Kraken Tech Robotics

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ABSTRACT

Kraken Tech has constructed an underwater remotely operated vehicle (ROV) to aid support efforts made by the UN to reverse the cycle of deterioration of the health of the ocean and produce improved conditions supporting the sustainability and development of the ocean. Sustainable Development Goals created by the UN that MATE has fixated their attention on are Life Below Water, Affordable and Clean Energy, Climate Action, Responsible Consumption and Production, and Zero Hunger.

Our company has spent the last nine and a half months building not only our ROV, but also our team website and social media accounts to complete the tasks assigned to us by MATE. We have equipped our ROV with a two-joint manipulator, a camera system, and four thrusters. Our manipulator has one joint to tilt vertically and another joint to open and close our claw, which is used to repair a damaged turbine, farm seagrass, and remove morts during our missions. Our ROV is equipped with a camera system so our pilot can survey the environment in the water from the robot's perspective, aiding in the mapping of the location of the sunken ship, measuring objects, and creating a photomosaic of the sunken Endurance. The four thrusters are used for vertical, horizontal, and rotational movements while the robot is in the water. Throughout our company's technical documentation, our design details and advancement process will be explained in meticulous detail.

Figure 1: Kraken Tech Robotics Company members

DESIGN RATIONALE

DESIGN EVOLUTION

Each aspect of our design process utilizes a step-by-step process allowing Kraken Tech to manufacture an ROV that will exceed our clients expectations whilst working within a modest budget. The design process means that each idea needs to be prototyped, tested, and then improved- steps that need to be repeated until the desired result is obtained. For the first step in designing our next generation ROV was for our company to take a step back and look at what worked and what did not on last year's build.

Step 1 Brainstorming, as a company we decided what worked, what did not, what we need and can we afford it. In addition, the company wanted to design an ROV tailored to our customers' needs while meeting all the requirements set forth by MATE. Improvements that the company felt would enhance the performance of the ROV was camera placement and manipulator design. Pilots experienced electromagnetic interference (EMF) with the cameras whilst trying to navigate the ROV during the mission, this was amplified when the ROV needed to return to the surface during missions and all thrusters were powered. The interference would cause the visual image displayed on the monitor to bounce, making it difficult for the pilot to navigate the ROV successfully. To eliminate the EMF, two tether lines were run between the ROV and the surface control box. One tether housed the wires for servos, cameras and the second the thrusters. In addition, an EMF shield tech flex was wrapped around the thruster tether to shield the second tether. During testing, the company observed and improvement when operating the visual system and thrusters.

Aspects of last year's ROV that the company felt worked was the lightweight, modular design of frame as it allowed the ROV to maneuver with ease throughout the water whilst providing optimum mounting space for payloads. Keeping the with the same modular design, shape and size of the frame, the company opted to utilize lightweight PVA sheeting which was CNC cut for accuracy and provided cut out spots for the up and down thruster, tether restraint and mounting for camera.

Step 2, designing the component allowed the companies the opportunity to research the benefits of buying or building the components. Costs and reliability of the component were the driving factors, once decided the designs are sent to each department for fabrication and assembly of a prototype. Step 3, prototype of the component is then tested for reliability. If adjustments were required, back to the drawing board for modifications until eventually in step 4, manufacturing and assembling the component are made and attached to the ROV.

Following the design process helps the company stay on track, allowing us to stay focused and complete the ROV build in the timeline needed and within the budget constraints.

MECHANICAL COMPONENTS

FRAME

This year our company used Autodesk inventor to design a prototype for our frame. Once we finalized the design of the frame, we used PVA sheeting cut using CNC machine which allowed the frame to be cut perfectly with no mistakes. The company decided to use PVA sheeting instead of

Aluminum bars from previous builds due to its lightweight, in addition less floatation was required to obtain neutral buoyancy during pool testing. The frame was assembled using aluminum brackets to ensure the frame was sturdy to support the vibrations of the thrusters and payloads. The frame modular, compact size measures 38 cm in width and 30 cm in height. Openings were cut into the side panels to allow water to flow easily through the frame. In addition, an opening at the top allowed the up and down thruster to be mounted, without obstructing the water flow. The decision to place the thrusters inside the frame, allowed the company to keep the compact modular design. The base plate of the frame provided mounting space for the transect line camera and manipulator.

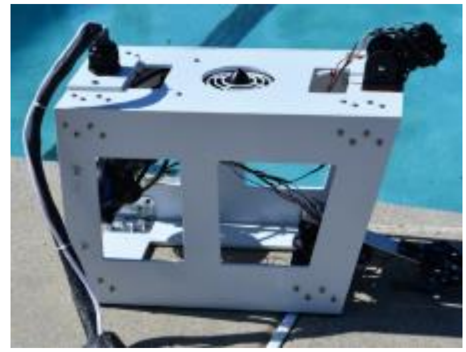

Figure 2: Assembled compact modular frame of Kraken.

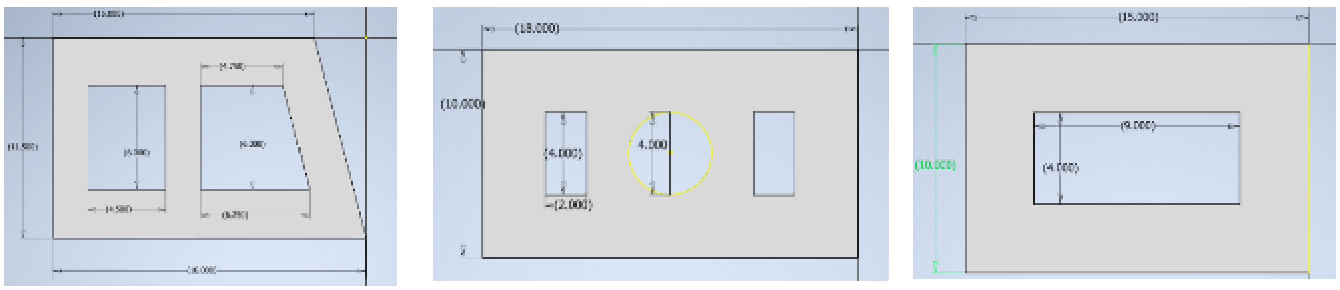

Figure 3: Autodesk design of ROV frame.

