Brother Rice Robotics

“Battling for a Bluer Tomorrow”

10001, S. Pulaski Ave, Chicago, IL, USA

Photo Credit: N Scott

TIGERSHARK

Brother Rice Robotics

Alex Kmak	‘25	CEO	Nate Sears	‘26	Fabricator
Oscar Roa	‘25	Assistant CEO	Dom McCann	‘27	Fabricator
Max Griffin	‘26	Electrical & Code	Eddie Garcia*	‘26	Apprentice
Vince Walker	‘26	Mechanical	Kim Victoria*	‘27	Apprentice
Dominic Lanuti	‘26	Asst. Electric	Derek Van Dyke		Club Mentor

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Abstract

Brother Rice Robotics is committed to using robotics to improve global ocean health. We have been in operation in Chicago, IL since 2014. We have developed our new Tigershark ROV to replace our highly successful NEMO 2.0 model. Based on customer feedback and NEMO 2.0's performance at MATE '24, our goals for Tigershark were as follows; our new ROV needed to be lighter, faster, stronger and needed to have the ability to utilize specially designed tools for precision tasks in an effective and efficient manner. BR Robotics believes we have succeeded on all accounts. Tigershark is lighter, smaller, stronger, better handling and incorporates specialty tools for specific, precision tasks. Named in honor of the great deep ocean submersible explorer Victor Vescovo[1], our second generation vertical profiling float, VESCO 2.0 (Vertical Environmental Survey Collecting Omnibus), is also significantly more reliable and capable than its predecessor. The tools and capabilities of Tigershark and VESCO 2.0 will allow them to perform well at MATE 2025 and to be used by the Global Ocean Community to meet the United Nation's Ocean Decade; 10 Challenges for Collective Impact[2], including investigating shipwrecks, maintaining marine renewable energy, studying and capturing wildlife and observing and mapping the ocean.

Company Photo

Front Row (Left to Right): Nate, Eddie, Dominic, Kim

Back Row (Left to Right): Mr. Van Dyke, Max, Alex, Oscar, Vince, Dominic

Photo Credit: N Scott

TIGERSHARK

Company Profile

Brother Rice Robotics is an employee driven company dedicated to delivering the highest quality products to our customers. BR Robotics is passionate about developing advances in robotics to help better understand and conserve the planet, specifically in the area of global ocean health. We have been partnering with the GOC for some time to help better understand and conserve the global ocean and meet the UN's 10 Ocean Decade goals[1]. We currently employ 9 team members who range in company experience between 1 and 4 years and have a good mix of returning (experienced) and new (inexperienced) team members. The team uses the following considerations (Figure A) to democratically assign team member roles (Figure B), within our three tiered club structure for each season.

Role Assignment Considerations

1. Previous roles
2. Previous performance
3. Skills and knowledge possessed
4. Organization and attention to detail
5. Team commitment level and number of outside commitments

Fig. A: Credit: Credit A Kmak

Description of Team Roles

Level 3: Chief Executive Officer (CEO) — This role can be assigned singly or to a pair of individuals. The CEO(s) is responsible to lead the club and provide strategic and decisional over sight to all areas of the project

Level 2: Lead — This role takes charge of a specific branch of engineering, Electrical, Software (coding), Mechanical, CAD, Quality Control (QC) and Marketing. Leads assist in every area of the project in which their discipline is utilized. Lead's often have assistants who are apprenticing for the Lead role in the future.

Level 1: Fabricator — This role is very general and those with this designation help out in any area of the project as needed and as determined by the team Leads. These members are gathering the skills and knowledge needed to one day ascend to level 2 or 3 leadership positions.

Fig. B: Credit: A Kmak

Planning and Scheduling

Each season BR Robotics engages in two distinct planning sessions.. Session 1 analyzed the performance of the previous year's ROV. Specific areas of improvement are determined and brainstorming for those specific advances is initiated. These advances are considered "global" as they are needed no matter what the needs of the GOC may happen to be. A schedule was then put together to finish these improvements prior to the MATE 2025 release. Session 2 was held in December when MATE released the Ranger Competition Manual[3] which outlined the needs of the GOC in 2025. The team then conducted an additional planning session to determine what new tools and capabilities will need to be developed. A summary of this work can be seen in Figure C. Team leads then took responsibility for the planning and execution from that point forward.

Global Improvments			
Capabilty	Specific Improvement	Assigned to	Taget Date
Stronger/smaller frame	Build from aluminum	Vince	End Oct
ESC Phoenix connectors	Install 3x connectors on ESC's	Oscar	End Oct
TCB wiring improvements	Arduino topper and screw terminals	Max	End Oct
WTE wiring organization	Phoenix connectors & neatness	Dominic	End Nov
Improved "modular" claw	Detachable and lead screw	Alex	End Nov
Thruster orientation	4 up/downs & no strafe	Alex	End Nov

2025 GOC Improvements			
Capability	Specific Improvement	MATE Task/s	Taget Date
Task specfic tools	Detachable and specific	1,2	End Mar
Camera fine tuning	Better veiws for tasks	1,2	End Mar
VESCO bouyancy engine	Syringe and VEX motor	3	End April
VESCO pressure sensor	Custom build to work with VEX	3	End April

