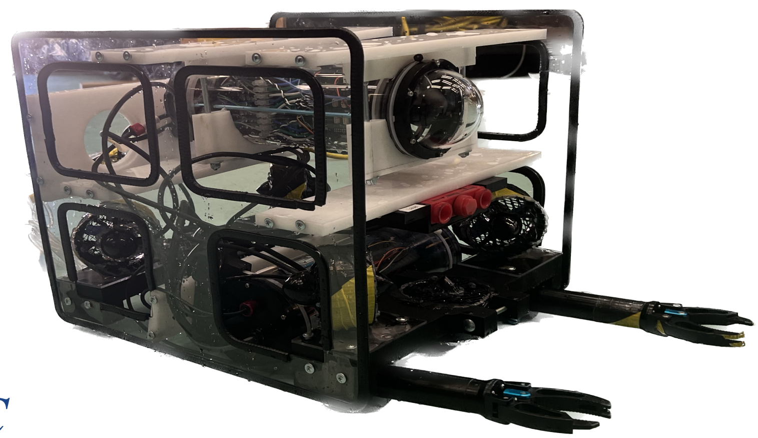


TR3-LC

Aquabot Technicians

Mission Statement "Revolutionizing the ROV industry by immersing in the ever-changing current of technology with efficiency, dedication, and reliability ".

Foy H. Moody High School
Corpus Christi, Texas, USA

Chief Executive Officer (CEO): Deiondra Washington

Chief Operating Officer (COO): Daniel Cantu

Chief Technical Officer (CTO): Alan Castañeda

Chief Financial Officer (CFO): Emery Johnson

Buoyancy Engine Designers: Albert Mendoza & Enyan Perales

Frame Specialist: Audree Alvarado

Navigation Specialist: Christian Estrada

Payload Specialist: Exavier Rodarte

Safety Engineer: Layla Chapa

Prop Specialist: Jonah Morales

Tether Specialist: Christopher Sosa

Mentors: Mario Bayarena & Kisha Charles

2023 MATE ROV Competition

Authored by: Castañeda, A., Estrada, C., Johnson, E., Morales, J., & Sosa, C.

Table of Contents

Abstract

Aquabot Technicians (est. 2015) is a company that is dedicated to creating sustainable technologies to meet the needs of the global community. This year, our company consists of thirteen employees. To meet the tasks included in the 2023 MATE ROV Competition, our team has designed *TR3-LC*. It is the product of hours of extensive research and unrelenting trial and error. Its analog and digital cameras provide it (i.e. its pilot) with a clear picture of the aquatic environment it is placed in. Its two claws enable the transport and deployment of materials necessary for the collection of data, sustainability of the ocean, and the repair and maintenance of turbines, coral reefs, and buoys. We are confident that *TR3-LC* is capable of overcoming any challenge it faces.

Company Photo

TR3-LC Components

Frame

Figure 1: plywood prototype of TR3-LC's frame
Source: Alvarado, A. (2023)

In attempting to replicate the successes and avoid the limitations of our last model, *TR2-Seahorse*, Aquabot Technicians decided to utilize the polycarbonate Lexan when designing *TR3-LC*'s frame. Lexan's translucency is visually appealing and, when combined with our acrylic Blue Robotics Watertight Enclosures, facilitates the user's ease of troubleshooting any performance issues. It is also lightweight, flexible, and durable, facilitating the ease of *TR3-LC*'s transport and deployment and minimizing the risk of damage. We also added a rubber guard to protect aquatic life and injury to the user by creating smooth edges. The holes within and openness of the frame allow for the free flow of water.

Tether

Figure 2: CTO Alan Castañeda and Frame Specialist Audree Alvarado insert tether into tether casing
Source: Sosa, C. (2023)

Power, ground, and signal are transferred from the control box on deck to the electronics enclosure on board *TR3-LC* through a 15-meter long tether. The tether is fastened through the use of Wet Links, plastic penetrating screws, and Strain Relief. Inside the tether are three sub-tethers and two tubes leading to our liquid extractor and air bag. A black 14 gauge 2 conductor sub-tether contains power and ground wires. A yellow sub-tether contains 4 pairs of 22 gauge wires which feed signal to the Fathom X. A gray sub-tether containing 8 conductor 18 gauge wires feeds signal to its claws, laser, and analog camera. The liquid extractor tube and air bag tube double as part of a hydraulic system attached to their respective payloads.