1.2.2 THRUSTERS

Kraken incorporates four Blue Robotics T200 thrusters, each costing approximately $200. Each thruster is strategically mounted to allow the ROV to maneuver effectively in the water. Two of our T-200 thrusters were originally mounted on the inside of the frame towards the back. However, after testing, the team realized that this design did not give the pilot optimal turning radius to successfully complete the missions. As a team, we decided to move the thrusters to the middle of frame on the outside of the ROV, this increased the ROV turning radius to allow us to complete the missions more effectively. Two additional thrusters were mounted on the top of the ROV for increased vertical movements.

Figure 4: Thruster with guard cover.

Each thruster is encased in a shroud and custom 3D printed guards wo prevent fingers or marine life from being entangled in the propellers. Each thruster weighs 176g in water, with an operating voltage of 12V and their maximum operating current is 12.5 A each, to stay within the power budget, the thrusters on Kraken were set a lower trust in the code so that they operated at 3.5 amps.

ELECTRICAL SYSTEMS

SURFACE CONTROL BOX

Kraken Tech Robotics designed a surface control box for maximum useability. The components are housed in a waterproof pelican case measuring 40cm in length, 33cm wide and 17cm in height. The case provides the space needed for our electrical engineer to design the layout for function and neatness. All wiring to and from each component is housed below the mounting board, protecting the wiring from water damage.

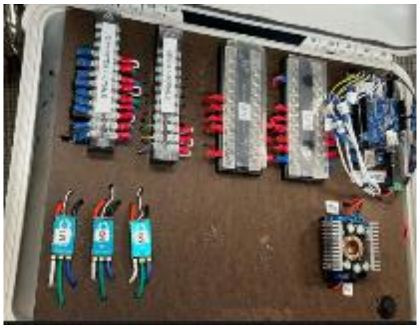

Figure 5: Kraken surface control, showing neatness and attention to workmanship.

Our surface control box is designed to facilitate communications to the ROV by powering components on the ROV. Our control box performs these actions by intaking power from an external battery and transferring it into our power busses. We have three power busses, one for our thrusters which is 12V, one for our cameras which is also 12V, and one which is 6.5V for our servos. Power gets stepped down by our two power converters to ensure individual components do not receive more power than is safely operable. Power is also transferred from our 6.5v power bus and is transferred to the Arduino which outputs signals based on the input from our controllers. The signals are sent from the Arduino to the signal busses which transfer the signals to the corresponding component on the ROV. Our thrusters' signals are received by an ESCs which controls the speed of our thrusters.

The camera multiplexer system is housed in the control box, utilizing the two input camera signals and one output signal, allowing the pilot to view both cameras on one monitor, providing the pilot multiple camera angles during the missions.

To meet the safety requirements of the MATE competition the team incorporated a 25amp fuse into the main power line. This small safety device will stop the ROV from working if the electric current exceeds the required amount, preventing fires, electrical shock, and damage to the main control box. In addition, tether restraints are placed along the one side of the control box, preventing the tether and camera wires from dislodging during testing, and mission practices. In addition, the surface box is equipped with an emergency on/off power switch, if needed the pilot can turn the power off to the ROV befote any damage can occur.

Figure 6: Fuse within 20 cm on main power line with Anderson Pole connectors

Figure 7: Emergency on/ off power switch located on surface control box.

TETHER

Figure 8: Tether restraint on the ROV side.

Figure 9: Tether restraints on surface control box.

The tether consists of CAT 5e Ethernet wire, 14 AWG 9 conductor cable, one main power and ground, 2 camera wires. The tether has a total length of 15 meters and is wrapped in a black Tech Flex to protect the wires. The tether allows the ROV to communicate with the main control system and the pilots. The tether is secured to the ROV using a waterproof plastic connector that is connected to both the bottom and the top of the frame. This ensures the tether is securely mounted and will not pull lose if caught or tugged on during mission practices. Floatation is added on the tether to obtain a neutral buoyancy and prevent the tether from being caught in the props during practices.

TETHER MANAGEMENT

Pool safety is a number one priority during practices and to ensure all safety protocol is followed our pool deck crew practice tether management before deploying the ROV. The tether is coiled neatly pool side during the pre-checks and during deployment of the ROV, the team member always holds onto the tether with two hands. If the tether is pulled back in, it is coiled neatly away from the main walkway of the deck crew to ensure no one trips. These steps not only ensure the safety of the deck crew but also prevents the ROV from being damaged.

Figure 10: kraken's tether wrapped in black Tech and pool noodles added to make the tether neutrally buoyant.

SOFTWARE TOOLS

CODE

Code for the operation of Kraken is split into two portions. The main code is written in Arduino and is what allows our pilot to control the robot. It is the most important code because without it, the robot wouldn't have any functionality. The secondary code is written in C++ and is what allows the autonomous capabilities of our robot. It is not as crucial to the robot, but it is still required to do anything autonomously. We are running our main code on an Arduino Mega 2560, and our secondary code on a laptop.

