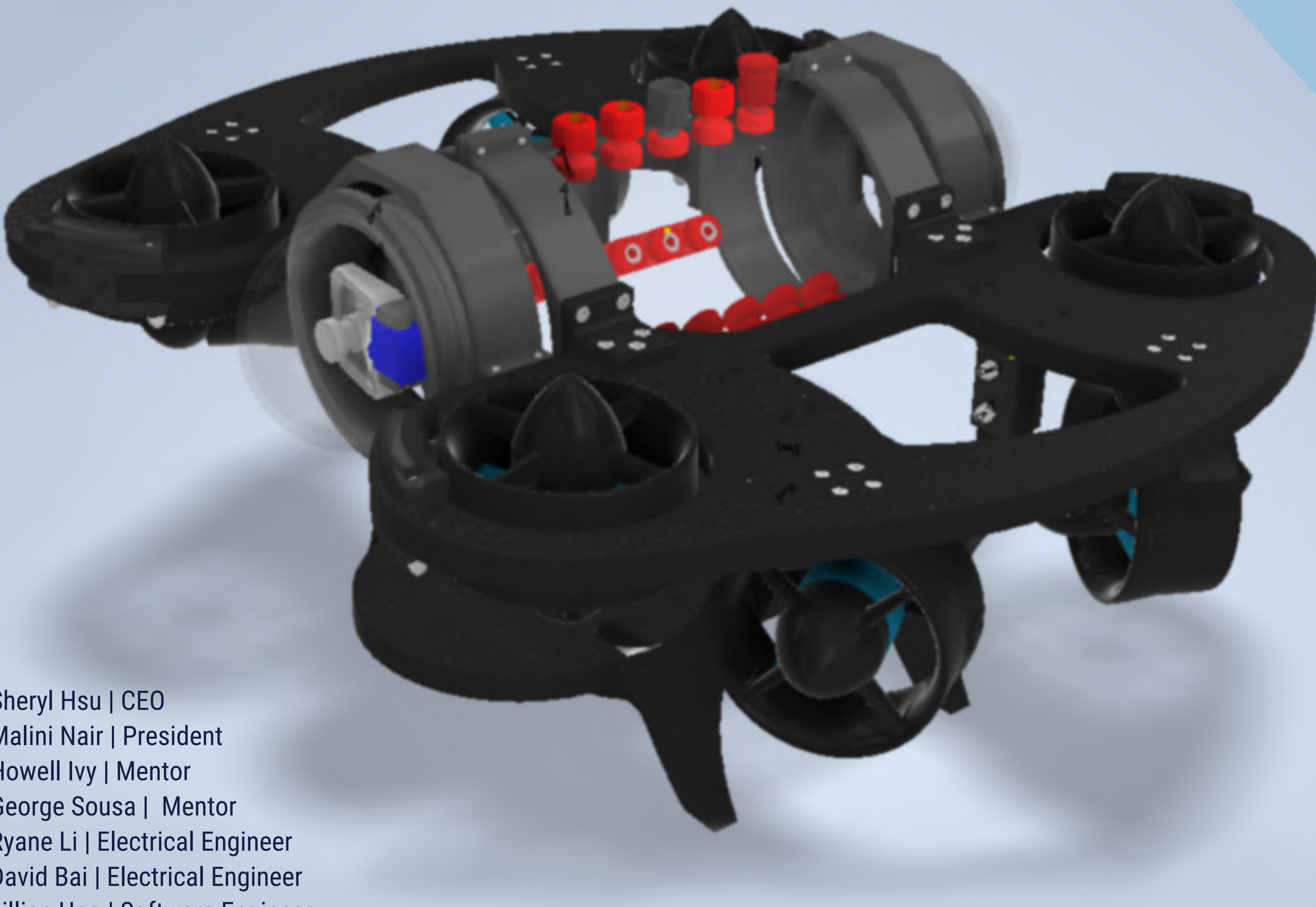
VALLEY CHRISTIAN
WARRIORTIDES
SAN JOSE, CA, USA

SOUSASUB

2021 MATE ROV RANGER CLASS TECHNICAL REPORT



Sheryl Hsu | CEO
Malini Nair | President
Howell Ivy | Mentor
George Sousa | Mentor
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WARRIORTIDES

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Figure 1: Teammates at 2019 WarriorTides beach clean up

Letter From the CEO

Being the WarriorTides CEO this year has been an insanely incredible experience. Our company consists of fifteen amazingly talented and hardworking high school students dedicated to improving their engineering skills and positively impacting their world. Throughout the year, we learned many technical skills, from project management to PCB design. Our team was also blessed with the opportunity to give back to our community by creating programming classes for underprivileged students on reservations and hosting beach cleanups at local polluted beaches.

From the COVID 19 to concealed leaks and communication issues, this year in the WarriorTides team has had many rough patches. However, with the effort every team member put into our company, we were able to thrive and grow as a family, creating a bigger and better ROV than ever before. Working on the SousaSub (named after our amazing mentor Mr. Sousa) was the highlight of my pandemic. This year with the WarriorTides team has taught me so much as an engineer and a leader, and I can't wait to learn more!

My experience in WarriorTides will always have a special place in my heart, and I hope that each and every member of my team enjoyed this year just as much as I did.

Sincerely,
Sheryl Hsu
Warrior Tides CEO

Abstract

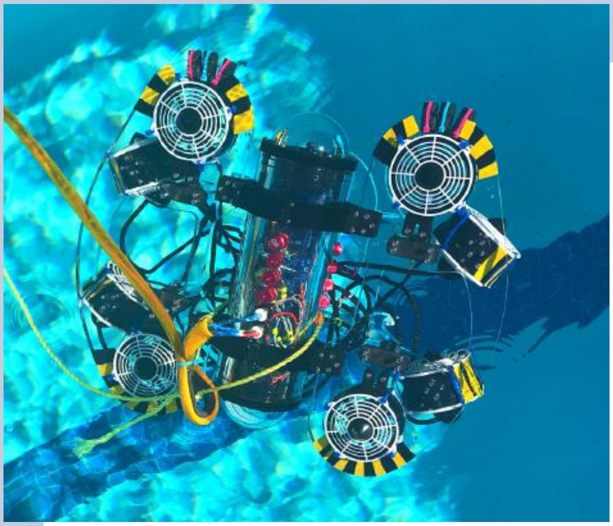


Figure 2: Photo of the SousaSub

VCS WarriorTides is a student-run and led underwater robotics company consisting of fifteen engineers from Valley Christian High School. WarriorTides prioritizes giving back to their community through engineering. This year the WarriorTides proudly presents its second ROV, the SousaSub (named after team mentor George Sousa), to deter the rise of plastic pollution in global waterways. The SousaSub features a sleek acrylic frame and an eight-thruster propulsion system, four low-light cameras, a claw manipulator, and a student-designed custom PCB.