Fig. C: Credit: A Kmak

Project Management

Collaboration and Flexibility

The success of Brother Rice Robotics has been built largely on a culture of collaboration and flexibility. The systems approach that we employ required that we collaborated on nearly every part of Tigershark and VESCO 2.0. Each device is an intricate combination of hardware, mechanisms, software and electrical power. Leads and the fabricators that work for them were constantly consulting, working alongside and sharing information with members of other disciplines. We also pride ourselves on being highly adaptable and flexible. Most of our team members are not exclusive members of Brother Rice Robotics and are members of one (and usually more than one) other club or sport. This meant that team members would often miss meetings or entire blocks of time to meet those other outside obligations. Team Leads and fabricators often had to be very flexible and juggle multiple tasks and parts of the project at a time. Clear and frequent communication in person, via paper notes and over email and text were key to staying on schedule. Team members also regularly utilized their lunch hours and study halls in order to keep Tigershark and VESCO on schedule while still meeting all their other outside commitments afterschool.

Design Rationale

Engineering Design Process

Brother Rice Robotics uses a very simple and nimble design methodology called Agile Design[4] (Fig. D). Agile Design includes all the classic steps of a traditional 6/7 step Engineering design process as well as being iterative or cyclical in nature. BR Robotics prizes the short, simplicity of the terminology and its focus on analyzing and using data so team members have the information to decide on a solid “next step” in the ACT phase. Agile Engineering has been instrumental to BR Robotics’ success over the years. For good examples of our use of Agile Design and the tradeoffs that were studied please see Frame and Cart System in figures F and G.

- Define the problem
- Define success
- Research & Design Matrix
- Incorporate prior lessons
- Plan for/design the solution

- Build the solution
- Test the solution
- Gather data related to the success criteria from PLAN

- Implement and finalize or...
- Adjustment & retest or...
- Go back to the PLAN phase if design is far from success

- Analyze testing data
- Rate the solution based on success criteria
- Highlight and note any issues

Agile Engineering Design
Fig. D: Credit: Nicola Piccinini

Design Rationale

Innovation

Innovation is defined as the process of bringing about new ideas, methods, products, services, or solutions that have a significant positive impact and value. It involves transforming creative concepts into tangible outcomes that improve efficiency and effectiveness, lower costs, and address unmet needs[5]. BR Robotics is committed to continuously dreaming up and executing new and creative solutions to meet the needs of our clients, especially the GOC. Below are just a few of our recent innovations!

- Modular claw with lead screw actuator (pg. 15)
- "Quick change" ESC's (pg. 11)
- Using Stock Bilge Pumps as Servos (pg. 15)
- Task specific tools (pg. 16)
- Custom VESCO 2.0 Pressure/Light sensor (pg. 17)
- VESCO 2.0 control interface/method (pg. 17)

Quick Change ESC

Lead Screw Actuator
Credit: N Scott

Problem Solving

Each day at Brother Rice is an exercise in problem solving, which is a key skill that our team members must possess. Significant tenacity and grit is required to meet challenges, and arrive at working solutions that are innovative and meet or exceed the desires of our clients. Most problem solving work occurs in the PLAN phase of our agile design process. The most difficult problem our team had to solve this season were designing innovative tools to reliably and quickly complete the complex tasks required by this year's proposal. Tasks such as capturing a jellyfish, collecting e-DNA, plugging in a power connector and removing a sacrificial anode were all tasks that our claw, as capable and versatile as it is, was unable to effectively complete. Our team spent considerable time devising, testing and modifying specialized tools to complete these tasks. Our team chose to use the claw as the attachment point for the e-DNA collection tool and the Power Plug Paddles. Using the claw as the mounting point made attaching these two tools as simple as closing the claw. The e-DNA collection tool further improves efficiency by being able to be pulled in by a deckhand without the ROV making a return trip. The Wildlife Collection System was designed to attach quickly to Tigershark's frame so that both it and the e-DNA collection system can be attached at once saving a trip to the surface and improving efficiency .

Alex working on new claw design
Credit: N Scott

BR Robotics Problem Solving Procedure:

1. Clearly define and understand the problem
2. Define success criteria
3. Brainstorm as many solutions as possible
4. Research existing or similar solutions
5. Value and assess ALL ideas without prejudice
6. Use success criteria and matrix to move an idea forward
7. Save all unused ideas for possible future use

Systems Approach

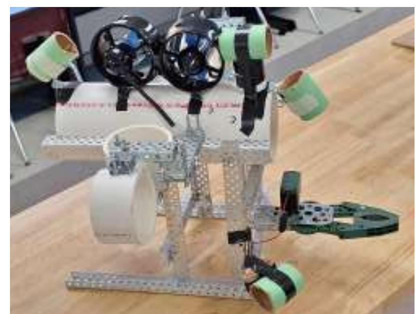
Living organisms are composed of many separate yet highly interconnected systems. Brother Rice Robotics followed this same approach when developing our "organism," Tigershark. Understanding that no system can function in isolation and that every system depends on at least one other system in order to function, we still felt it was the best choice to break Tigershark's development down into individual systems. Team members were then assigned to manage and develop each system. Due to the high level of interconnectedness between systems, team members from different systems were constantly working, communicating, and collaborating with team members from other systems. This approach dramatically sped up our build time, as all systems were in development simultaneously. Our attention to detail and collaboration efforts have allowed all of Tigersharks's systems to function together seamlessly. Organization of our systems can be seen in Figure E.