The main code is written in Arduino because of the versatile use of Arduino boards. They allow us to easily set the positions of servos and write to ESCs which control the speed of our thrusters. This code takes in inputs from an Xbox controller and turns those inputs into actions for our robot.

The secondary code is written in C++ for efficiency, reliability, and its ability to communicate with the Arduino. In addition, C++ has access to the OpenCV library which allows for image processing, allowing our team to autonomously complete our missions. This code is used for items such as image recognition and other autonomous tasks. During the autonomous tasks, we can gather data from the ROV, and send it to the laptop. Then once the data has been processed, we can send instructions to the Arduino and have it provided information to instruct the ROV on next steps.

AUTONOUMOUS DOCKING

Companies are tasked with docking their ROV, we are using a time-based detection system to identify where the docking station is, and when the robot needs to dock. The system will alert the pilot once the robot has begun docking by vibrating the controller. It also has an optional cancel feature if the pilot decides to stay longer.

INSPECTING THE FISH PEN NETTING

Teams are tasked with flying along the red transect and inspect the netting for damage. The team decided to have our robot do this autonomously. We are using the OpenCV image tracking software to accomplish this task. The program will realign and move the robot automatically, so that we can get a clear view of the pen. This will allow us to identify the damaged areas of the net. Teams are then tasked with patching the damaged area once detected.

AI RECOGNITION

In this task, the team is tasked with determining the difference between the morts and live fish. Using OpenCV edge detection to find these irregularities, the program will then determine if the detected irregularity is a mort or not by using image tracking. After that, the AI will draw red boxes around the morts. The red boxes indicate that the AI recognition has successfully differentiated between the live fish and the morts.

WRECKAGE PHOTOMOSAIC

Creating a photomosaic of the wreckage seems easy for a human, but the challenge comes when trying to get a computer to do it. Thankfully OpenCV has a built-in function for image stitching. This allows the images to be assembled into a photomosaic once the pilot has taken the photos.

PAYLOAD TOOLS

CAMERA SYSTEM

Kraken's camera system is equipped with two underwater waterproof fish finder color cameras with built-in lights. The camera offers a 92-degree field of view and measures 2.5 cm in diameter by 5 cm in length. The operating temperature of the cameras is -20 – 60^{o}C, allowing the cameras to operate in cold temperatures. One camera is mounted to a DDT500 tilt system with a built in Savox-1210SG waterproof servo, to the top of the frame. The camera is housed in a plastic connector to secure the camera to the tilt system. This allows the pilot to maneuver the camera up or down during the missions with a rotation of 150-degrees, optimizing the front view of the ROV and the manipulator during the retrieval of the Mort samples. Our original design had a second camera mounted at the bottom of the ROV pointing down, however after testing we realized that our front camera could view the transect line on the ocean floor, therefore allowing us to move the second camera to the side of the ROV. This new design of our second camera allows us visual imaging of flying the transect line and mapping points on the coral reef.

Figure 11: Main camera and tilt mechanism.

Both set of camera wires run through the tether to the surface control box to the camera multiplexer system. This allows the pilot to see both cameras at the same time on the single monitor.

MANIPULATOR

Due to the number of mission tasks that require collecting and retrieving of samples, Kraken Tech Robotics designed a manipulator that is both reliable and versatile. The manipulator utilizes a SPT 400 tilt mechanism to control the up and down movement. The platform made from ABS plastic, provides a sturdy base, and attachment for the waterproof Savox servo to the shaft hub. The servo allows the tilt to maneuver 45^{o}C upwards and 90^{o}C downwards. An aluminum bar is attached to the tilt mechanism with a parallel gripper at the end. This allows the manipulator to extend outside of the frame, allowing competition of tasks to completed more effectively. The parallel gripper moves in a parallel motion with the aid of a Savox waterproof servo and can open 7 cm to help with collecting larger objects from the bottom of the pool. The manipulator measures 17 cm in length and is mounted to the base of the ROV frame, below the top camera, allowing the pilot full view of the manipulator whilst completing tasks.

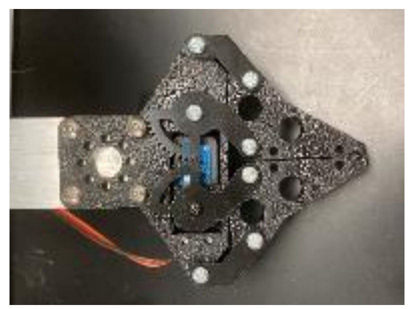

Figure 12: Manipulator claw.

Figure 13: Assembled manipulator on base of frame.

NEW VS REUSED

Kraken Tech Robotics had to operate on a tight budget as the schools were still limiting events and fundraisers due to COVID restrictions. To overcome this hurdle the company brainstormed which components needed to purchased verse which ones could be reused. Reusing components that have been locked up over a summer and not used always puts the team at risk of things not operating correctly. The company carefully selected components that they knew were reliable and with adequate testing would perform and function correctly when placed in the surface control box or on the ROV. Components were salvaged from last year's control box, such as bus bars, step down transformers, Arduino mega, cameras. In addition, the company tested last year's T200 thrusters in water and found that they functioned correctly and could be salvaged for this year's ROV.

New components such as the tilt mechanisms for the camera tilt and manipulator had rusted over the summer, so the company opted to purchase new ones. I addition, servos were purchased new as the reliability of using old servos put the team at risk of having manipulator or camera tilts form not working correctly during pool practices, which would lead to down time and loss of valuable mission practice.