The SousaSub was built entirely from scratch on campus and at home while following Santa Clara County social distancing procedures. The team utilized engineering experience from their previous year's ROV, the HubeTube, and knowledge from other STEM classes and programs at Valley Christian High School to make appropriate design choices to complete all mission tasks.

This year the WarriorTides team decided to trade the previous PVC frame for a more versatile and professional acrylic frame laser cut on campus and a student-designed PCB to get more customizability. The team upgraded its previous 3D printed stick for a rotating claw for higher mobility when completing tasks.

Thanks to the long hours and hard work put in by the WarriorTides team, the SousaSub is WarriorTides' most advanced and innovative ROV to date. The team is confident that the SousaSub is a valuable asset to keep the earth's waterways clean and healthy.


Figure 3: WarriorTides team

Engineering Design Rationale

Planning and Design Process

Overview: The SousaSub was designed with ease of piloting and functionality as our top priorities. For mechanical, this translated into an acrylic frame with good stability and six degrees of motion and a two-joint claw manipulator and net system. For electrical, we created an aesthetically pleasing and easy-to-use topside station as well as a custom PCB onboard our ROV. Our software team created drive software using an Xbox controller as well as a GUI and computer vision systems for the transect line and coral tasks.

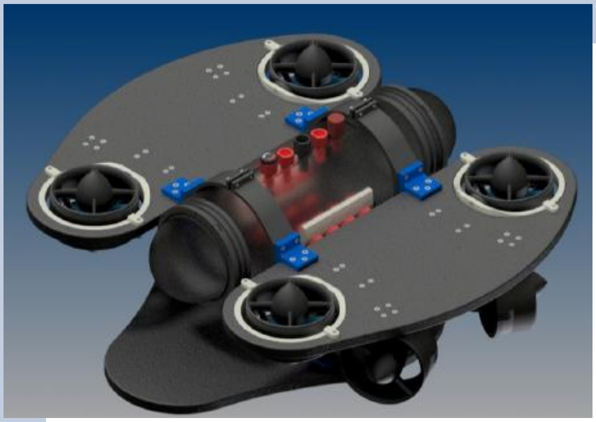


Figure 4: Original CAD of the SousaSub frame

Process: We began the year by analyzing our past robot and identifying aspects to keep and improve on. We spent the first few months working on core systems such as propulsion, frame, and a claw manipulator. When the competition was released, we had a meeting to discuss the mission tasks. This was a collaborative process, with everyone from veterans to rookies contributing and brainstorming on a whiteboard. We created a decision matrix to help us determine which tasks and manipulators to focus on. Our existing WarriorTides claw and drive system could already perform many tasks. We then began working on additional manipulators such as the net manipulator to perform the other tasks. The electrical and software teams continued to add features such as a fine and coarse driving mode, support for the manipulators, and computer vision systems.

Trade Offs: We had many check-ins about progress throughout the year and focused more on certain tasks. For example, we chose to stop working on the mini-ROV and instead focus on fine-tuning our other manipulators. We felt that it was unlikely that that it would be finished in time and that it would be more advantageous to improve our claw and net and spend more time doing drive practice. Another hard decision was whether or not to make a custom PCB, as it took much time to design, manufacture, and troubleshoot. However, we decided that the compactness, increased organization, and the experience we gained from making it made it worthwhile. We also had a difficult time deciding whether to switch to T200s as we had been using T100s that were purchased in previous years. Switching to T200s was expensive and time-consuming, but based on thorough research and published data on the T200s capabilities, we determined that they would allow us to move more efficiently while staying under our power budget.

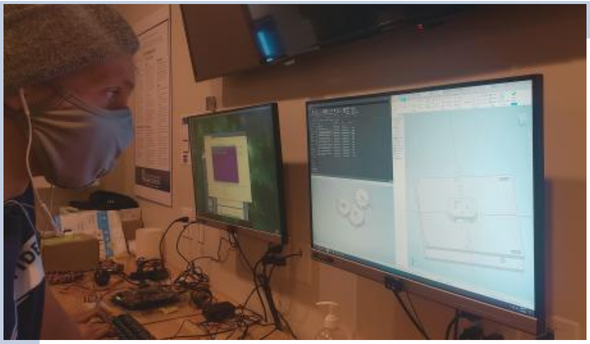


Figure 5: Team member CADs the ROV

Testing

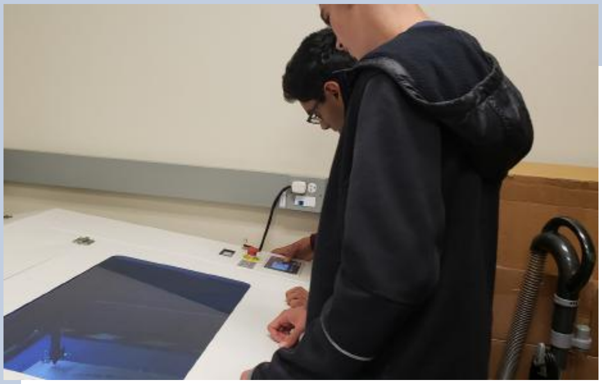


Figure 6: team members laser cutting a prototype of the ROV (photo taken in 2019)

We continuously tested our products as we built them. As we assembled our electrical board, we tested individual ESCs before soldering them onto our PCB. We also tested the conductivity of crimp connections and solder joints. On the mechanical side, we made sure everything was waterproof. We conducted vacuum tests as well.

We tested our final product in multiple ways. We first tested all of the thrusters and controls on land. Then we then conducted a pool test where we evaluated the maneuverability and stability of the ROV. We also built our own props to assess manipulators.

Based on what we saw, we constantly revised and modified designs. For example, we added additional pieces to prevent gears from slipping and better grippers to the claw after noticing that props tended to slide from them.

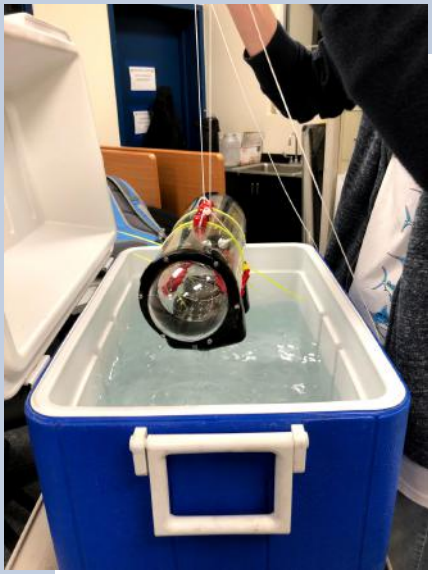


Figure 7: Submersion test

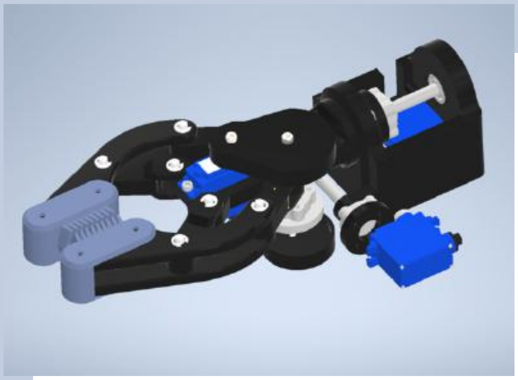


Figure 8: CAD of the new claw

Our troubleshooting process was thorough. Every time a part malfunctioned we would identify the issue, and potential relationships or parts that were causing the issue. We would then eliminate each of these potential factors/reasons, until the problem was solved or there was one left to solve.