#	System	Oversight by:
1	Coding	Max
2	VESCO 2.0	Vince
3	Bouyancy	Dominic
4	Propulsion	Alex
5	Frame	Vince
6	Tether	Nate
7	TCB	Max
8	Claw	Alex
9	Cameras	Oscar
10	WTE	Dominic
11	Cart	Nate
12	Safety	Oscar

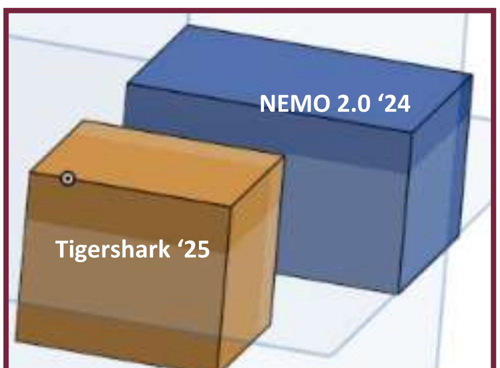
ROV Systems Organization
Figure E: Credit: Alex Kmak

Vehicle Structure: Frame

Significant time and numerous discussion sessions were spent on deciding the material and shape of Tigershark's frame. A summary of the material considerations can be seen in figure G below. Ultimately we chose to build a completely new frame out of marine grade VEX aluminum. This material came from kits in our PLTW engineering class. The metal comes in a variety of shapes and sizes and has predrilled square holes every 13mm. These holes are designed to accept the VEX nuts and bolts that also come with these kits. The material itself is much stronger than previous models that used HDPE and although is it significantly more dense we were able to use significantly less material than in previous designs. The fasteners are also much stronger than the screws used on NEMO 2.0, further strengthening the frame. The predrilled holes reduce the weight of each piece, allow us to connect a new component virtually anywhere and increase hydrodynamic flow around and through Tiger shark. We also focused on making the ROV as small as possible. Our frame design reflects this. We were able to make Tigershark 33% smaller (fig. F) and 5% lighter than 2024's NEMO 2.0. This makes Tigershark the nimblest, fastest and most maneuverable ROV we've ever built.



Tigershark Initial Concept Model
Credit: N. Scott



ROV Footprint Comparison
Fig. F: Credit: O Roa

Material	Cost	Modifiable w/ handtools	Density	Strength	Production time	Ease of attachement	Final Score	Ranking
PLA	3	2	3 (1.24g/cm)	1	1	3	13	3rd
HDPE	1	4	4 (0.97g/cm)	3	2	2	16	2nd
PVC	2	2	2 (1.45g/cm)	2	3	1 (too round)	12	4th
VEX Metal	4	3	1 (7.85g/cm)	4	4	4	20	1st

4 = Best, 1 = Worst

Frame Matrial Analysis Matrix
Fig. G: Credit: O Roa

Miscellaneous Vehicle Systems: Chariot Cart System

The cart is an all-in-one transport system and workstation; it was designed with mobility, stability, reliability, and serviceability in mind. The upper section of the cart holds our three monitors that are centered, balanced, and secured to the cart. These monitor mounts also are adjustable if needed for transportation purposes. Apart from the monitors the upper part of the cart also holds the two controllers for the propulsion and claw systems. The middle section of the cart is where the Topside Control Box (TCB) and 12v power supply are housed in a pull out drawer. When the drawer is in, the TCB is protected from the elements. When the drawer is removed, the inside of the TCB can be accessed for adjustments or maintenance to any electrical components. The drawer also can be completely removed for major repairs if needed. The bottom section of the cart houses the Tigershark. This spacious housing was custom fit to Tigershark, protecting it from bumps and drops and the wide side opening allows easy removal and placement of Tigershark on and off the cart. On the left hand side is the mount for the tether. This mount allows the tether to be secure, safe, and untangled, as well as able to be unspooled quickly. On the right hand side is a hook forthe specialized task tools we have created. The cart is versatile in not just carrying all of our needed components, but also in being a mobile workstation. The cart can be rolled easily by just one person, reducing the risk of musculoskeletal injuries to the crew. The cart has two large handles that allow four crew members to team lift the cart up or down stairs or across uneven terrain. When setting up shop, the cart's custom wheel chocks are activated to ensure the cart remains stationary. Every plug connector for power, signal and camera feed can be removed. These plugs can also be left in place to greatly speed up setup time, reduce the change of a "plug-in-error", and reduce wear and tear on the plugs and wires themselves. Finally, the cart comes equipped with a 120v AC power strip that eliminates the risk of a power surge and allows the large monitors and the 120v AC to 12v DC power supply to be plugged in. This power strip is the only connector that needs to be plugged in to activate all of NEMO 2.0's systems. The team spent considerable time early in the Tigershark build, discussing and determining the tradeoffs of a cart system vs. transporting each component individually. A summary of this work can be seen in figure H below.