Thrusters

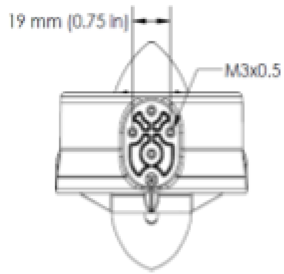


Figure 3: T200 Bottom View
Source: Bluerobotics.com

Figure 4: T200 Front View
Source: Bluerobotics.com

TR3-LC makes use of six Blue Robotics T100 Thrusters (Figures 3-4). These thrusters are a vital component of our ROV, as they facilitate all system-wide movement, including thrust, yaw, and sway. Two thrusters are located forward and aft at the bottom of our ROV and facilitate heave and pitch. Four corner thrusters are located port-side forward and aft and starboard-side forward and aft, each at an angle of 45°. Speed and polarity of the thrusters are regulated by ESCs (electronic speed controllers). When running at 12V, RPM of the T100s are as follows: with an ESC PWM (pulse-width modulation) value of 1900 µs, a T100 operates with a maximum forward speed of 2995 RPM; with an ESC PWM value of 1100 µs, a T100 operates with a maximum reverse speed of 2975 RPM.

Claws

Figure 5: Newton Subsea Gripper
Source: Bluerobotics.com

TR3-LC uses two modified Blue Robotics Newton Subsea Grippers (Figure 5) as its claws. These two claws provide it with the ability to retrieve, interact with, and secure resources in the aquatic environment it is placed in. The tip of the claw has a grip force of 97N, and the middle of the claw has a grip force of 124N.

Cameras

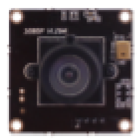


Figure 6: Digital camera
Source: Bluerobotics.com

Figure 7: Analog camera
Source: Amazon.com

TR3-LC uses an analog (Figure 7) and digital camera (Figure 6), both encased in Blue Robotics Watertight Enclosures. Its digital camera, a Blue Robotics Low-Light HD USB Camera, is encased in the upper digital enclosure and is facing forward. The camera is able to be moved using a tilt servo. The analog camera, an analog car reverse camera, is encased in the lower enclosure and is facing vertically downward to allow the user to see objects below the ROV.

Laser

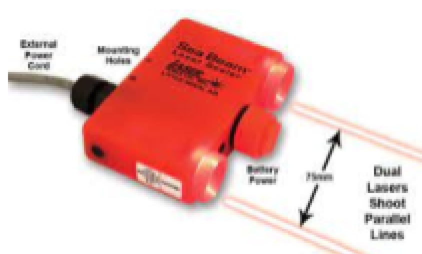


Figure 8: Sea Beam laser
Source: Lasertoolsco.com

TR3-LC makes use of a Sea Beam laser set (Figure 8). The set was originally purchased for use on the *TR2-Seahorse*, but Aquabot Technicians was unable to secure authorization for its usage until this year. The set includes two propelling lasers set at 75mm which may be used as a scale to measure set distances. It is waterproof, easily attachable, and small in size.

Control System

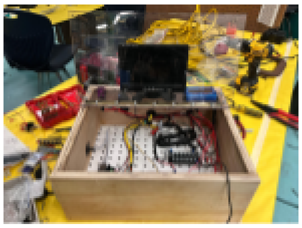


Figure 9: Control box
Source: Chapa, L. (2023)