BUILD VERSE BUY

Kraken Tech Robotics decided to purchase tilt mechanism for the camera and manipulator due to the reliability and cost. To 3D print these components would not have saved the company any money. In addition, we would have built our own housing and cameras this year but during our planning stage another team offered for us to use theirs as they had no use for them. This allowed the company to put that money to other components of the ROV.

The guards for the thrusters were custom built as the specifications of the 12.5mm mesh opening required by MATE was hard to find. The Company opted to custom designing the guards and 3D printing them to ensure we met the safety specifications.

One of the key factors that helped our company save money in the budget this year was our sponsorship from Automation Direct. The company was able to acquire all wiring needed for the tether, and connections at no cost to the team. This along with the donations from Automation Direct, reused, and salvaged items from old ROVs the team managed to save $1752.44 of their overall budget.

TROUBLESHOOTING AND TESTING TECHNIGUES

TESTING

Testing Kraken followed a set routine during poolside practices. The ROV was dry tested before placing the vehicle into the pool. Following the safety checklist, the deck crew work through each step, checking each component before powering the ROV up. The deck crew is checking for any exposed wiring, waterproofing that is no longer secure, and ensuring all fasteners are secure.

Figure 14: Team member testing code pool side.

Once the initial inspection is completed and all deck crew are satisfied, the pilot gives the command, and the power is connected to the surface control box. Allowing both the deck crew on ROV side and the pilot to check if all components powered on correctly. The pilot checks that the camera feed for both cameras is displayed correctly on the monitor. That the main power supply is at 12V, that the propellers are spinning freely and not obstructed. Pilot initializes the controller to test movement of thrusters, manipulator, and camera tilt. If any issues arise, the deck crew will run through a series of checks to eliminate the problem. First one is to check the fuse. Again, following the pilots instructions Kraken is placed into the pool and a wet test is conducted. The thrusters are tested to ensure forward, and back motion works with the controllers, and that the ROV can submerge and resurface correctly. Given all clear signal, the deck crew proceeds with the ROV practices. By practicing the missions, the pilot and deck crew can test the capabilities of the ROV, it's performance of both thrust power, manipulator function and cameras. If modifications are needed the ROV is removed, and adjustments are made.

TROUBLESHOOTING

During the testing of the surface control box, errors were detected with our electrical wiring. Our engineers used the Ohm meter to test connections, and a voltmeter to test voltage drops. One issue that occurred was the ESC for one of our blue robotics T200 thruster was not working, through testing and use of the voltmeter we had found that we had a bad crimp. Once fixed, the thruster worked to full capacity. Another concern that we encountered was during the assembly of Kraken's frame. The initial brackets purchased did not offer enough support to the frame, as a result, when the thrusters were tested, the frame vibrated. By replacing the mounting brackets for larger ones, the frame was more secure and sturdy. By correcting this early during testing, we eliminated running into future problems at the pool with components on the frame vibrating lose.

Figure 15: Team members adjusting floatation to achieve neutral buoyancy.

SAFETY

COMPANY SAFETY PHILOSOPHY

Kraken Tech believes that all accidents are preventable and with adequate knowledge, training, and guidance our company offers a safe environment for its members to work in. Everyone feels responsible for safety of themselves and fellow workers and are encouraged to pursues it daily. Members are encouraged to call out unsafe conditions, for example if a mentor or coach is not wearing proper protective wear when operating machinery, team members can direct them ask to put them on.

TRAINING

At the beginning of each new competition year, mentors refresh the members on safety protocols on machines or soldering devices to ensure the returning members or new members are using the devices correctly and efficiently. Members of the company that may not be experienced enough in a specific task may be tutored by a fellow member of the company. Peer-to-peer training helps the members of our company to better understand the techniques of the machine that they may be operating on. Our company takes training very seriously because it helps each team member to be able to conduct reliable operation of machinery that the company may be utilized throughout the year, and it also allows the company to work at an efficient rate.

LAB PROTOCOLS

While working in any workspace there must always be a mentor present. Any member that must work with a machine is required to ask a mentor for permission first. When a member is about to power on the ROV they must say “Power on” to alert any team member that may be working on the

ROV at that time to release their hands from the ROV to prevent any chance of an accident from happening. Open-toed shoes are prohibited in the workspace, open toed shoes can increase the chance of a member getting injured because if any sharp or heavy tool/object is dropped the foot is exposed and can easily be injured. Each member is also required to put tools in the respective spot, this prevents our toolboxes from becoming clustered and not neat. If tools are put in the correct place it allows for the tools to be quickly located and accessible. If any member has long hair, they are required to have it tied up, this prevents any hair from getting caught in something like a drill that could cause harmful injuries. Members are also required to use gloves when working with harmful chemicals that could damage the skin.

Each member is required to wear safety goggles in any workspace to prevent any small debris from getting into the eyes. While any team member is working with heavy machinery a mentor is required to stand and supervise at the station while the student is working. The mentor is required to show the student how the machine is supposed to be manipulated and properly handled. The mentor is also required to present how to be safe while using any machine that may be used, before the student uses the machine, they must show the mentor how they would operate the machine to ensure the student is not doing anything that may danger the safety of our members, if the student makes a mistake the mentor will address the issue to ensure that the student gets it correct the next time.

Our company also highly encourages our members to ask fellow members of the mentor questions on how to perform a specific task correctly to prevent any accidents from occurring in the workspace.

VECHILE SAFETY FEATURES

At the beginning of each new year, our company runs though the MATE safety guidelines to ensure all safety features are incorporated onto the ROV. The ROV has smooth curved edges and no sharp corners, and exposed bolt threads are secured with cap nuts in order not to cause any injuries. Thruster guards completely cover any openings on the thrusters and have a mesh size that meets IP-20 standards to prevent entry of foreign objects and/or subjection of human hands to the thruster blades.

