in-house, so we turn to buy.

Mechanical: We **purchased** the fasteners, sheet material for our frame, and enclosure due to the need for precise machining on these parts. We milled penetrator holes into the lid and bottom of the enclosure and laser-cut our frame. However, we **designed** our claw by 3D printing the majority of its pieces. All camera enclosures were printed in resin with transparent face plates cut from acrylic.

Electrical: We **purchased** components such as ESCs, USB Extenders, and our Arduino Microcontroller because, though some of these component's schematics and layouts are open source, fabrication would be too expensive and time-consuming. We did **design** a custom PCB to interconnect these electronics and made modifications to components like the ESCs to interface them with the rest of the ROV.

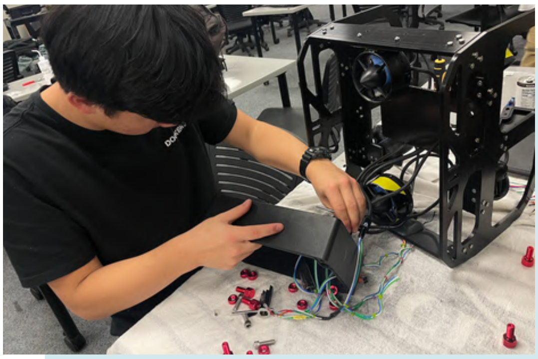


Fig 28. Working on enclosure

NEW VS. USED

As a policy, WarriorTides seeks to **maximize the reuse of individual components** to save money and prevent unnecessary waste while innovating improved systems with every ROV.

Mechanical:

- We have reused our **BlueRobotics T200 Thrusters** for three years as they have shown no significant drop in thrust output.
- We have reused the **Pelican case**, **monitors**, and **acrylic** panels of our topside station due to the high expense of replacement and lack of performance benefit from redesigning.
- We reused our **penetrator blanks**, **o-rings**, and **tools** such as vacuum pumps unless they showed repeated internal leakage.

Electrical:

- **Software:** We have continued to reuse **Autodesk EAGLE** as our PCB design software because it is free via an educational license and offers useful features such as forward and backward annotation. While there are more powerful packages for PCB design like Altium, we do not need all of their capabilities nor have the budget to purchase a license.
- **EScs, SMDs, etc:** This year, we purchased **new ESCs** and aggregated old ESCs within our inventory. This is because the ESCs from previous years are attached to previous PCBs and are therefore unusable. We carefully document the **SMD components** we already have in our inventory from previous years. Thus, we can reuse common components such as 4.7KΩ 0603 resistors and 10K μF 0603 capacitors. Components such as loose wires, crimps, connectors, and heat shrink are reused whenever possible. Stock for commonly used components is also carefully documented so re-ordering before runout can prevent any break in progress.
- **Tools:** We reuse all of our tools, from hand crimpers to soldering irons.

PROTOYPING

The process of prototyping follows a traditional structure that ensures we achieve our team's goals for the ROV. The **first step** to this year's prototyping system is to **define the goals** of the project and how the prototype may be integrated with the ROV. This includes utilizing a decision matrix to evaluate different ideas to determine which best suits the team's goals for the ROV.

The **next step** typically involves creating a detailed **2D or 3D ROV design** that considers the specifications and goals defined in the first step. Various design software was used for each subteam, such as Autodesk Inventor and EAGLE. Once the initial design is complete, the prototype needs to be built–either using recycled parts/3D printing or purchasing cheaper materials to avoid overspending on a component that is not final.

The most important part of the prototyping process is **testing and troubleshooting** the design, typically done in a controlled environment with safety protocols. At this point in the design process, further adjustments can be made to the prototype based on the results–this is repeated until a **final design** is created. Additionally, each subteam has team-leads and qualified mentors to review and offer guidance at each step of the design process, which we have strongly implemented this year.

TESTING PROCEDURE

During the development of Triggerfish, we conducted **numerous tests** on each component. Before each **pool test**, we performed a **thruster test** and checked the electronics enclosure for leaks by **vacuum pumping** it. We also tested individual electrical components like the cameras and ESCs before conducting an overall board test. Although this testing process was time-consuming and occasionally cumbersome, we believed it was necessary given the potential consequences of a failure.

Fig 29. Vacuum testing camera enclosure

TROUBLESHOOTING

Our approach to troubleshooting involved **maintaining a calm demeano**r and logically **simplifying the situation** to identify the problem. When issues arose regarding an electrical component, the electrical sub-team would turn off the power and disconnect unnecessary components before using multimeters to locate the issue. The software team typically isolated specific pieces of code and focused on fixing them, before moving onto the next error. When the mechanical team encountered problems with initial prototypes, like the first claw design, the design was analyzed for failures before creating an improved version.