Figure 10: Logitech controller
Source: Bluerobotics.com

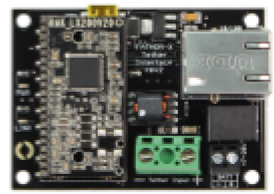


Figure 11: Fathom-X
Source: Bluerobotics.com

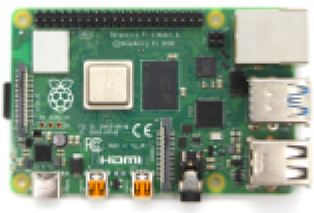


Figure 12: Raspberry Pi
Source: Bluerobotics.com

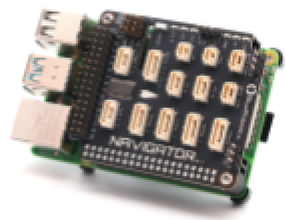


Figure 13: Navigator
Source: Bluerobotics.com

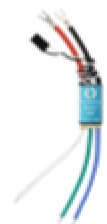


Figure 14: ESC
Source: Bluerobotics.com

All electronics necessary for control of the ROV are placed inside of a Birch Plywood Control Box (Figure 9). Power is fed through a 12V power supply separate from the box and is connected directly to a SPST (single-pole single-throw) kill switch. This kill switch allows for immediate start-up and shut-down of the system; in the case of malfunction, the ROV is able to easily be powered off and retrieved. A wattmeter is attached to the box and allows the user to monitor the flow of power throughout the ROV. A monitor in the control box displays camera feed transferred from the onboard analog camera. *TR3-LC*'s thrusters are operated using a Logitech controller (Figure 10). Once a button is pressed or moved on the controller, signal is transmitted to the laptop being used. From the laptop, this signal is transmitted to a Fathom-X (Figure 11) inside the control box, which in turn transmits the signal to a Fathom-X onboard. This signal is then transmitted to an onboard Raspberry Pi microcomputer (Figure 12) and Blue Robotics

Navigator Flight Controller (Figure 13). From there, signal is transmitted to the ESCs (Figure 14) and finally to the thrusters. Three additional switches, two DPDT (double-pole double-throw) to control the two claws and one SPST to control the laser, are contained within the control box.

Payloads

Liquid Extractor

Figure 15: Liquid extractor
Source: Rodarte, E. (2023)

The liquid extractor was built to meet two requirements of Task 2 of the 2023 MATE ROV Competition: collection of a water sample from above a coral head and deployment of probiotic fluid in an area with diseased coral. Its design consists of two syringes bolted together through the use of PVC pipe. The liquid extractor operates through the use of a hydraulic system, in which pressure, applied to water contained within one of the syringes, is transmitted undiminished. One needle is connected to a hose. The hose is manually pumped with air on deck. The pressure applied by the increased air causes the syringe plunger to move and fill the syringes with the desired amount of liquid.

Basket

The basket was built to meet the requirements of Task 2.5 of the 2023 MATE ROV competition: reintroduce endangered native northern redbelly dace fry into a new location without predators. The design consists of a plastic mesh, corrugated plastic sheeting, zip ties, rope, electrical tape, 15 meters of rope, and pool noodles for buoyancy. The basket is used to deposit fry in a safe location, once the camera locates the safe environment the basket is placed and the rope is pulled to flip the Basket and release the fry. The bottom of the basket has a piece of corrugated sheeting painted black, which is used to complete part of task 2.3.

Flashlight

The flashlight was built to meet the requirements of Task 2.3 of the 2023 MATE ROV competition: administer Rx to diseased coral. We designed the flashlight to shine light into the hole in the syringe and not allow water to enter the flashlight and break it. To do this, we fastened a flashlight to a syringe; the flashlight is operated using the syringe's plunger.

Lift Bag

The lift bag was built to meet the requirements of Task 2.6 of the 2023 MATE ROV competition: ensure the health and safety of Dillon Reservoir. We designed the lift bag to assist our ROV in lifting up the heavy container in task 2.6. Its design consists of a beach ball attached to a hanger with multiple hooks, used to attach to the heavy container's U-bolt. The lift bag is operated through inflation by an air pump on deck