All cables inside the frame are secured away from the moving propellers. A fuse is attached to prevent the ROV from exceeding the maximum operation value of 25 amps. All connections are waterproofed with liquid tape. The ROV is free from any chemical substances or pollutants that may affect or harm the marine environment.

Figure 16: Danger labels on thrusters to warn operators of moving propeller parts.

Figure 17: Guards on thrusters to prevent fingers from touching propellers.

Figure 18: All exposed copper wire is waterproofed using heat shrink and liquid tape.

Figure 19: All sharp edges on frame was smoothed away, and caps were placed over fasteners.

Figure 20: Safety fuse 13cm within main power line.

OPERATIONAL AND SAFETY CHECKLIST

All members of the company must follow the safety checklist before operating the ROV. A visual inspection will occur to locate any issues that can be addressed before the ROV is deployed into the water. A dry test will also take place, so the company knows that the ROV is properly working and that no problems are being presented to us while the ROV is operating in the water. While standing poolside each member is prohibited from touching the control box while on to prevent any injuries or causing damage to the hardware (Appendix A: Operations and Safety Checklist)

TASK RELATED SAFETY PRECAUTIONS

During our missions, while poolside and near shipwreck Endurance22, we have tether coiled up tighter to alleviate potential threats upon the shipwreck. Our manipulator has a sponge like material to avoid damaging anything picked up within the manipulator. The thruster shrouds were designed to avoid marine life from getting inside the thrusters.

LOGISTICS

COMPANY ORGANIZATION

Kraken Tech Robotics comprised of 5 team members competing for their first time in the Ranger division of the MATE competition. The company is made up of 4 departments, mechanical, electrical, programming, and marketing. Each team member was assigned a department and was responsible for the competition of specific tasks. Each department reported daily to the CEO for updates on their progress, needs or expected delays. The team had the continue support of an external coach from one of our key sponsors, Automation Direct who specialized in electrical and mechanical engineering. Company CFO, tracked all purchases, keeping the company on track and within their budget guidelines.

SCHEDULE PROJECT MANAGEMENT

Kraken Tech Robotics met every Tuesday and Thursday afternoon. The initial meetings were allocated as the pre-planning phase. Here the team developed a timeline for certain tasks, criteria of their ROV to be completed, taking into consideration of their allocated budget, what needed to be purchased, and what could be reused. Once this was established the team discussed the design of the ROV, looking at the MATE requirements of what was needed for the missions, size, and weight of the ROV specifications. A detailed schedule was prepared, and deadlines set to ensure that the ROV would be built and completed by the agreed upon deadline. Providing the team time for pool testing and practices as indicated in the Gantt chart below.

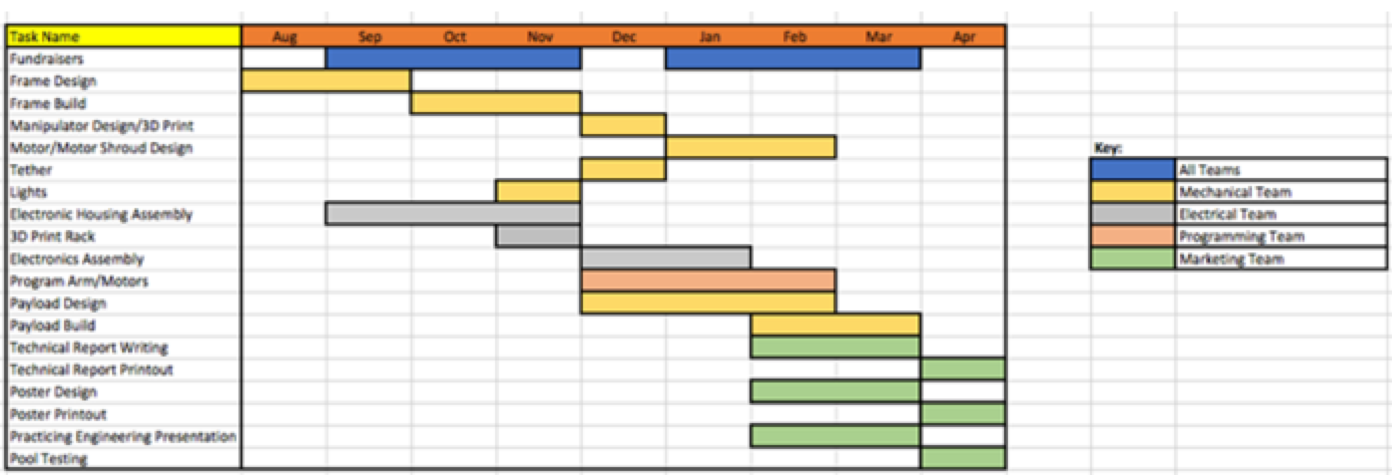

Figure 21: Gantt chart showing the timeline of the ROV build for 2021-2022 year.

BUDGET AND PROJECT

Kraken Tech Robotics is a school run program that depends entirely on member fees and fundraising. The company assessed the requirements for the 2022 MATE competition and expenses incurred from previous build to help establish a budget. Due to the limited funds this year, the company had to rely on reusing components from previous build to keep the costs down. Thrusters, and control box components were salvaged from last year's build, allowing the company to pledge $1800.00 to vehicle development and $2000.00 to operating expenses including travel and accommodation. Actual vehicle costs totaled $1689.72 and operating costs totaled $2175.00. Leaving a $10.28 balance in the account. Budget and Costing sheets can be found in Table 1,2and 3.