Build vs. Buy

We have done our best to build as much of the ROV as possible, as building gives us more opportunities to learn and develop our skills. Simultaneously, we recognize that given our time and expertise constraints, we need to buy certain items. We purchased T200 thrusters, given the difficulty of reliably waterproofing thrusters. However, even with these purchased parts, much work was done in-house, such as the 3D-printed camera endcap mounts we designed, the work we did replacing SMD chips on broken Fathom boards, and our student-designed T200 mounts. In addition, we created our enclosure by machining penetrator holes into an acrylic tube. This gave us additional customizability and was more cost-effective. We even developed a custom PCB and chose to assemble it in-house using a reflow oven, allowing our team members to have the opportunity to work on surface-mounted parts.

NOTE: WarriorTides does NOT use fluid power

NOTE: WarriorTides is NOT attempting the mini ROV task

New vs. Used

Figure 9: Photo of the SousaSub

We chose to reuse endcap domes and Fathom boards, given the difficulty of making these components. We had spare endcap domes that were not used before, so we decided to save money by reusing them. Our PCB and entire electrical system were designed around the Fathom S boards, which were discontinued, so we had no choice but to reuse them. Thankfully, we had purchased many boards when they were end of life, so we had brand new ones to work with.

Mechanical Design

Frame

The ROV's frame features a wing design allowing for modularity and room to attach thrusters and manipulators. The frame is laser cut from acrylic (all edges are smoothed out) and utilizes 18-8 Stainless steel corrosion-resistant bolts and nuts to prevent rust. The frame is also symmetrical, which keeps the center of gravity and buoyancy in the center of the ROV. It features two rear standoffs to mount a net, as well as an acrylic bottom tray to mount the claw and other manipulators. Additionally, there are two domes on either side of the enclosure to hold cameras. One tradeoff we had to make was using acrylic instead of HDPE. Acrylic was heavier and more expensive but was more accessible and easier to machine.

Figure 10: CAD of the ROV frame

Buoyancy

Because we used acrylic, a heavy material, to build the frame, small blocks of industrial grade foam were required to ensure neutral buoyancy. The blocks of foam also ensure that the center of gravity is below the center of buoyancy, preventing our ROV from flipping during operation.

Propulsion

The SousaSub has eight T200 thrusters. We chose to use 8 thrusters in a vectored configuration to allow for all 6 degrees of freedom and increased stability. The horizontal thrusters are configured to achieve sway, surge, and yaw, while the vertical thrusters give us pitch and heave. The two significant trade-offs of using eight T200 thrusters are power consumption and cost. Running one of the thrusters at full current would result in a blown fuse, so we had to lower the current draw leading to less thrust from each T200. Additionally, each thruster is $179, resulting in a total cost of $1432, compared to the T100's, which we would have reused.

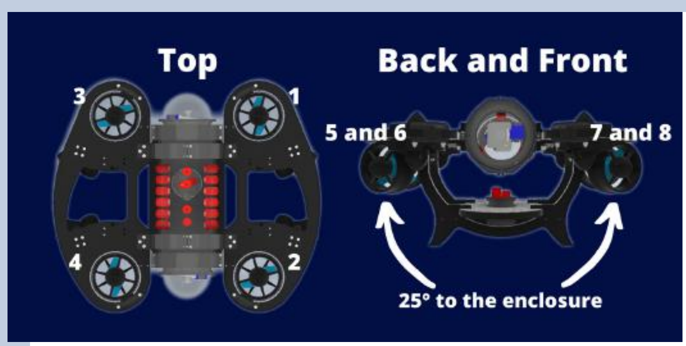


Figure 11: diagram of the propulsion system

Electrical Design

ROV Electronics

This year, our ROV electrical team implemented a custom built PCB designed through the Autodesk EAGLE application for our ROV electronics systems. Our custom board connects an Arduino Mega 2560 R3 to corresponding ESCs for the T100 thrusters. The board allows our topside laptop to interface with the Arduino computer through the ROV-side component of the Fathom-S Tether interface board. It includes the sensor connectors attached with Bar30 pressure/depth sensors. This sensor helps maintain depth by automatically adjusting thruster power through software in order to aid maneuverability. For power regulation, the board features a BR5V regulator, after which power is directed to the servos, ESC boards, and motor LEDs and the board handles their corresponding PWM signals. It also handles the video transmission through the Fathom-S interface through its camera connectors. The board serves as a hub through which every electrical component of the ROV is powered and programmed.