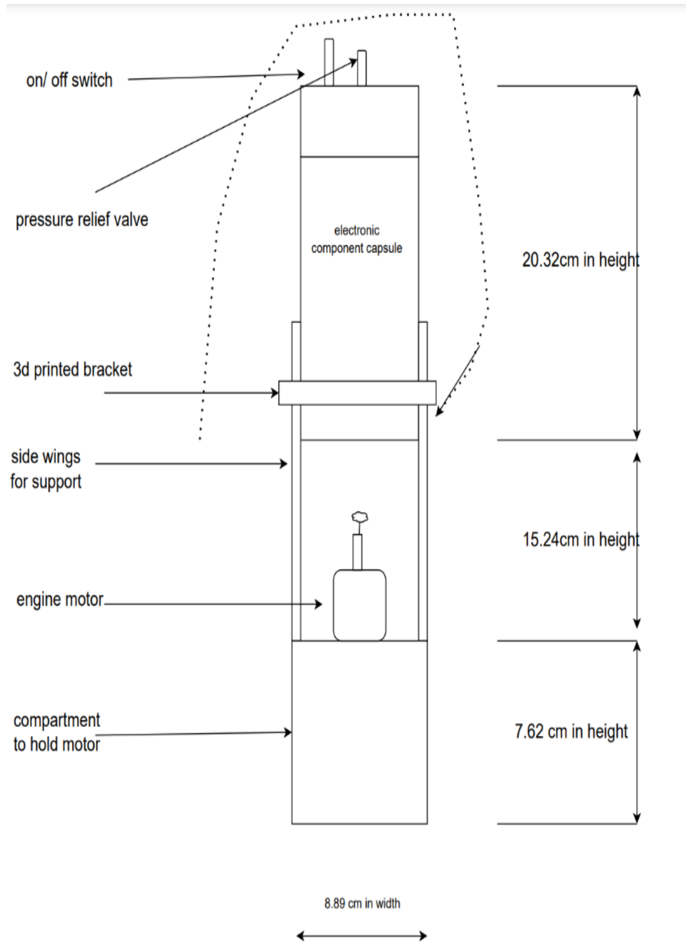
Design Rational

Figure 17: A longhorn cowfish
Source: Projectnoah.org

Figure 18: A schooner
Source: Seaindependent.com

Various benefits of each feature of *TR3-LC* and *The Schooner* were already discussed in previous sections. The "TR" in *TR3-LC* stands for "Trojan Runner," in honor of our school newspaper of the same name. It is the third in its series, a series of ROVs with translucent frames. The "LC" in *TR3-LC* stands for "longhorn cowfish," an aquatic organism which, like *TR3-LC*, is cube-like (Figure 17). We decided to use six thrusters to allow for swift movement in the water. The placement of the heave thrusters meant that we would have to sacrifice the ROVs ability to roll. However, we believed that the ROV's ability to pitch was far more important. Pitching would allow the user to easily maneuver and grasp objects immediately above and below *TR3-LC*. Its digital camera is useful in all tasks, as it allows the user to see forward. We contemplated installing a digital camera for rear view, but decided against doing so due to the complications that would arise from using multiple digital cameras. The analog camera, as was mentioned earlier, allows the user to see objects located below the ROV. The analog camera is particularly useful in task 2.4, which involves identifying the state of a seagrass bed, simulated by a grid at the bottom of a pool. *The Schooner* was named after a two-masted ship of the same name (Figure 18) due to its two black PVC stabilizers.

Non-Rov Device: *The Schooner*



In order to accomplish the requirements of Task 3, Aquabot Technicians created *The Schooner*, a buoyancy engine. *The Schooner* is programmed to complete multiple vertical profiles through the use of a Johnson Bilge Pump Motor and a timer relay. After being activated by a switch, it will remain off for a period of 90 seconds, during which it will be deployed by the ROV. After 90 seconds, the thruster will activate and push *The Schooner* downward for 60 seconds. After 60 seconds, the thruster will deactivate and the buoyancy engine will be carried upward by its positive buoyancy. This process will repeat until *The Schooner* is returned to the surface and powered off. *The Schooner*'s electronics, save its thruster, are located inside an acrylic Watertight Enclosure. Inside the Enclosure is an analog camera displaying Universal Coordinated Time (UTC) in hours, minutes, and seconds, as well as the name of our company. The entire system is encased in a modified PVC pipe

Project Management

Although Aquabot Technicians only had one returning employee this year, our workforce has enlarged tremendously; this is due in part to our introduction of spring and summer interns last year, inspiring interns to seek employment in our company. This year, our company divided itself into three groups, each presided over by an officer. We had a team focusing on the development of *The Schooner*, presided over by our CTO; we had a team focusing on the development of *TR3-LC*, presided over by our COO; and we had a team focusing on marketing, finance, and props, presided over by our CFO. This allows for members and group leaders to be responsible, help with teamwork, and be efficient in work. With the group leaders monitoring all their members safety is guaranteed. What comes with responsibility to the tasks and at hand finding the right time to complete them. Since the school year started, we met after school from 16:10 to 18:00, plus the hour class time we have during school. We also met on weekends and holiday breaks. Holiday meetings typically lasted around six to seven hours.

Innovative Solutions

Despite our company's desire to purchase new components when developing *TR3-LC*, these desires were unable to be fully realized due to budget constraints. As such, many of the parts used to construct our ROV were either taken from previous models or from our inventory of years past, such as our T200 Thrusters and digital camera. In addition, this year, our company took the innovative approach of using 3D printing as an alternative to buying new parts and digging into our inventory. For instance, both our laser mounts and brackets were created using a 3D printer.

Buoyancy

Buoyancy is an important factor when designing an ROV. In order to move effectively through the water, our Rov needs to be neutrally buoyant - that is, it should neither sink or float to the surface. Achieving this balance can be challenging, as it requires careful consideration of factors such as the weight of the robot, the weight of any attached equipment, and the volume of air in the ROV buoyancy chamber. Overall, achieving buoyancy is an important factor when designing an ROV, and can have a major impact on the Rov's performance and effectiveness.