Kraken Tech Operating Income 2021-2022		
Fees	5 team members @ $475 each	$2375.00
Fundraising	Fundraisers/ Donations	$1500.00
	Total Operating income	$3875.00
Kraken Tech Operating Costs 2021-2022		
Travel/ hotels	5 Team members	$1875.00
Shipping		$100.00
Registration	MATE Ranger Division	$200.00
	Total Operating Costs	$2175.00
	Balance	$1700.00

Table 1: Operating Income and Costs for 2021-2022 Build Year

Kraken Project Costs 2021-2022						
Component	Item	Notes	Type	Amount	Quantity	Running Total
Frame	PVA sheeting	US Plastic	Purchased	58.58	2	117.56
	Fasteners	Home Depot	Purchased	0.91	15	131.16
	CNC Cutting	Custom cutting	Donated	123.00	1	254.16
Thrusters	T200	Blue Robotics	Reused	200.00	4	1054.16
	ESC's	Blue Robotics	Purchased	36.00	4	1234.16
Viewing	cameras	Fish finder underwater cameras	Donated	72.60	2	1266.16
	Tilt mechanism	ServoCity	Reused	49.00	1	1411.36
	Multiplexer	Amazon	Reused	53.49	1	1464.85
	Cable extenders	Amazon	Purchased	17.26	2	1499.37
	Savox Servo	Amazon	Purchased	98.37	1	1597.74
	Connectors	Amazon	Reused	7.99	4	1629.70
Manipulator	Tilt mechanism	ServoCity	Purchased	76.00	1	1705.70
	Savox Servos	Amazon	Purchased	98.37	2	1902.44
	Aluminum Bar	Home Depot	Purchased	9.89	1	1912.33
	Parallel Gripper	Servo city	Purchased	14.99	1	1927.32
Tether	Cat 5e cable	Automation Direct	Donated	49.60	2	2026.52
	8 stranded Cable spool	Automation Direct	Donated	145.00	1	2171.52
	Red/Black 14 AWG wire spool	Automation Direct	Donated	85.00	1	2256.52
	Tech flex covering	Amazon	Purchased	17.99	1	2274.51
	Tether restraint	Automation Direct	Donated	16.00	1	2290.51
Measuring Tool	Lasers	Amazon	Purchased	6.29	2	2303.09
	Safety Glasses	Amazon	Purchased	16.00	4	2367.09
	Waterproof case	Amazon	Purchased	69.54	1	2436.63
	Mounting board	Home Depot	Purchased	8.85	1	2445.48
	Arduino mega	Amazon	Reused	23.99	1	2469.47
	Bus Bars	Amazon	Reused	14.90	3	2514.17

Surface Box	Step down transformer	Amazon	Reused	62.41	2	2638.99
	Multiplexer	Amazon	Reused	33.49	1	2672.48
	Arduino pins	Amazon	Purchased	8.55	1	2681.03
	18 AWG wire colored	Amazon	Purchased	16.99	4	2748.99
	Tether restraint	Amazon	Purchased	9.90	2	2768.79
	Switches	Amazon	Purchased	4.70	2	2778.19
Pilot system	controller	Amazon	Reused	24.99	1	2803.18
	TV monitor	Best Buy	Reused	156.00	1	2959.18
Marketing/ competition costs	T-shirts	Custom Ink	Purchased	41.33	6	3207.16
	Printing	KSU	Purchased	35.00	1	3242.16
	Registration	MATE registration fee	Purchased	200.00	1	3442.16
Minus cost of donated /reused items						1752.44
Total Project Cost						1689.72

Table 2: Project costing sheet for 2021-2022 ROV build.

Balance Sheet 2021-2022	
Operating Income	$3875.00
Operating Costs	$2175.00
Project Costs	$1689.72
Balance	$10.28

Table 3: Balance sheet for 2021-2022 ROV build.

CONCLUSION

CHALLENGES

Challenges our company faced were shipping delays, loss of team members, loss of our robotics room, and less funding than previous years. Due to the Coronavirus Pandemic, there have been shortages of workers causing shipping to slow, so the construction of our company's ROV has been substantially slowed and our team only being able to build with the materials we already had. Another challenge we faced was the loss of a teammate. Towards the beginning of the season, one of our team members stepped away from the program for personal reasons, leaving just five members on our team to complete the whole ROV building process. This caused all team members to take up another job to fill the gap of our old teammate.

We also lost our robotics room we have worked in for the past several years, so we had to work in school classrooms and store our supplies any place we were allowed to. Our company has also received less funding this year because we have only been able to acquire one sponsorship and set up one fundraiser. To work around this challenge, we must pay attention to our budget and spend it cautiously.

LESSONS LEARNED AND SKILLS GAINED

Throughout the year, the members of our company have learned to always have a backup plan and have gained the skills of effective communication and improved teamwork between our members. Learning to have a backup plan is important because with shipping delays or a wide range of objects constantly staying out of stock, we have had to find other jobs on the ROV to work on or find an alternate way to complete the same task we were originally working on. Also, learning to communicate effectively and improve our teamwork will help us later in the competition when our teamwork is crucial to performing our best. Improving our teamwork will make completing tasks easier and quicker to accomplish.

FUTURE IMPROVEMENT

In the future, our company hopes to continue to improve our chemistry between members and overall efficiency and productivity as a team. Improving these would greatly help us because we would finish work faster and be able to complete more work. This way we won't ever be rushed for time to finish a task for our robot again.

Kraken Tech would like to set their standards higher and move away from the surface control box to an onboard control box. We believe with the skills gained throughout the years in the program, that our company is more than ready to incorporate an onboard control box on the next generation Kraken ll.