Carriot Cart System
Photo Credit: N. Scott

Transportation System	Chance of operator injury		# of operators needed for transport		Set up time		Chance of damage to equipment		Allow for large monitors		Any other item required for setup?		Final Score	Ranking
Induvidual Carry	Higher	1	Four	1	Longer	1	Higher	1	NO	1	Table	1	6	2nd
Cart System	Low	2	One	2	Shorter	2	Lower	2	Yes	2	Nothing	2	12	1st

1 = Worst 2 = Best

All-In-One Cart System Tradeoffs and Decision Matrix
Figure H: Credit: Alex Kmak

Miscellaneous Vehicle Systems: Safety

Safety is top priority at Brother Rice Robotics. Our team follows numerous safety protocols during the build process and has also carefully selected and incorporated many safety features directly into Tigershark in order to keep operators, crew and marine life safe during use. Our notable safety features are highlighted in figure I. Additionally we have developed a Job Safety and Environmental Analysis (JSEA) and an operational safety checklist to be used by the pilots and crew during ROV operation. This checklist is included on page 25.

Safety Feature	Description
Thruster Guards	Custom domed design, 3D printed and conforms to IP-20 standards to ensure safety of human and marine life
Warning Labels	Custom, brightly colored warning labels denote spinning blades and pinch points
Mesh Netting	Custom mesh netting prevents hands or aquatic life from getting near the moving claw components
25 Amp Fuse	Located between the powersupply and the TCB, this fuse prevents amperage overload which could be dangerous to the pilots/crew and could damage sensitive electrical components
Tether Sheath	The tether sheath keeps all the tether wires tightly bundled and prevents tripping and entanglement
Tether Strain Relief	Strain relief has been built into both the ROV and TCB end of the tether to ensure that electrical components do not experience any undue stress/strain
Cart System	The cart system ensures that operators do not undergo significant muscular strain during ROV transport
Cart Wheel Chocks	The custom wheel chocks lock the All-in-One cart in place during ROV operation
ROV Lift Handle	The lift handle allows Tigershark to be placed in the water and removed from the water with only one hand, allowing the crew member doing this task to stay balanced during this delicate manuever
High Visability Color Scheme	The orange color choice ensures that Tigershark is highly visible to other teams/operators during joint missions
Claw circuit	The claw circuit defaults to an "open" non-powered state, allowing "pinched" objects to be quickly removed

Tigershark Notable Safety Features
Figure I: Credit: O Roa

Miscellaneous Vehicle Systems: Functional Theming

Tigershark Color Palate
Credit: N Scott

"Fin" Themed Control Surface
Credit: N Scott

Thruster Guards
Credit: N Scott

Every component on Tigershark has been carefully selected and crafted to be highly functional, and to serve a significant purpose. The theming and color scheme of Tigershark are no exception. While these features may seem completely aesthetic, each serves an important functional role. Our main theme features include a "Tiger" Shark color scheme, a dorsal and two pectoral fins that serve as control surfaces and domed thruster guards that are both unique and highly noticeable. Aesthetically the orange, white and black coloration of Tigershark invokes the color pattern of the terrestrial Tiger. Additionally orange is also our main school color. Functionally the orange frame is very noticeable, making surface or underwater recovery of the ROV easier in the event of a major malfunction. Orange also makes our ROV highly visible to other companies during team operations, reducing the risk of collisions and ROV damage. The white on the thruster guards was intentionally chosen as it is highly noticeable against the orange frame, making this dangerous part of the

ROV very visible. Having black as our third color was a cost saving choice, as a majority of purchased ROV components come in some shade of black, eliminating the need and cost of painting those components. Aesthetically the dorsal fin and two pectoral fins mirror the body design of the aquatic Tigershark and the tiger stripe paint pattern again invokes the terrestrial Tiger. These three fins are also extremely functional. The dorsal fin can be tilted left and right and can be used as a correctional rudder in the event the ROV veers to one side due to a payload or thruster imbalance. The pectoral fins also tilt and can be used as correctional ailerons in the event the ROV does not travel level through the water. When ever the ROV is functioning without issue these fins remain in their neutral (no effect) positions. Care was also taken that these fins did not cause the ROV to become caught on subsurface object. The dorsal fin is the same height as the navigation camera and the pectoral fins stick less than 2cm past the thrusters, making it highly unlikely that they would impede usability of the ROV in tight spaces. underwater.

Control and Electrical System: Topside Control Box (TCB)

Topside Control Box
Credit: N Scott

The TCB is where all the ROV magic happens! All power, signal, and camera feed enters and exits through the TCB. Multiple voltage converters are utilized to transform the 12v DC current that enters the box into the additional, 9v, and 5v loops we need to power additional components on Tigershark. An Arduino UNO stores and runs the propulsion code. Great care was taken to ensure that all wires and wiring pathways were neatly organized and well executed. Wiring pathways are neatly arranged and all wires are securely connected through, screw and snap connectors. All screw and snap connecters themselves are securely attached to the control box. Two major improvements that were made to our TCB this year were a.) an Arduino "topper" that allows all wires to be screwed into the Arduino and two distribution blocks that allow for cleaner and more secure wiring connections. Our TCB has been mounted on a drawer in the cart that seals it from the elements. This drawer slides out to allow every part of the box to be checked and adjusted as needed. Additionally, the drawer is also completely removable in the event major repairs are needed. This accessibility is key should any issues arise during MATE '25 or in the field.