Testing & Troubleshooting and Problem Solving

Testing our ROV in the water is a crucial step in the design process. It's important to make sure that our robot can actually perform the tasks ya'll have designed it for, and that it can do so without encountering any challenges . Some common issues we considered we might encounter were leaks in the watertight enclosure, problems with buoyancy, and difficulty maneuvering in the water. To avoid these issues, it was important to test our ROV thoroughly before the competition. Once we tested out Rov we noticed there was something wrong with the control box and system because we kept losing connection. We went back to our Natatorium many times in order to keep checking out control systems. And in the end we were able to fix some problems it may have had but we still ended up losing connection at the regional competition. Each year our company is split up into groups, one for the Non ROV and the other group for the ROV. Each of these groups are assigned to design and sketch a model of what these devices would look like.in most cases the design is identical from the year before in addition to fixing any issues the ROV and Non ROv had from the previous years which could be a frame design issue, size or even electronic concerns. In the process of constructing these devices, if any problems or concerns arise our members come together to analyze what is happening, how it's happening, and why it's causing a roadblock in the construction of either the ROV or Non ROV device. Once our issues are analyzed the next step is coming up with a solution to solve this problem or concern. In order for this to occur, multiple ideas are drawn on the table by various group members of each department and decide on which is realistic and which solution could lead to more problems. All of these solutions require trial and error. Once this solution is chosen the process of the ROV and Non ROV is resumed in the construction.

Some of the problems we had as a company this year were time management, problems with connection of our ROV and being able to sink our Non-ROV device into the water. The way we solved time management was coming to school out of service hours and working on constructing the robot. The Problems with our connection was that when the ROV would be afloat in the water we would lose connection from our laptop. Fortunately the way we fixed this was not by adding or removing any electronics from the ROV, more so it was a screw that was loose and plugging our ethernet cord into our raspberry pi. The third problem we solved was involving our float, the problem was that the float would not sink. The way we solved this was by add more weight using rebar and allowing the motor to push the capsule up.

Safety Review

Figure 20 : Aquabot Technicians CEO Deiondra Washington and Buoyancy Engine Designer Albert Mendoza seen wearing safety goggles while setting up a prototype frame for *TR3-LC* on our CNC machine, the ShopBot
Source: Alvarado, A. (2023)

While creating both the *TR3-LC* and *The Schooner*, Aquabot Technicians made safety our top priority. To ensure safety, each employee was required to pass a shop knowledge and safety test prior to entering our work space. Our Safety Engineer, Layla Chapa, made sure that our work environment, while full of potential hazards, minimized the risk of injury to our employees. When cutting materials, employees made sure to follow all proper safety procedures, such as wearing safety goggles and tying up loose hair. The Safety Engineer made sure that employees understood the function of and how to properly and safely use each tool.

Table 1: Safety Features & Procedures
• Hair must be up and out of face • No jewelry • No baggy or open clothing • Closed-toed shoes only • Safety goggles and gloves used when cutting material or working with hazardous

materials

- Tools unplugged and properly put away when they are not being used
- All sharp edges filed down
- Lexan frame is surrounded by rubber guard for further protection
- Thrusters and claws covered with hazard tape to discourage direct human interaction
- Thrusters have plastic shrouds covering blades to prevent injury to aquatic life
- Tether is covered by tether casing
- All wires and enclosures are waterproofed
- All wires in the control system are labeled
- A 12V DC power supply and 25A fuse are used for the ROV
- Power cables are effectively covered and out of sight
- An effective system check is performed prior to beginning any task

Expense Report

Expense sheet

This gives us information on how much money we need in order to build a ROV and it also gives the buyers a describition on what items we used to build this fantastic robot.

Catagory	Description	Starting date	Ending date	Type	projected cost
School Name	Foy H. Moody High School	Sept 11 , 2023	April 26 2023		
Instructor	Morio Bayarena				
income	Citgo,CCISD, Marine Technical Society company , and A & B Plastics				
					Amount
Eletectronics	Dell laptop			Donated	349$
Material	lexan sheet			Donated	63.99$
Material	camera enclosure			Purchased	97.00$
Electronics	Power switch			Purchased	5.08$
Material	power wire			Purchased	40.24$
Material	Tether			Purchased	30.24$
Hardware	SD Micro Card			Purchased	8.94$
Hardware	Electronics tray			Purchased	55.00$
Electronics	120 RPM 12 Volt DC Motor			Purchased	12.67$
Electronics	Digital Camera Servo			Purchased	64.00$
Material	Control Box			Purchased	41.56$
Material	4" Acrylic Tube			Purchased	90.00$
Material	Penetrating Bolts			Purchased	31.75$
Material	Nuts/Bolts/Screws			Purchased	41.69$
Sealant	Marine Grade Epoxy			Purchased	43.21$
Electronics	SOS Leak Senor			Purchased	32.00$
Electronics	Thruster Commander			Purchased	60.00$
Material	Electronics Tray Terminal Blocls And Hardware			Purchased	45.00$
Material	Wet Link Penetrator			Purchased	95.00$