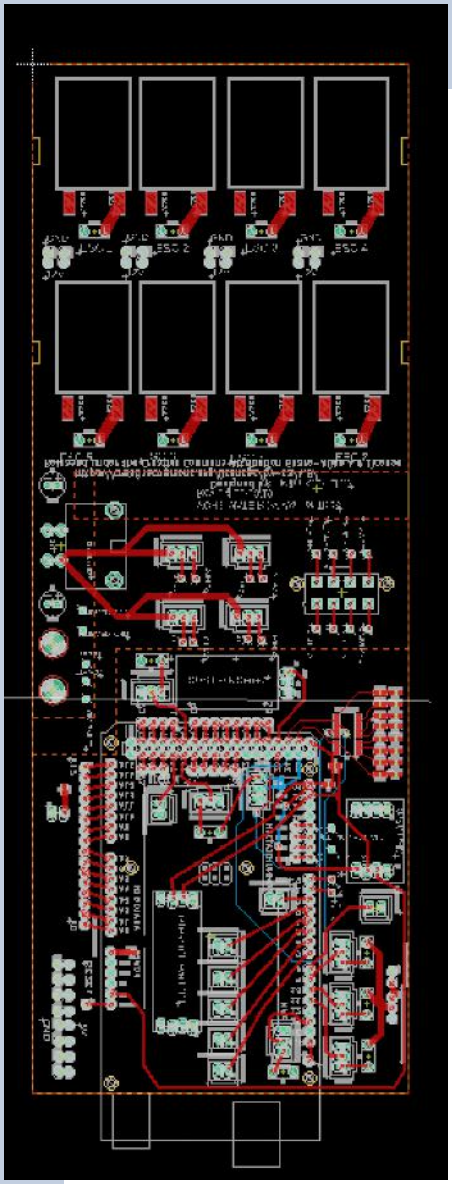


Figure 12: PCB Design in Eagle

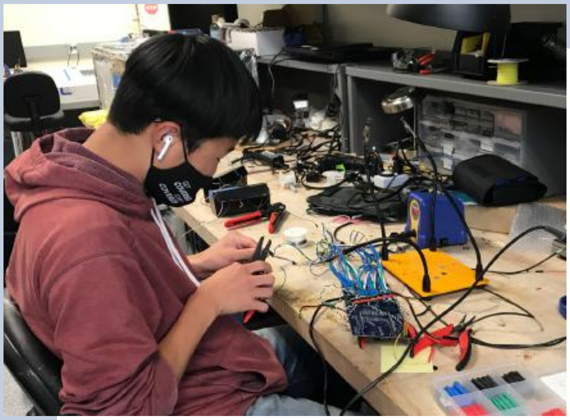


Figure 13: Team member works on PCB

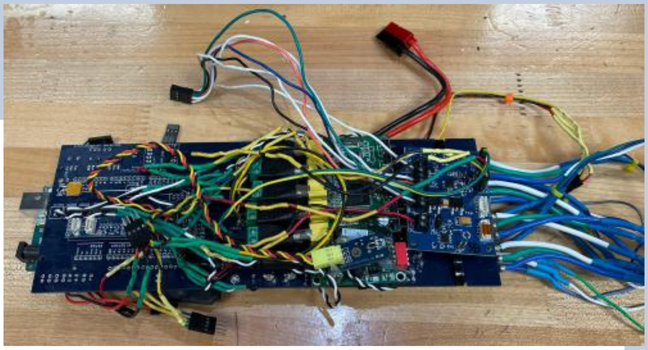


Figure 14: Photo of PCB

Electrical Cont.

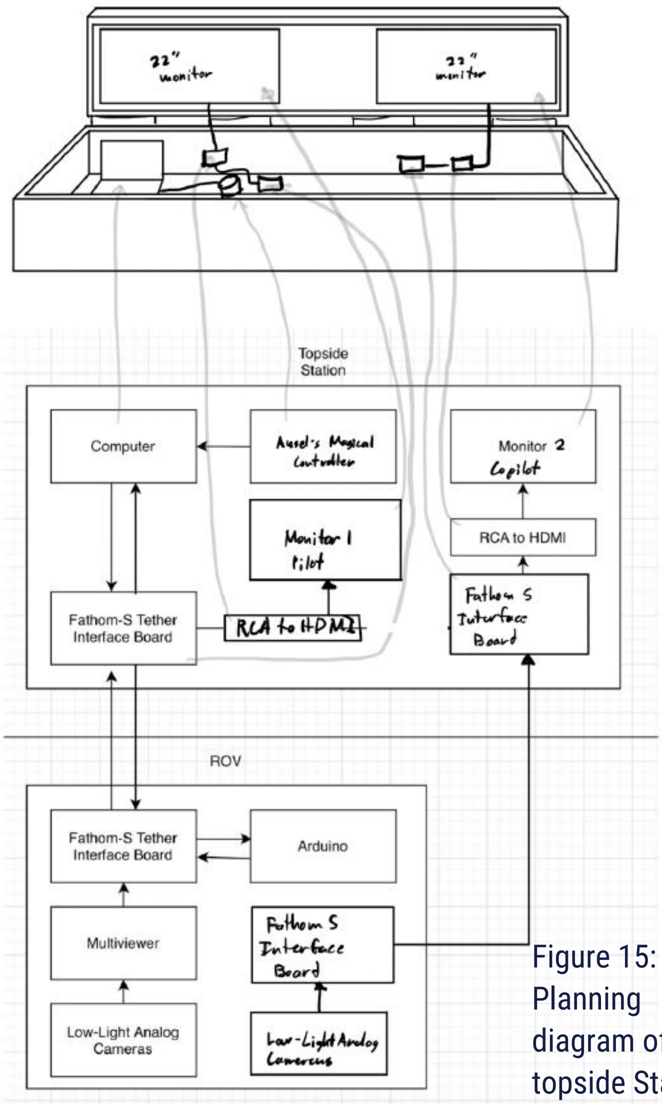


Figure 15: Planning diagram of the topside Station

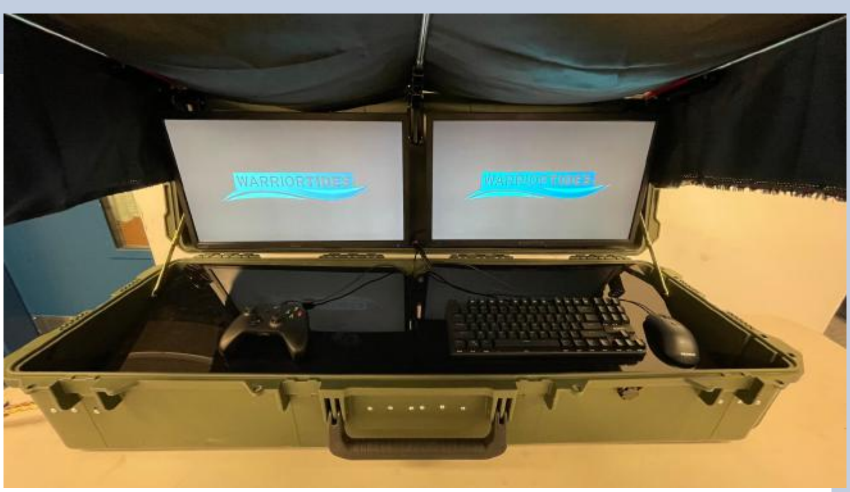


Figure 16: Photo of the topside station

Topside Station

Our topside electronics include a Fathom-S Tether Interface board, laptop, Xbox controller, RCA to HDMI converter and two 22" LED monitors. The Xbox controller directs the ROV's movements through the onboard laptop. The Fathom-S board sends input from the laptop to the ROV and receives video feed and data from the ROV's cameras and sensors. The RCA to HDMI converter converts the RCA signals from the Fathom-S into HDMI signals which allow the camera feed to be displayed onto the two 22" LED monitors. Each monitor can display up to 4 camera signals, allowing the people at the topside station to easily maneuver the ROV and perform identifying or analyzing tasks at the same time. 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 rugged in-line wheels for easy and safe transport. We also installed brass hinges to help support and stabilize the lid of the case when open. Two acrylic panels hide the cables underneath, and provide a flat surface for the keyboard, mouse, and Xbox controller. Folding shelf brackets and extending flagpoles and a piece of cloth form a sunshade in order to make the LCD screens more visible for the drivers in direct sunlight.