Alex Adjusts the TCB
Credit: N Scott

Control and Electrical Systems: Tether

The Tether system plays a crucial role in the functionality of the NEMO 2.0, providing the necessary hard wired connection for underwater operations. Our first task was determining the appropriate length for the tether. To achieve this, we measured the dimensions of the MATE Demonstration Field, which spanned 6 meters in length, 10 meters in width, and 4 meters in depth. Utilizing the Pythagorean Theorem we went about calculating the maximum length of tether needed. That length is the distance between the two farthest corners, which are the top left and the bottom right corners respectively (fig. J). First, we obtained the hypotenuse of the surface length between opposite

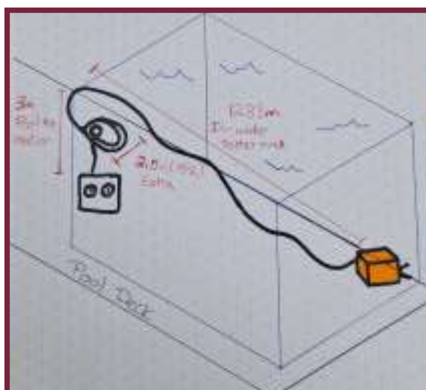


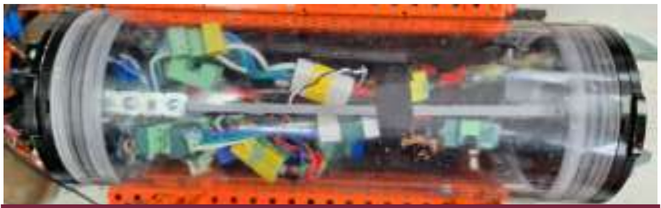
Diagram of Tether Length
Figure J: Credit: D Lanuti

demonstration corners (11.7m). We then used that 11.7m distance as a new leg of another right triangle that went down 4m to the bottom of the pool and came up with a maximum in water tether length of 12.33m. Next we added the 3m distance between poolside and control station for a total of 15.33m and lastly to account for anything unexpected we added an additional 2.5m (15%) for a total tether length of 17.83m (58ft). A diagram of our tether length methodology can be seen in figure I on the previous page. We are confident that these calculations ensure that Tigershark has ample tether for any task without inefficiency or wasted funds. The tether is composed of multiple wires, each tailored to transmit specific power and signal feeds to and from the ROV. A specialty, highly flexible 12-gauge MTD wire delivers power to the ROV, while an 8-strand Ethernet cable handles signal transmission to and from the thrusters. Additionally, 20-gauge wires manage the camera power and camera feed and 4 18-gauge wires power the two claw motors. To protect these essential wires and prevent tangling or damage, they are encased in a woven Velcro tether wire enclosure. The choice of Velcro was deliberate, as its quick disassembly and reassembly allows for future modifications or repairs while still being robust enough to protect the tether wires in both marine and terrestrial environments. This upgrade enhances the tether's versatility and ensures seamless operation of the ROV during underwater missions. The tether also is equipped with strain relief at either end to reduce the likelihood of damage.

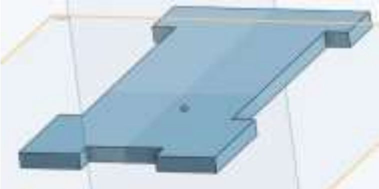
TigerharkTether
Credit: N Scott

Control and Electrical Systems: Watertight Enclosure

Brother Rice Robotics has again chosen to use a single Blue Robotics[6] 10cm dia. by 38cm long WTE. These enclosures are expertly designed and rigorously tested and are of a higher quality and reliability than anything we could construct or innovate on our own, despite their $400.00 price tag. A reliable watertight seal is vital, as a poor seal would result in mission and device failure. This enclosure houses all the incoming power and signal wires for the 6 thrusters, the electronic speed controllers (ESCs) for each motor, and the return (ground) lines before sending them back up the tether to the TCB . By completing all the power and signal connections and splits for power and signal within the water-tight enclosure we greatly reduce the amount of waterproofing that is needed and greatly reduce the risk of motor/signal failure and short-circuiting. The WTE is centered on the top of the ROV where is it above the center of mass and where it will provide the most stability. This also allows for easy access for maintenance and upgrades as well as allowing for easy visual inspection for issues. We designed a custom 3D printed electronics shelf to hold and organize all the WTE wiring. This year we innovated our new “quick change ECC’s by attaching three phoenix connector plug ends to each ECS so that replacing a broken ESC takes only seconds once the WTE is opened.