Catagory	Description	Starting date	Ending date	Type	projected cost
Hardware	Waterproof Adjustable NPT Cable Glad			Purchased	$17.30
Material	Double Sided Duct Tape			Purchased	$4.78
Material	Gutter Guard			Purchased	$7.17
Electronics	Dc/Dc Converter			Purchased	$11.99
Electronics	Timer Module DC			Purchased	$19.35
Material	Seal Wire Connections			Purchased	$39.99
Material	Switch			Purchased	$20.00
Material	M10 Enclosure Vent			Purchased	$9.00
Hardware	Hand Operated Vacuum Pump			Purchased	$98.00
Material	Vacuum Plug			Purchased	$8.00
Sealant	Molykote Glue			Purchased	$32.00
Electronics	Sea Beam Laser SB20			Purchased	$2,652.92
Material	Double A Batteries			Purchased	$18.10
Electronics	Claw Switch			Re-used	$7.99
Electronics	Logitech Hand Controller			Re-used	$16.69
Electronics	Tv Monitor			Re-used	$169.99
Electronics	Phathom X			Re-used	$196.00
Hardware	Power supply			Re-used	$68.99
Electronics	Low-Light HD USB Camera			Re-used	$99.00
Material	Anaolog Camera Wire			Re-used	$78.00
Electronics	Gripper Claw x2			Re-used	$439.00
Electronics	Digital Camera			Re-used	$19.99
Electronics	ESC x6			Re-used	$216.00
Electronics	T100 Thrusters x6			Re-used	$833.94
Material	White HDPE			Re-used	$52.71

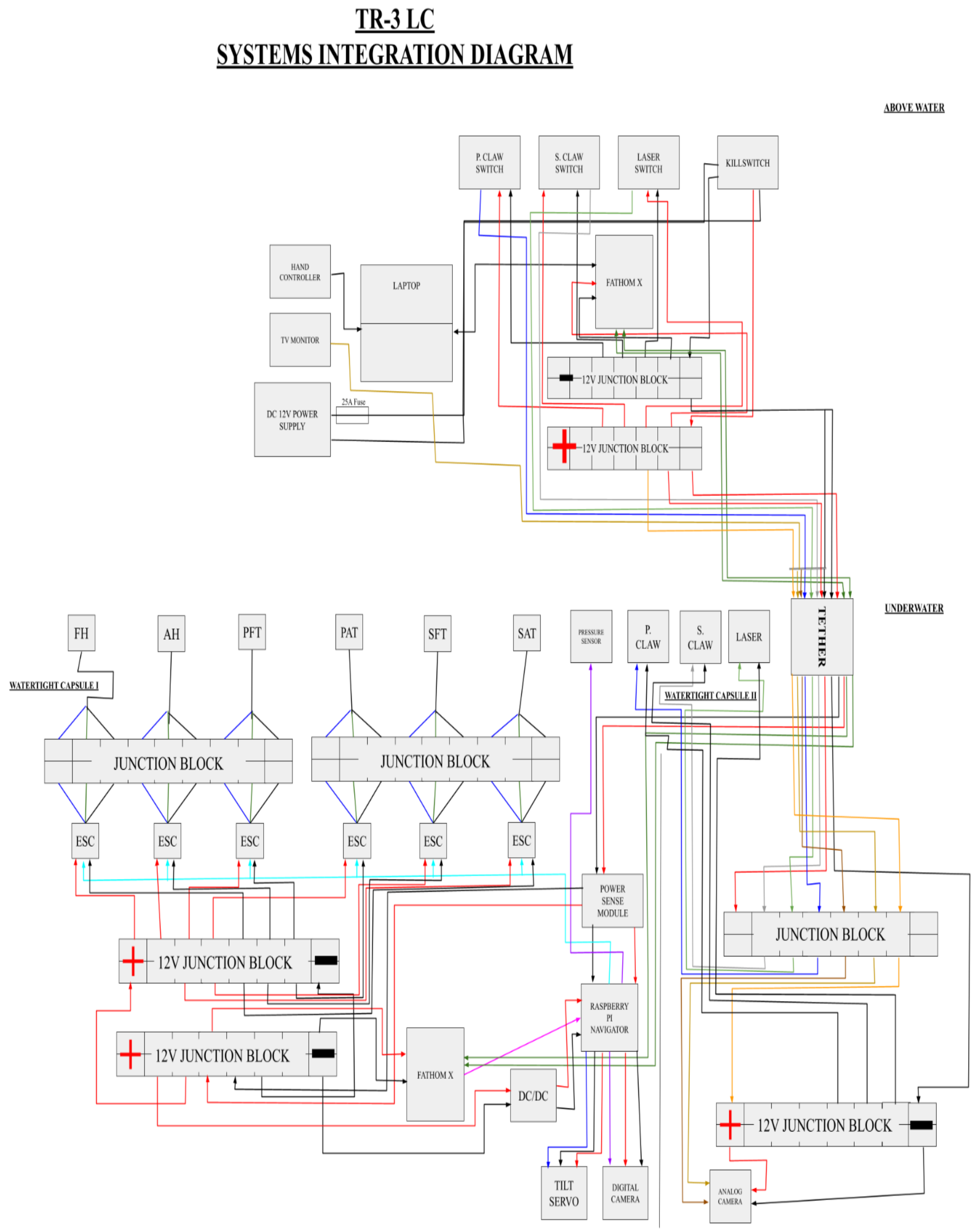
Catagory	Description	Starting date	Ending date	Type	projected cost
Material	Roller Transport Cart			Re-Used	$267.27
				Total cost	$6,611.00
			Total cost of Re-used items		$2,198.30
				Non used items	$4,145.25