Electrical Cont.

Tether

Our tether consists of a pair of power wires (12V and ground) and the Blue Robotics ROV Tether which contains 4 twisted pairs (8 total wires), for a total of 10 wires. Three of these pairs utilize differential signaling. One pair of wires is for NTSC video communication. Two pairs of wires are for RS422 serial communication - one pair for Rx and Tx respectively. The final pair of wires contains a line to force the board and arduino to reset for uploading and ground. Our tether management system includes strain relief on both the topside and ROV ends. We use a spool for easier transportation. Our tether management protocol included at least one person by the poolside managing the tether. We yelled power on when turning on the ROV and setup commands for our video system. We communicated with commands such as "let more out" or "coming back up."

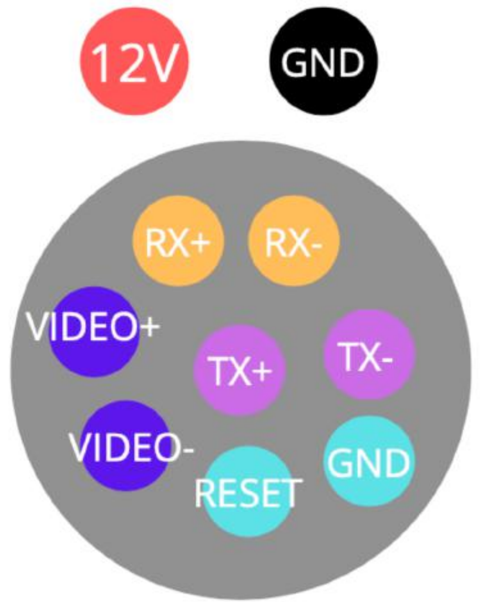


Figure 17: Diagram of tether cross section

Figure 18: Cameras inside enclosure

Cameras

There are four cameras placed around the ROV; 2 Blue Robotics Low-Light Analog Cameras mounted on servos in the main enclosure's front and rear domes, and 2 Adafruit TTL Serial JPEG Cameras running on 5V in individual enclosures. This particular placement was used to give the driver all the camera angles needed to complete the tasks and orient themself in the pool. 2 cameras are in domes on each end of the main enclosure, and 2 cameras are in separate enclosures for views of the net and bottom of the pool. A multiviewer on the ROV is used to multiplex the 4 NTSC camera feeds into a single video signal feed.

For the camera enclosure, we cut 100mm Blue Robotics enclosures from the 2'' series to form the basis of the watertight compartment. We also used resin printing to make an “endcap” for the enclosure. This endcap facilitated the use of Blue Robotics penetrators to pass the wire through a waterproof seal, along with water-tightness testing. Using enclosures from Blue Robotics, an endcap flange was used to secure the dome to the acrylic tube itself. The flange has mounting holes for an electronics sled in the bottom, which we utilized to create a new camera mount inside the enclosure. Lastly, the 3D-printed endcap was epoxied to the cut acrylic tube.

Software Design

GUI

Our Graphical User Interface is a Python program that utilizes pygame, tensorflow, and more. The GUI allows the drive team to visualize thruster, joystick, and button values from our xbox controller. It provides a calculator for the mussel filtration task and allows us to switch camera views from quad to single view. We are also able to control the camera angle to allow for a larger field of view. The GUI also enables us to rotate the claw and the "X" button on the xbox controller allows the ROV to drive in fine mode, which we use for more precise movements. Lastly, we can run our AI transect line task through the GUI which uses image classification and depth control

Figure 19: GUI

Control System

Our control system consists of an Arduino program on the ROV and we used python to program our topside computer. We utilized Pygame to record joystick inputs.

Our ROV can be driven in two modes: coarse and fine control. The driver can switch between the two modes using a button on our Xbox controller. This mode assists the drive team as our controls are proportional, meaning the more you pull the joystick away from the center, the thruster power goes up exponentially.

Figure 20: Control Systems

Computer Vision

Transect Line and Artificial Intelligence
We chose to complete it autonomously using a custom artificial intelligence object detection system for the transect line task. We created our own custom dataset by manually flying the transect line and capturing the video feed. Using Tensorflow and our dataset, we built and trained a custom AI model. This system can detect the blue bars of the transect line and has the ability to straighten itself and surge forward autonomously. Additionally, using depth sensors, it can autonomously keep itself at a set depth to see both blue bars at all times.

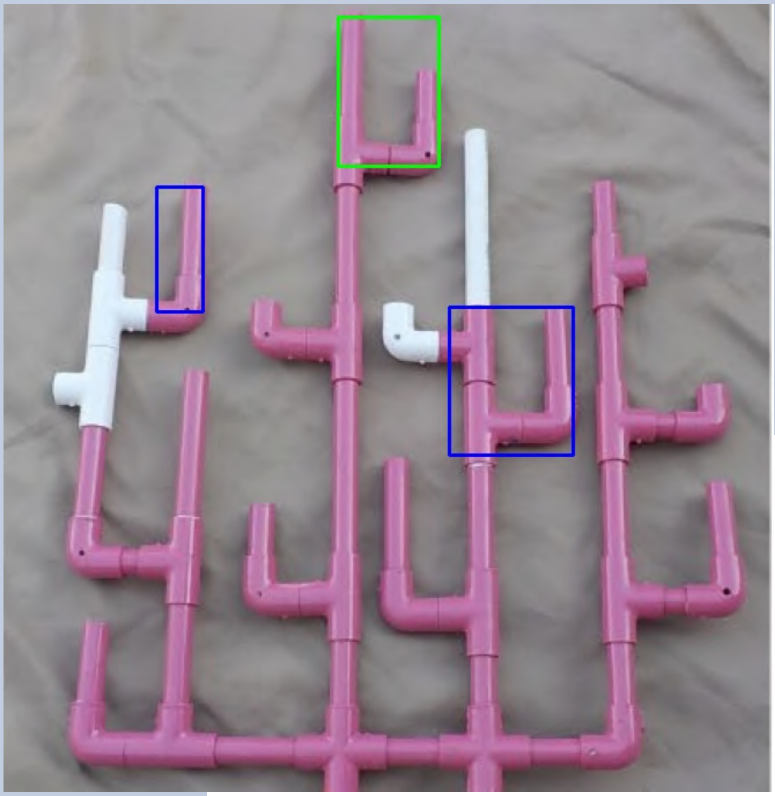


Figure 21: Output of Coral recognition program

Coral

WarriorTides developed a multi-step algorithm for identifying areas of coral change. To begin with, we applied a mask to the image, removing anything except for the pink and white PVC parts. We then aligned the before and after images using the Scale-invariant feature transform (SIFT) to identify key points and then computing and applying a homography. We then split the image into 2 images: one with just the pink PVC pipe and one with just the white. For each of these, we computed the structural similarity index measure (SSIM) and identified bounding rectangles where the SSIM was lower. Finally, we combined the bounding rectangles from both the white and pink images, removing repeats. We identified whether it was originally white, pink, or did not exist for each rectangle and what it changed into. We then displayed the final image with the appropriate colored rectangles.