Tigershark WTE
Credit: N Scott

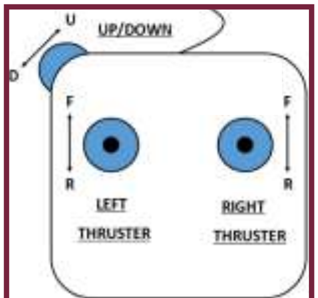


CAD of Electronics Shelf
Credit: A Kmak

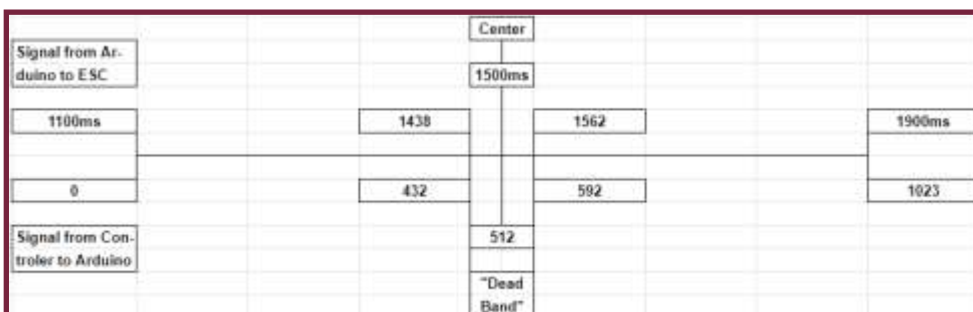
Control and Electrical Systems: Coding

Our code is written in C++ on the Arduino Uno coding platform[8] and is downloaded, stored and executed on an Arduino Uno. We like the simplicity and cost effectiveness of Arduino, as Tigershark is not currently undertaking any tasks that would require the use of more sophisticated hardware or software. The actual coding of Tigershark is elegantly simple, a sample of which can be seen in figure K. Brother Rice Robotics sees this simplicity as a significant advantage, as it leads to very few software issues and makes troubleshooting a potential software issue much easier and faster than it would be if the code were more complex. Tigershark's code execution begins at our repurposed DJI drone controller with four potentiometers which constantly send a degree value to the Arduino (Fig. L). When in the neutral position the potentiometers send a value of 512, as the stick/wheel is pushed "up" from neutral the value increases to its max of 1023. As the stick/wheel is pushed down from neutral the value decreases to its minimum of 0. We instructed the Arduino to read this incoming value and then to MAP it to the signal frequency, in microseconds, that the Electronic Speed Controllers (ECS) want to read in order to control the thrusters. The frequencies the speed controllers need is between 1100ms and 1900ms. They use this to increase or decrease thruster voltage and direction. A MAP function essentially aligns the min and max of two separate scales, in order to set them proportional to each other, so that we reach the max and min of the thruster power as we reach the max and min of the potentiometer range. A model of this MAP can be seen in figure M. After receiving the potentiometer signal the Arduino follows the MAP, calculates the frequency of the signal it needs to send and then sends it out through the assigned output port, down the tether wiring to the desired thruster. 1500ms is the center of the thruster range, and 512 is the center of the potentiometer degree range. We programmed a dead band of +/- 80 around this point to keep the controls from being too "touchy". This means that values from 1562ms to 1900ms spin the thruster forward and values of 1438-1100ms spin the thruster backwards. We re-wrote a significant portion of the code for Tigershark so that the signal from the Up/down potentiometer was sent identically to four separate outputs for our four Up/Down thrusters, as opposed to physically splitting the signal in the water tight enclosure.

Section of Tigershark Coding
Figure K: Credit: M Griffin



Controller Layout
Figure L: Credit: M Griffin

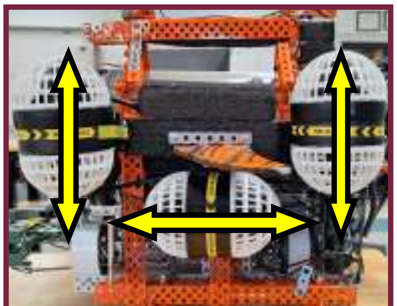


Tigershark Coding Potentiometer to Thruster Signal MAP
Figure M: Credit: M Griffin

Propulsion

Tigershark's propulsion system consists of six Blue robotics thrusters, two for forward/back control and four for up/down control. The two forward/back thrusters are T-100's that still work great after many years of service and the four up/down thrusters are T-200's. We were also able to reuse three of the four T-200's from our previous ROV. This allowed us to cut costs on Tigershark without sacrificing performance. The tether sends 12v power down the 12 gauge braided MTD wire specifically chosen to have the amp capacity to power all 6 thrusters. One power and one return line run down the tether and is split off to each thruster inside the water Tight Enclosure (WTE). Each thruster receives a control signal that runs through an Ethernet cable which splits off to each thruster inside the WTE. Tiger shark uses "tank" style steering as opposed to the more common vectored thrust configuration on many popular ROV's. Our "tank style" steering uses two thrusters for forward and back control four thrusters for up down control. The four up down thrusters work as a unit, and the forward and back thrusters work independently of each other allowing the ROV to "spin turn" left and right. All thrusters had to be placed on the outside of the ROV's frame due to our prioritization on a compact ROV design. Careful planning was undertaken to unsure that the thrusters did not "cover each other up" and thus degrade their performance. After a failed "wing" inspired design we finally settled on our current design. We chose to place the four up/down thrusters on the corners of the ROV. This gives the ROV excellent stability and roll resistance when ascending and descending due to this wide "stance". These four thrusters were placed just far enough apart that their prop flow would not come in contact with the forward/back thrusters. The forward/back thruster was placed between the up/down thruster pair on each side, just low enough that their prop flow was not impeded by the up/down thrusters. We also had to take great care to ensure that these motors were very nearly on the line of center of mass to prevent the ROV from naturally wanting to do a front or back flip when ever it is moving forward. We intentionally placed the four up/down thrusters above the center of mass, which ensures ascent stability, leaving us just enough room to fit the forward/back thrusters exactly where they needed to be installed, as seen in figure N.