Acknowledgements

We at Aquabot Technicians would like to give a special thank you to all those who contributed to the development of *TR3-LC* and *The Schooner*. Our company would not have been successful without their generous support. First, we would like to thank the Citgo Petroleum Corporation and Corpus Christi Independent School District (CCISD) for covering our travel expenses and providing us with most of our funding. Aquabot Technicians would like to thank the Marine Technical Society, and Ike Hoffman for their generous monetary donation. We would like to thank Foy H. Moody High School, our home campus, and our instructors, Mario Bayarena and Kisha Charles, for offering us guidance and support in our times of need. We would also like to thank Blue Robotics for providing us with technical support for our ROV. Finally, we would like to thank MATE for hosting their ROV Competition and providing our employees with exceptional opportunities and experiences. Lastly, we would like to thank Oceaneering for making our Texas Regional contest happen this year. Without the support of Oceaneering, we would not have been able to compete. We truly appreciate Oceaneerings hard work and dedication!

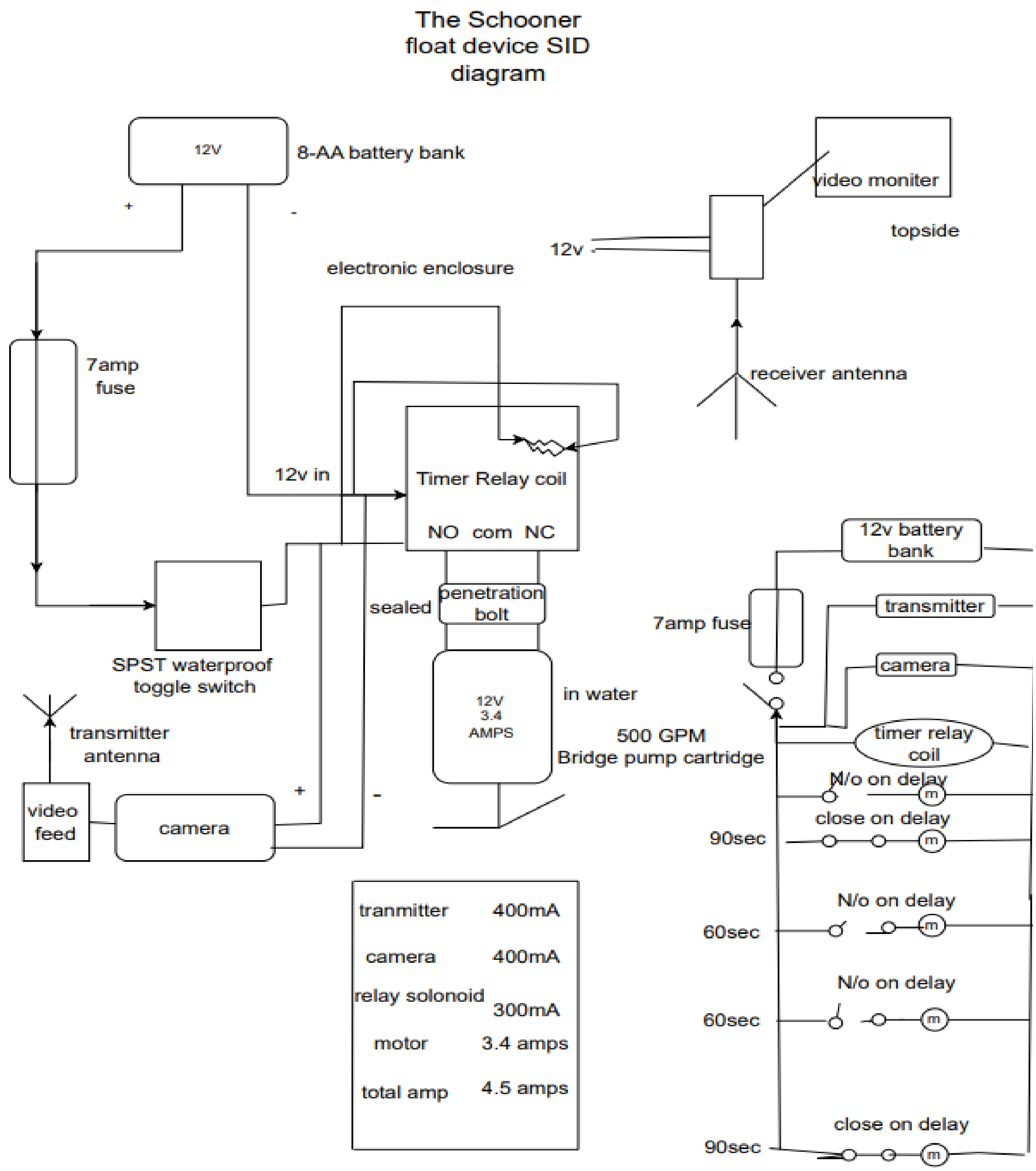
Appendices

A) *TR3-LC* Systems Integration Diagram (SID)



AMPERAGE CALCULATIONS	
	A
FH (FORWARD HEAVE)	3.1
AH (AFT HEAVE)	3.1
PFT (PORT-SIDE FORWARD THRUSTER)	3.1