Mission Tools

Design Process

In order to decide which tools to use, the team created a decision matrix for each suggested manipulator type. The manipulators were then compared based on complexity, cost, weight, efficiency, and point values for completing tasks. We settled on designing a claw and a net system. The claw was chosen due to its ability to complete multiple tasks and relatively simple design, while the net system was chosen to complete tasks that the claw could not. We also developed software to perform the health of coral and transect line tasks, which are discussed in detail on page 13.
We also used a Bar02 pressure/depth sensor, which helps us maintain a constant depth when flying the transect line.

Claw

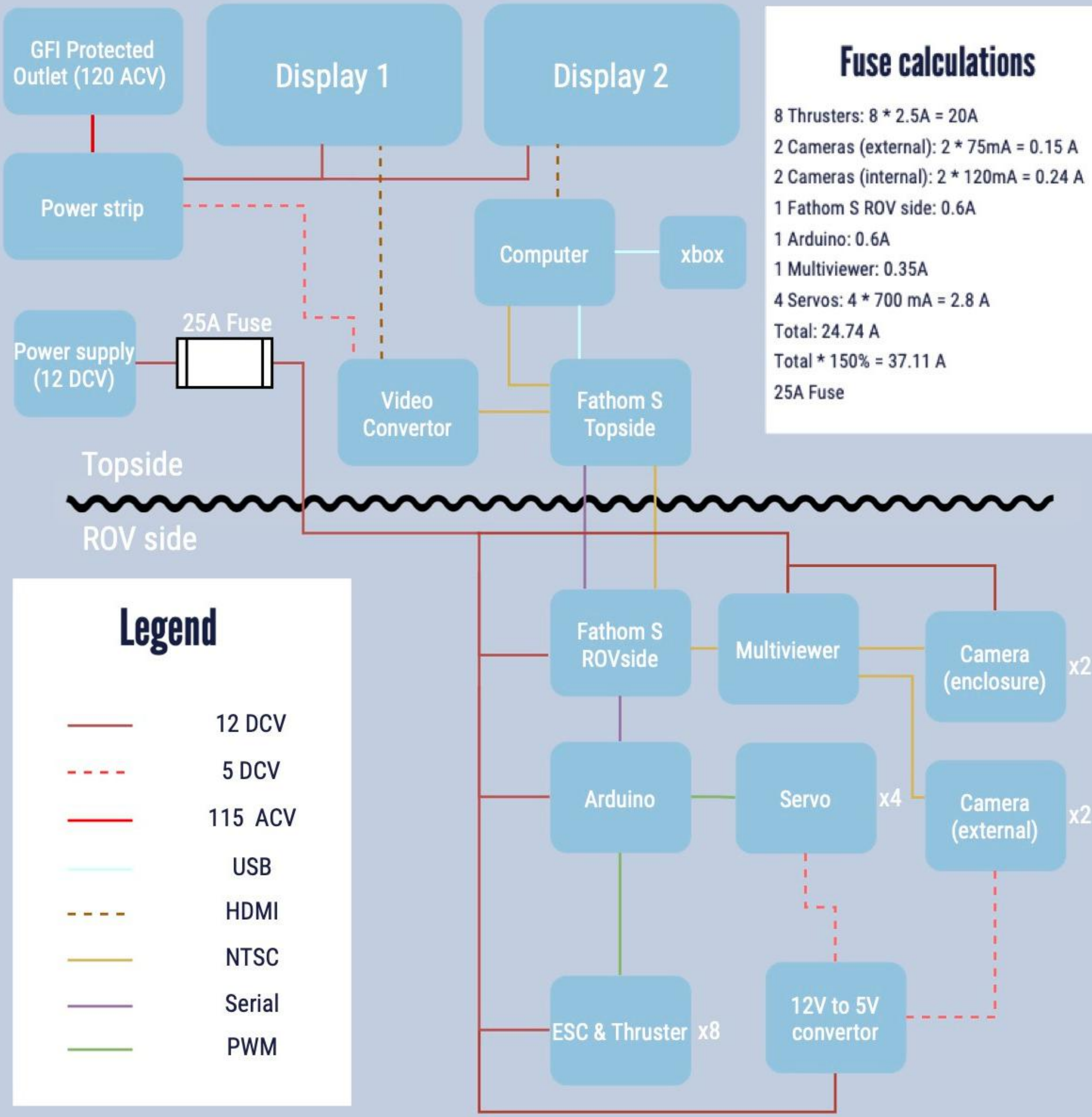
The claw consists of a single servo which powers 3 gears to move two hooks. At the end of each hook is a rubber grip which allows the claw to hold objects for longer periods of time without the risk of dropping the object. Utilizing a claw allows us to complete a multitude of tasks including the Seabin task, the coral reef tasks, and the healthy river tasks.

Figure 22: Claw

Net System

When brainstorming a way to remove the surface plastic pollution, Warrior Tides initially had to choose between an L-shaped acrylic rod, or two standoffs as net mounts. We decided to use two standoffs, for its simple design, cost-effectiveness, and lowered weight. The standoffs are 25cm tall and contain a net in between them which has an opening of 15cm x 15cm. This allows us to efficiently collect all 6 floating plastic debris from the surface of the water, and keep them secure for the remainder of the product demonstration.

System Interconnection Diagram



Fuse calculations

8 Thrusters: 8 * 2.5A = 20A

2 Cameras (external): 2 * 75mA = 0.15 A

2 Cameras (internal): 2 * 120mA = 0.24 A

1 Fathom S ROV side: 0.6A

1 Arduino: 0.6A

1 Multiviewer: 0.35A

4 Servos: 4 * 700 mA = 2.8 A

Total: 24.74 A

Total * 150% = 37.11 A

25A Fuse

Safety

Safety Philosophy

Our company, WarriorTides, takes the safety and health of our employees into consideration in every aspect of production. It is of utmost importance to guarantee and maintain each employee's safety by calculating and preventing any electrical or mechanical dangers. With that in mind, the SousaSub was designed to fulfill safety requirements and standards to minimize injury risks during operation. Not only is our vehicle designed under the model of safety, but the company workspace is also outlined with safety procedures and guidelines. All employees follow a strict set of safety rules printed out and displayed at various locations throughout the lab, especially in areas densely packed with machinery. Company members must go through training with individual machines to work unaccompanied to eliminate the risk of preventable error. All training is conducted by qualified adult mentors who provide certification cards after the training is complete. The certification cards are later used to verify if an employee can use the equipment.