Fig 30. WarriorTides members pool testing

Fig 31. Testing waterproofing

SAFETY

SAFETY PHILOSOPHY

At WarriorTides, we prioritize the safety of our employees through every aspect of production. Maintaining safety guidelines ensures risk prevention, paramount to guaranteeing employee safety by averting potential electrical or mechanical dangers. The ROV was designed to fulfill safety requirements to minimize injury risks during operation, emphasizing our philosophy.

Operational Safety Protocols
Masks will be worn and CDC guidelines will be followed at all times during meetings
Safety glasses are worn when soldering, using drills/dremels/bandsaw, and when thrusters are on
Fume extractor used when soldering
Team members wears closed-toed shoes while working on deck
No running on the deck
No team members in the pool with the ROV
No food/drink near the equipment/ROV
Machinery will only be operated by those with the certification to do so
All shared materials will be wiped down and sanitized in between use

Construction and Operation Checklist
ROV has no exposed/unsealed wiring
ROV has no sharp edges/any sharp edges are marked
Tether has proper strain relief on both sides (ROV-side and topside)
25 amp inline fuse on positive line
All ROV components fastened to frame
All topside station components/wiring fastened to box

SAFETY FEATURES:

- **Eye-catching hazard labels:** Possibly harmful aspects of the ROV, such as hazardous components or moving parts, are distinctly labeled with caution tape.
- **Rounded Edges:** The ROV frame is designed to have smooth edges to prevent against injury. All 3D parts are sanded down before being added to the ROV.
- **Thruster shrouds:** The T200 motors are fitted with 3D printed shrouds that meet IP-20 standards.
- **Fuses:** There is 1 25 Amp fuse installed on the ROV to protect it from short circuits.

Fig 32. Mentor supervising member on bandsaw

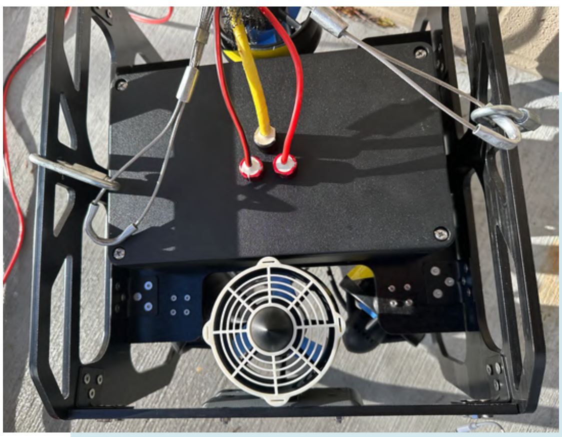


Fig 33. Thruster shroud

CORPORATE RESPONSIBILITY

At WarriorTides, we **highly emphasize** practicing **corporate responsibility**. Though intellectual growth is essential to us, it is just as crucial that we use our abilities to impact our community and environment positively.

Fig.34 Answering questions

COMMUNITY:

WarriorTides has **taught classes on underwater robotics** to middle school science classes at Valley Christian Junior High School. We covered the basic functionalities of ROVs, how they are fabricated, and their practical applications in various domains, from archaeological endeavors to habitat restorations. We also bring our ROVs to provide a firsthand glimpse of their appearance.

Fig.35 Drive Day

To foster an engineering and leadership excellence environment at Valley Christian High School, we **founded WarriorWaves**, a Navigator class company. WarriorTides employees often take on mentorship roles by offering training and advice to WarriorWaves whenever necessary. Under our guidance, WarriorWaves has grown to be a greatly successful company employing many talented engineers.

WarriorTides also **hosts annual Drive Days**, inviting all interested members of our local community to learn about our ROVs and receive the chance to drive them. We aim to educate and inspire students to pursue engineering through these opportunities.

ENVIORNMENT

Fig.36 Creek Cleanup

We **started an initiative to participate in cleanups** to gain a more profound understanding of the pollution plaguing our waterways. Years prior, WarriorTides partnered with Save Our Shores, a marine conservation nonprofit, to collect waste at beaches in the Bay Area region. Recently, we traveled to a local creek affected by flooding to dispose of harmful substances and litter. This tradition has led us to recognize the significance of human actions on the environment and marine ecosystems.

BUDGET

This season, to avoid unnecessary spending, WarriorTides implemented a **justification requirement**. When a team member put in a purchase request over **30 dollars**, they wrote a short memo it answering questions like "**Why is the part necessary?**", "**Why are we building over buying?**" and **"What research shows we chose this part over cheaper alternatives?**". The company member also wrote about how they believe the ordered part fits in with the ROV's overall **goal** and the subteams **tenet**.