Figure 22: Kraken Team and Sea Life Technology both celebrating their success after first pool practice.

ACKNOWLEDGEMENTS

Kraken-tech engineers would like to recognize several sponsors and individuals for their continuous support and help throughout the year.

- MATE Center and Gray's Reef National Sanctuary for creating the 2022 missions and organizing the competitions.
- Automation Direct for their generous donation of cable for our tether, and connectors for our ROV and support throughout the ROV build.
- Automation direct for sponsoring our shirts for the WORLD 2022 Competition

- Magical Vacations Travel for their Bronze sponsorship
  1MATE sponsors (Marine Technology Society, Marine Technology Society ROV Committee, National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), Oceaneering, Marine Technology Society, Department of Environment and Conservation, Martin Klein, Oceaneering, Ocean Exploration, Schmidt Ocean Institute, Ocean Infinity, Reach The World, Bulgin, Blue Robotics.

- Jody Patterson for ongoing support towards our program.
- Mr. Leach for the continuous coaching and support throughout the year.
- Glen Lewis and Michael Lees, for their assistance and guidance throughout the year.

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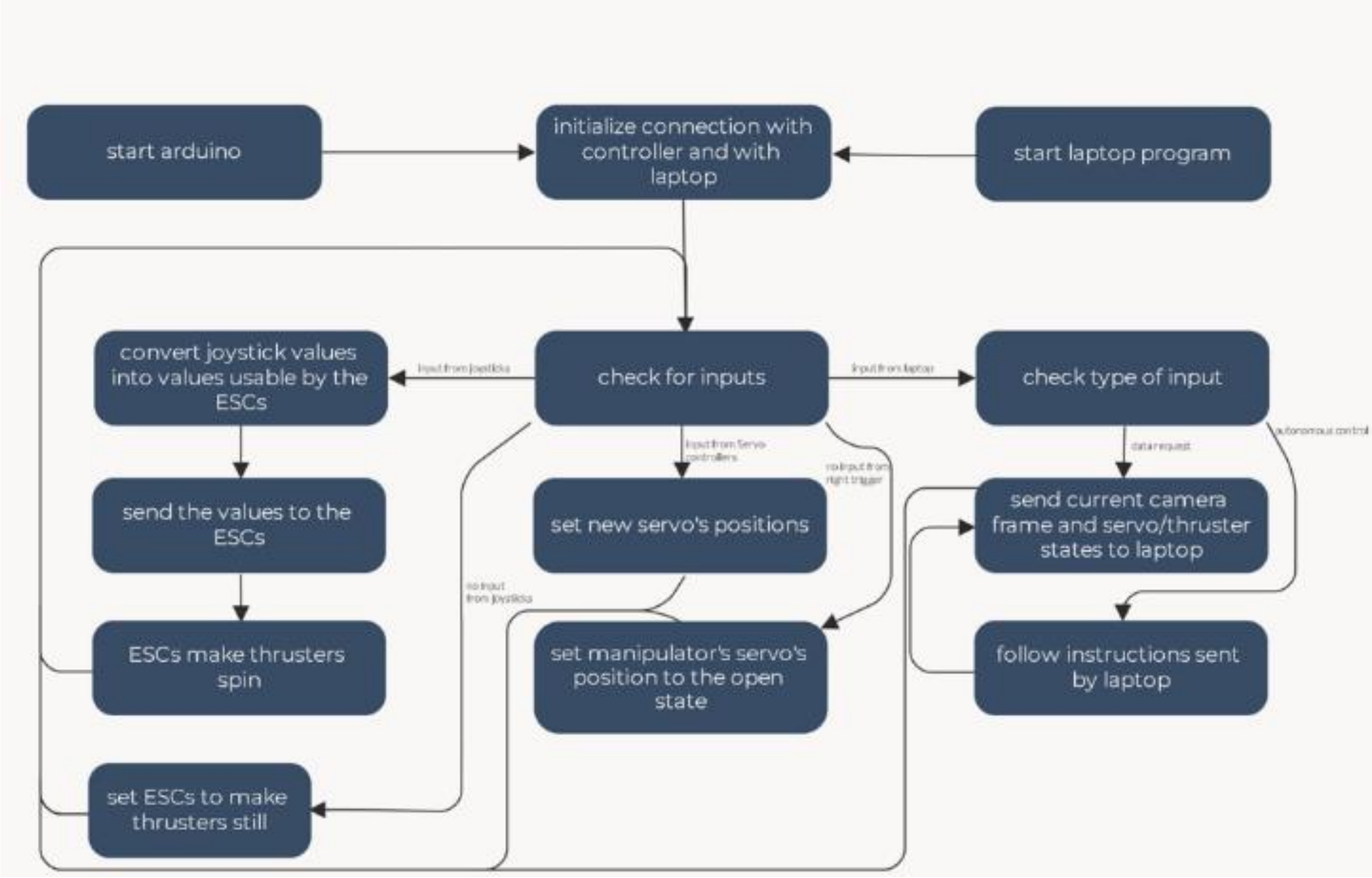
APPENDIX