This year our team has also taken a multitude of measures to protect our employees from COVID-19. All teammates must measure their temperature and wear a mask before entering the workspace, and all desks must be sanitized before

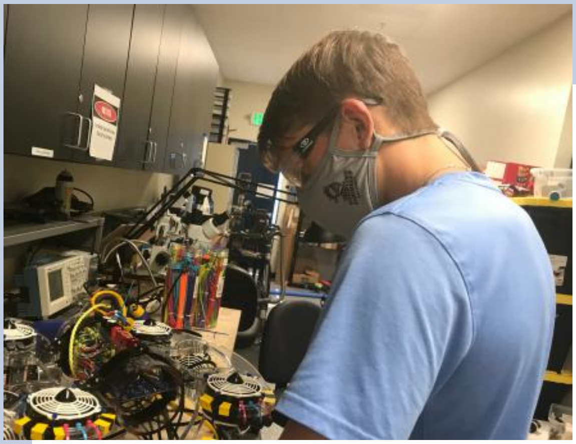


Figure 23: Teammate works on ROV while wearing safety glasses

Figure 24: Collaborating while wearing masks

leaving the workspace. All students were required not to attend in-person meetings if they were experiencing any of the symptoms of COVID-19, including fever, nausea, fatigue, etc. The team also strictly follows all California and Santa Clara COVID-19 regulations. Before receiving approval from the county to meet in person, all team members worked from home. Team members who were picking up or returning parts from campus were required to sanitize parts before and after using them.

Thanks to our rules and regulations, WarriorTides was able to conduct accident-free and safe meetings. No team members experienced injury or were diagnosed with COVID-19, and a multitude of safety features were incorporated into the SousaSub.

ROV Safety Features

Feature	Function
Eye Catching Labels	Noticeable labels to warn about moving parts or hazardous components
Handles	Two handles on each side of the frame to reduce risk of injury while transporting the vehicle
Rounded Edges	The structure was designed to have a rounded shape which ensures that the ROV has smooth edges; additionally, sharp edges on 3D-printed parts are sanded down.
Motor Shrouds	The T100 motors are fitted with 3D-printed shrouds that meet IP-20 standards.
Fuses	Two 25A fuses are installed on the positive power line of the ROV, one next to the connection to the MATE power supply and one directly before the connection to the ROV's tether.
Desiccants	Two BlueRobotics Moisture Indicating Silica Gel Desiccant bags are located in the ROV's electronic enclosure. These desiccants absorb moisture from inside the enclosure and allow for more visibility into the tube as well as reduced chance of short circuits from exposure to water.

Safety Procedures and Checklist

	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

Team Management

The WarriorTides is a high school student-run team with a mentor who provides expert input but does not make critical decisions. For the most part, WarriorTides maintained the same team structure as previous years. There are two team leaders, a CEO and a President, both specialized in different aspects of the team. The CEO is in charge of overseeing the entire team, while the President helps the CEO make crucial decisions. Both parties are responsible for recruiting, mentoring, and assigning tasks to team members. Since the team only consists of fifteen employees, there was no need for specialty leads such as mechanical or electrical leads. Not having these positions helps promote better inner team communications and all employees, despite seniority, get to provide their input. This structure also allows team members to gain experience outside of their specializations and prevents inner team competition or hierarchy. All team-wide decisions related to the MATE competition and design of the ROV are made during group meetings with all team members.

Figure 25: Gantt chart


Figure 26: WarriorTides teammates conversing

Scheduling

WarriorTides developed a schedule, setting deadlines for first individual systems and then pool tests with certain features such as simply driving, then driving with cameras, and then driving with certain manipulators. We created a Gantt chart to visualize our schedule and organize efficiently. Team members were given these deadlines. We then organized two week sprints. At the beginning of each sprint, team members would summarize their progress as well as their goal for the next two weeks. This helped us stay accountable and on track, especially when working from home for the first half of the year. For day to day problems, the CEO and President would typically discuss and consult others as appropriate. If we felt that an additional opinion was needed, we would ask our mentor Mr. Sousa for advice but the ultimate decision was always made by the students.

Critical Analysis

Testing and Troubleshooting

Testing Protocol
Verify all items on the Testing Safety Checklist are completed before any testing protocols are started.
Team members must be wearing appropriate safety glasses and gear when working around sensitive equipment.
ROV is connected to correct power input.
Thruster tests are to take no more than 10 seconds due to overheating issues.
Verify clear camera feed on topside monitors.
Verify all sensors are operational during underwater testing.

Testing Safety Checklist
All thrusters have proper shrouds.
O-rings on ROV are properly greased and sealed.
PCB, mission tools, and tether are properly secured to ROV
ROV has no sharp or cutting edges that can harm team members or team equipment.
Wire insulation is complete along the entire length of wiring. No fraying or exposed wires present.
No loose screws/joints/mounts.
Leaks are fixed before testing any underwater testing with electronics onboard.
Tether is not tangled.

Challenges and Improvements for the Future

One of the largest technical challenges this year was the Fathom S boards. From the very beginning, our Fathom boards worked inconsistently. Throughout the year, more and more would stop working. Many frustrating hours were spent trying to get the Fathom S boards to communicate. Since the Fathom S boards are no longer being produced, we became increasingly concerned about running out of Fathom boards. We helped minimize this problem by reducing our use of Fathom boards, only using them for actual pool tests and simply using a usb cable to the Arduino the rest of the time, and beginning to repair existing boards by replacing SMD chips. We will also either manufacture our own Fathom S boards or switch to Fathom X this summer.

The biggest mechanical obstacle was finalizing the design. Since the original CAD was put together by one of our graduated seniors, it was somewhat challenging to finish a project begun by someone no longer at our meetings. Also, the acrylic that we used was brittle, which led to frustrating setbacks when some finer elements of the ROV would shear off. Another challenge was sealing the electronics enclosure. Many meetings were spent attempting to find the leaking sources all because of a couple faulty penetrators.

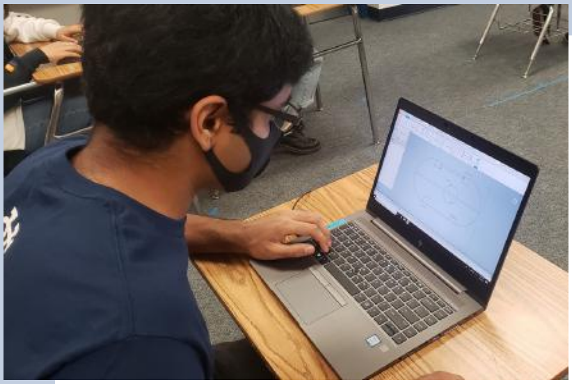


Figure 27: Working on the Frame CAD

On the software side, some improvements for the future include developing a more modular software library. We also hope to develop more automated control for the robot such as adding PID for roll and pitch and a system to prevent accidental turning or drifting of the robot.