Thruster Install
Credit: N Scott



Thruster Orientation & Flow Diagram
Figure N: M Griffin

Buoyancy and Stability

In order to function effectively, ROV's need to be as close to neutrally buoyant as possible. Neutral buoyancy can be defined as having the same density as water (1g/cm^3). This is achieved by making the ROV's displacement in cm^3 be equal to its mass in grams. Aluminum has a density of 7.85g/cm^3, and despite being very efficient with how much we used, still meant that we had a lot of mass to offset. Our WTE offset a significant amount of our mass and then we systematically added foam to the ROV until it was neutrally buoyant and balanced. We then measured the volume of all the foam we added during testing and then cut and attached neat foam blocks of equal volume. For an ROV to be stable in the water its center of buoyancy needs to be above its center of mass. We made sure to achieve this by installing the WTE and all the foam in a single layer near the top of the ROV. The claw, more than 90% of the frame and the two T-100's are below the buoyancy layer, and our four T-200's are centered on the buoyancy layer (fig. O). Only a tiny fraction of Tigershark's mass is above the buoyancy layer, ensuring that its center of buoyancy is above its center of mass. This makes Tigershark an extremely stable and well balanced ROV.

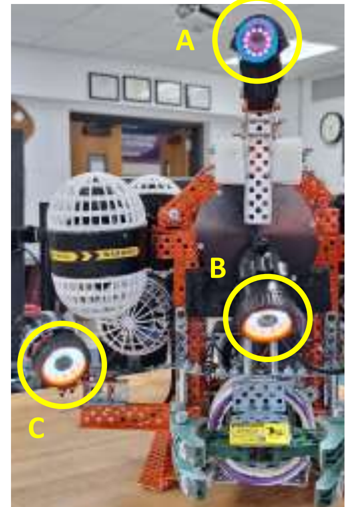
Blue = Flotation + WTE
Red = ROV mass to be offset

☆ = Center of Buoyancy
⊕ = Center of Mass

Center of Mass vs. Buoyancy
Figure O: M Griffin

Payload and Tools: Cameras

Tigershark Camera Monitor Setup
Photo Credit: N Scott



Camera Positions
Figure P:
A—Nav Cam
B—Claw Cam Top
C—Claw Cam Side
Credit: V Walker

Tigershark has three underwater rated cameras mounted to its frame. Two of the cameras are installed to provide two different close up views of the claw manipulator, giving information about the X, Y and Z axis and allowing for the completion of delicate and precise tasks. Both claw cameras possess LED lights for increased visibility in the manipulator area. The third camera is the “navigation camera” and is mounted on top of Tigershark’s frame. This positioning gives the operator a wide angle view in order to easily navigate through the environment. When the ROV surfaces it has the ability to act as a periscope allowing the operator to see crew members and easily navigate back to the entry and exit point. Additionally, the top camera is equipped with infrared lighting, a thermometer and a depth sensor (discussed in the next section). Due to their importance and the significant difficulty in custom constructing a waterproof camera the team chose to reuse all three cameras from NEMO 2.0. The navigation camera includes its own 23cm (9”) monitor that allows the operator to navigate the ROV into position and then switch to the larger claw monitors for precision tasks. The claw cameras are connected to two large, 61cm (24”) monitors that allow for greater precision in object manipulation. All three camera placements on the Tigershark can be seen in figure P.

LED Claw Camera
Photo Credit: N Scott

Infra-red Nav Camera
Photo Credit: N Scott

Payload and Tools: Depth and Temperature Sensors

Tigershark is able to measure depth as well as water temperature through two sensors incorporated into the blue navigation camera. The readings from these sensors are displayed on the navigation camera monitor allowing the pilots and crew to use and record this data as needed. While no tasks in this year’s request for proposals use these specific features we feel it is never a bad policy to give customers more than they asked for. We believe that water and temperature data could be very beneficial information to record when mapping shipwreck sites, capturing jellyfish in their native habitat and gathering e-DNA, acidity and dissolved CO2 levels, even though they are not specifically requested in the proposals for MATE 2025. Finding components that serve multiple functions is a great way to increase functionality, reduce costs and create high customer opinions.