PAT (PORT-SIDE AFT THRUSTER)	3.1
SFT (STARBOARD-SIDE FORWARD THRUSTER)	3.1
SAT (STARBOARD-SIDE AFT THRUSTER)	3.1
PORT-SIDE CLAW	1
STARBOARD-SIDE CLAW	1
ANALOG CAMERA	800 mA
FATHOM X	500 mA
RASPBERRY PI	500mA
NAVIGATOR	200mA
DIGITAL CAMERA	100 mA
ESC (ELECTRONIC SPEED CONTROLLER) FH	100 mA
ESC AH	100 mA
ESC PFT	100 mA
ESC PAT	100 mA
ESC SFT	100 mA
ESC SAT	100 mA
TILT SERVO	100 mA
LASER	60 mA
TOTAL	23.46
x150%	35.19

B) *The Schooner* SID Source: Perales, E. (2023)



Work Cited

N/A, N. A. (2022). Mate rov competition website. MATE ROV Competition Website. Retrieved May 24, 2023, from https:// materovcompetition.org

N/A, E. (2006, January 19). Archimedes' principle. Encyclopedia Britannica. Retrieved May 24, 2023, from https://www.britannica.com/science/Archimedes-principle

NA, N. A. (2022, April 13). The Sea Beam Underwater Laser IM. Laser Tools Co. Retrieved May 24, 2023, from https://lasertoolsco.com/product/the-sea-beam-underwater-laser/

N/A, N. A. (2023, May 24). Home. Blue Robotics. Retrieved May 24, 2023, from https://bluerobotics.com/

N/A, N. A. (2022). Overview. Overview • QGroundControl Developer Guide. Retrieved May 24, 2023, from https://dev.qgroundcontrol.com/master/en/index.html

N/A, N. A. (2022). Amazon.com. spend less. smile more. N/A. Retrieved May 24, 2023, from https://www.amazon.com/

N/A, N. A. (2022). Your success is our priority. ShopBot Tools. Retrieved May 24, 2023, from https://www.shopbottools.com