This year has been nothing less than chaotic, but thanks to its ups and downs, our team received numerous learning experiences. With the knowledge we acquired during the process of this year, we will be able to run next year much more smoothly.

Reflections

"This year in MATE started pretty rough, from meeting online where communication was hard, to not being able to physically do things I could usually do in person. As time progressed and restrictions loosened, working with the team became so much easier. This year has been filled with ups and downs and there are still many obstacles to overcome, but I believe we will be at the best of our abilities in the end."

- Brayden Tam (10th)

"I have learned so much over the past three years in MATE. Not only have I learned technical skills such as soldering and waterproofing, but also life lessons that I will bring with me into the future. Although the past year has been different than most, I have learned that even the most difficult of challenges can be overcome with hard work and determination."

- Melia Atienza (12th)

"Over the course of this year, I've had the opportunity to see the passion of the team come to life through our ROV. I've seen it through the design process, through the construction, and through the testing phase of the vehicle. While the team has dedicated much time to the ROV, there are still many improvements to be made in our inventory systems and organization. The efficiency of the team would be greatly improved through these changes and would make it easier for the next generation of team members to construct their ROV."

- Ryane Li (11th)

Corporate Social Responsibilty

The WarriorTides team prioritizes giving back to our community. From cleaning up our beaches to providing classes for underprivileged students, our team hopes to foster a better world for future engineers.

In 2019, inspired by MATE ROVs' intent to reduce pollution in oceans, our team hosted a beach clean-up in collaboration with Ocean Blue Project, an organization that works to clean up beaches around the West Coast. We collected over five buckets of trash at Ocean Beach, San Francisco.

Because of the pandemic, many students could not access computer science classes and engineering courses this year, so our team hosted our very own free programming classes. More than a dozen middle school students from around the bay joined our zoom room to learn python. Thanks to the Cheyenne River Youth Project, we also received the incredible opportunity to host Java classes for underprivileged kids living in Native American Reservations in South Dakota.

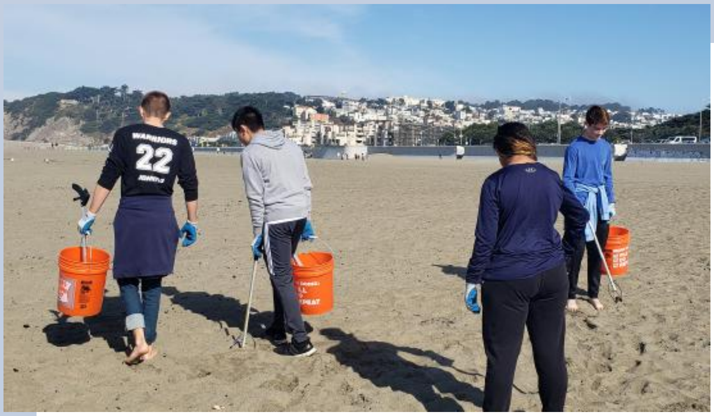


Figure 28: Teammates during the beach cleanup

Figure 29: Teammate picks up trash

Figure 30: Students in the WarriorTides zoom programming class

Finance

Budget Breakdown

Income	Amount		
Valley Christian	$7,000.00		
Type	**Category**	**Description/Example**	**Budgeted Amount**
Purchased	Hardware	Complete enclosure (penetrators, endcaps, potting)	$600.00
Purchased	Hardware	Build Materials	$350.00
Purchased	Hardware	Pelican case	$350.00
Donation	Hardware	Tether	----
Purchased	Hardware	Thrusters	$2,000.00
Purchased	Electrical	Cameras + Sensors	$300.00
Purchased	Electrical	Complete topside	$500.00
Purchased	Electrical	Onboard electronics	$1,000.00
Donation	Software	Computer	---
Purchased	Miscellaneous	Tools (Hammer, Vacuum Pump, etc)	$500.00
Purchased	Miscellaneous	Misc (Stationary, Towels, Organizational items, etc)	$500.00
Purchased	Miscellaneous	Props	$400.00
Donation	Miscellaneous	Travel expenses (note: we are competing telepresence)	----
		Total Value:	**$6,500.00**
		Budget remaing:	**$500.00**

Project Costing

School Name:		Valley Christian High School	From: 8/14/2020
Instructor:		George Sousa	To: 7/1/2021
Income	**Amount**		
Valley Christian	$7,000.00		
Type	**Category**	**Description/Example**	**Price**
Re-used	Mechanical	Enclosure Tube	$90.00
Purchased	Mechanical	Enclosure materials (Endcaps, Penetratos, Vent Plugs, O-rings)	$326.00
Purchased	Mechanical	Pelican case	$299.95
Re-used	Mechanical	Acrylic and other buid materials	$325.14
Donation	Mechanical	Tether	$175.00
Purchased	Mechanical	T200s	$1,512.00
Purchased	Electrical	Sensors (depth sensor, cameras, etc)	$264.75
Purchased	Electrical	Topside Electronics (HDMI Adapter, Fathom S, etc)	$142.67
Purchased	Electrical	Monitors	$301.42
Purchased	Electrical	PCB (manufacturing, ESC, fuse, capacitor, etc)	$691.99
Purchased	Electrical	Electrical Misc (Wires, Heat Shrink and Solder)	$387.95
Donation	Software	Computer	$1,839.21
Purchased	Miscellaneous	Epoxy and potting	$136.29
Purchased	Miscellaneous	Tools (Hammer, Vacuum Pump, etc)	$422.14
Purchased	Miscellaneous	Misc (Stationary, Towels, Organizational items, etc)	$295.89
Purchased	Miscellaneous	Props	$345.71
Donation	Miscellaneous	Travel expenses (note: we are competing telepresence)	$120.00
		Total Value:	**$7,676.11**
		Total Expenses (not including Donation or Reuse):	**$5,541.90**
		Budget remaining after season:	**$1,458.10**
		Total ROV Cost(excluding miscellaneous):	**$6,356.08**

Acknowledgments

We would like to thank our mentor Mr. George Sousa for his stellar support and astute advice, as well as Valley Christian High School for providing us with facilities and funds. To Mr. Stephen Huber, whose lab we used and cluttered daily, we sincerely apologize, and we thank you for your patience. As well as to our graduated founders Mihir Kasmalkar and Ansel Austin, for introducing us to the MATE competition and sharing their knowledge all the way from college. Thank you, of course, to Blue Robotics for supplying us with numerous parts. Thank you to the MATE ROV team for hosting and planning the competition during a global pandemic. Last but definitely not least, thank you to the amazing MATE Center for providing us with this opportunity to learn and compete.

References

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