Because these memos encouraged each team member to think **deeper** about the part they chose to order, they facilitated **budget management** and reduced our **wasteful spending culture**. Reading through memos also enabled us to **self-reflect** on our **values** and **mission** and plan to continue this beneficial practice in the future

School Name:		Valley Christian High School	From:	8/14/2022
Instructor:		George Sousa	To:	4/2/2023
Income				
Income at start of project (if any)				
Source				**Amount**
Valley Christian High School				$ 6,000.00
Expenses				
Category	**Type***	**Description/Examples**	**Cost**	**Budgeted Amount**
Hardware	Purchased	Fastening hardware, extrustion, enclosure hardware, acrylic tubes, tools	$ 617.00	$ 700.00
	Purchased	Subconn Connectors	$ 527.00	$ 650.00
	Re-Used	T200 Thrusters	$ 1,200.00	--
	Donated	3D Printing Filament	$ 800.00	--
Electronics	Purchased	ROV sensors (Cameras, depth sensor, etc)	$ 200.00	$ 350.00
	Re-used	Topside materials (Pelican Case, Monitors)	$ 480.00	$ 480.00
	Purchased	PCB manufacturing, ESCS, other electrical	$ 695.00	$ 750.00
Miscellaneous	Purchased	Stationary, Snacks, marketing materials, merchandise, etc	$ 620.00	$ 700.00
	Re-used	Tools (Ifixit kit, Drill, etc)	$ 500.00	--
	Purchased	Props	$ 250.00	
		** either purchased, donated, or reused.*	Total Income:	$ 6,000.00
			Total Expenses:	$ 5,889.00
			Total Expenses-Re-use/Donations:	$ 2,250.00
			Funds Used:	$ 3,639.00
			Funds Remaining:	$ 2,361.00

Fig. 37 Budget Breakdown

Fig. 38. Project Costing

School Name:		Valley Christian High School	From:	8/14/2022
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			Funds Used:	$ 3,639.00
			Funds Remaining:	$ 2,361.00

WarriorTides began with a budget of 6,000 dollars this year, provided by Valley Christian High School. This budget was split into categories of Hardware, Electrical, and Miscellaneous. The sheet below shows our projected cost and the actual cost we spent. The re-used items from last season were our topside materials, T200 thrusters, and tools previously purchased. Valley Christian High School provided 3D printers, filament materials, and transportation to the regional.

REFLECTIONS

CHALLENGES:

This year, we faced many bottlenecks in ROV development, especially with **parallelization**. For example, to develop and refine our control system, our software team had to wait until our drive electronics were ready. This process continued across sub-teams as the PCB, for example, would be dependent on the dimensions of the enclosure, which would be dependent on the frame design. While we planned for efficient parallelization of tasks in our Gantt Chart, things did not work out as expected. We plan on remediating this next year by doing **more pre-season work** and **developing prototyping and testing technology** for subsystems so they aren't dependent on others.

LESSONS LEARNED

This year we learned the importance of **workshopping.** Through a series of workshops held at the start of the year by our subteam leads on their specialties, we were able to educate and train our incoming members as well as members of the Navigator team. These workshops, including practical training, have **improved satisfaction** on subteams and **increased efficiency**.

Additionally, we sought to include everyone in the design process and ensure that everyone "saw" the same picture of the ROV that the CEO and President did. In previous years, we realized that subteams having different visions of the ROV but working together on a **shared vision** led to clearer communication and a better product.

CEO'S REFLECTION

This year has been a successful one for WarriorTides. Although our majority-senior team had to first overcome a veritable slough of college applications, we were able to develop our technical skills, bring the ROV design in a new direction, and prepare the next generation of engineers. Important pieces of technology have been tested and evaluated, and beneficial policies such as changes to our order form have been implemented. We've also continue to foster our sense of corporate responsibility. Working with all of our team members personally has shown me their intelligence and determination, and I look forward to seeing where our graduating members go and how our continuing members do next year!

-David Bai, 2022-2023 WarriorTides CEO

ACKNOWLEDGMENTS

Our team would like to thank our advisor **Mr. Reese** for his support and guidance this season along with **Johnny Lim** and **Mr. Ortiz** for being such amazing and gracious mentors. We are indebted to **Valley Christian High School** for providing WarriorTides with funding, a workspace, and the opportunity to expand our team. We are grateful for **Blue Robotics** for being the supplier of numerous ROV components. Thank you to the **MATE ROV** team for hosting the annual MATE ROV competition and challenging us to build an ROV capable of remediating global environmental concerns. Finally, we thank you to the **MATE Center** for working to improve marine technical education and providing us with the opportunity to learn and compete.

REFERENCES

T200 performance - https://bluerobotics.com/store/thrusters/t100-t200-thrusters/t200-thruster-r2-rp/
Trace width calculator: https://www.4pcb.com/trace-width-calculator.html
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2022 WarriorTides Technical Documentation: https://drive.google.com/drive/u/0/folders/1SwfLfzdstwhqbtkTzZAJeufBysTFXgnf