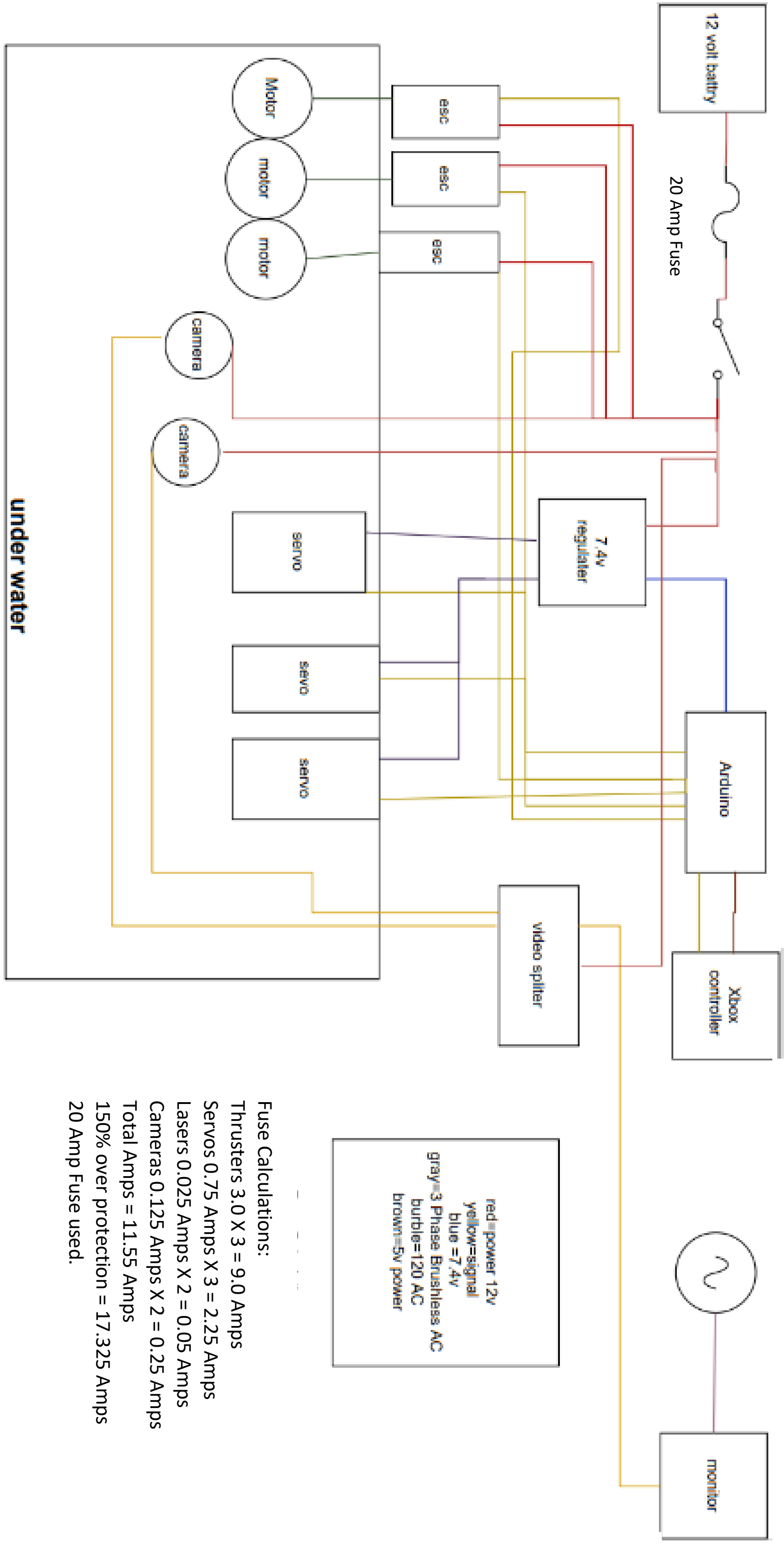
A. SOFTWARE FLOWCHART



B. OPERATIONS AND SAFETY CHECKLIST

1. ROV physical Checks	
• All items attached to Kraken are secure.	√
• Thrusters are shrouded and with guard cover over propellers	√
• No sharp edges on frame are exposed that could cause injury to a person or damage to the pool	√
• No exposed wires are visible on ROV. All wiring is covered with heat shrink	√
2. Pre-Launch Checks	
• Tether is secured to ROV and surface control box	√
• Surface control box is neat, no exposed wires are evident before powering on	√
• Fuse is connected and working properly, power supply produces 12V	√
• Thrusters respond to control dry test	√
• Cameras respond to control dry test	√
• Laser guards are in place during dry test to prevent injury to deck crew eyes.	√
• Anderson Power connectors and all fasteners are secure and in place.	√
• Safety labels are clearly displayed on all moving parts of the ROV.	√
3. Operating Checks	
• Once ROV is submerged in water, deck crew monitors thruster movement and reports any issues or concerns to the pilot immediately.	√
• Tether is neatly coiled and not obstructing the walkway of the deck crew during missions.	√
• Pilot gives commands to the deck crew and diver when lasers are being turned on.	√
• Safety glasses must be worn when lasers are in operation	√
• Deck crew will remove safety shields on lasers when ROV is placed in the pool.	√
4. Retrieval Checks	
• ROV is powered off once the ROV is at the edge of the pool.	√
• Deck crew lift the ROV from the water, using the correct lifting technique to avoid back injury	√
• Lasers guards are replaced over the lasers when ROV is placed pool side.	√
• Tether is neatly coiled and placed to one side to avoid deck crew from tripping over it.	√
• Equipment is secure and accounted for before leaving the pool side.	√

C. SID



Fuse Calculations:
Thrusters 3.0 X 3 = 9.0 Amps
Servos 0.75 Amps X 3 = 2.25 Amps
Lasers 0.025 Amps X 2 = 0.05 Amps
Cameras 0.125 Amps X 2 = 0.25 Amps
Total Amps = 11.55 Amps
150% over protection = 17.325 Amps
20 Amp Fuse used.