Depth & Temp Readout From NAV Camera
Photo Credit: N Scott

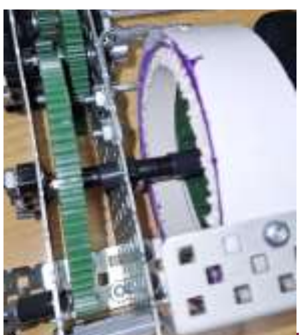
Payload and Tools: Claw

Custom "Modular" Claw Manipulator
Credit: N Scott

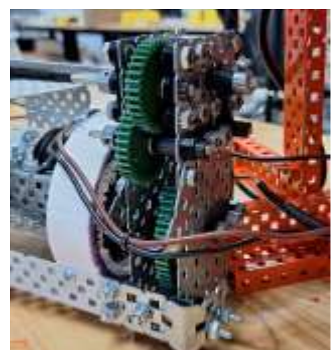
The claw manipulator on Tigershark is one of the most innovative and versatile tools in the industry. The claw is capable of grasping, carrying, and twisting objects up to 10cm in diameter. The claw can be closed and used to push objects around underwater. Two strong neodymium magnets have been built into the ends of the claw to easily pull pins, like the hydrophone release mechanism, and to pick up any other metal objects as needed. Finally the claw is the attachment point for the e-DNA extraction tool. The claw uses a lead screw connected to a 500 GPH bilge pump motor to control opening and closing of the claw. This design is significantly more reliable than previous chain and sprocket and gear train designs. An additional 500 GPH bilge pump motor rotates the claw assembly 90 degrees allowing us to twist and grab objects in numerous positions. As stated, the claw is extremely versatile and allows us to complete tasks such as moving hydrophones and PCO2 Sensors, pulling release pins, replacing thermistors, and as a mounting point for specially designed, highly task specific tools. The thickness of the claw gripper has been doubled this year, providing a more secure grasp. We also intentionally chose to have the claw open and close at a faster rate than many other competing ROVs, this allows Tigershark's gripper to hit the mark even while the ROV is drifting slightly. The submarine environment is constantly changing and ROV's are rarely ever completely stationary. In our view a claw that "strikes" quickly is a significant advantage. Rotating the claw assembly required more torque than the bilge pump motor could provide so we designed a compound gear box with a 52:1 gear reduction, slowing the rotation to an acceptable speed and significantly increasing the rotational torque the motor can produce. The ability to rotate the claw remains one of our greatest innovations and has helped us save significant costs. We chose to use bilge pump motors which are cheap ($20), yet reliable motors that come pre-sealed and can be easily controlled by a simple 3-way switch without any additional coding or potentiometers, greatly reducing complexity. Most conventional grippers would be powered by waterproof servo motors that cost upwards of $150 each and an "off the shelf" gripper from Blue Robotics[8] costs close to $1000.00. Our claw costs less than $100.00 to produce and we feel that in most ways it is superior to any other claw on the market. A matrix of our deliberation, trade offs, and final decision can be seen in figure Q. Finally, we made our claw "modular" in that the entire assembly can be removed with only two bolts. This allows it to be quickly and easily repaired in the field.

Initial Claw Concept Bench Test
Credit: N Scott

Claw Magnets
Photo Credit: N Scott



Rear Claw Cradle
Photo Credit: N Scott



Rotation Gear Box

Component	Cost	Ease of integration	Precision	Actuation Speed	Safety	Final Score	Ranking
Waterproof servo	2 ($300.00)	1 (must be coded through arduino and requires an additional potentiometer	2 (can precisely hold in any position)	1	1	6	2nd
500gph bilge pump motor	2 ($20.00)	2 (only needs power and a 3 state bi-directional switch)	1 (cannot hold, when swtich is in nuetral claw is non- energized	2	2	9	1st
1 – Worst 2 – Best							

Tradeoffs & Decision Matrix for Claw Motors
Figure Q: Credit. Oscar Roa

Payload and Tools: Wildlife Capture Cradle

Wildlife Capture Cradle (WCC)
Credit: N Scott

WCC Mount
Credit: N Scott

Affectionately referred to as the "undertaker", our Wildlife Capture Cradle (WCC) allows us to sneak up from underneath a specimen, such as the medusa jelly fish, and safely capture it. The top half the WCC's sides are made from mesh netting. This allows enough water to drain during capture so that the specimen does not "roll off", while the solid bottom half of the sides allows water from the specimen's environment to be collected as well. The WCC has 4 flags that stick up above the netting to allow the pilot to properly align the apparatus underneath the specimen prior to capture. The entire assembly attaches via a notched grove on the front of the ROV that allows it to be attached and detached in seconds.

Payload and Tools: e-DNA Syringe

E-DNA Syringe with Funnel Closeup
Photo Credit: N Scott

The claw is used as the mounting point for this tool. The frame of the e-DNA syringe was intentionally offset to allow the pilot an unobstructed view of the end of the syringe and sections of the attachment end were precisely removed to further enhance line of sight through the main claw camera. Special brackets ensure that the syringe is attached correctly each time it is used and also prevents the syringe from twisting during use. The "business" end of the syringe is funnel shaped to help it slide easily into place and three sharp prongs have been placed around the syringe inlet to puncture the plastic wrap and allow the sample to be extracted. A topside crew member feeds the tubing and works the siphon pump once the syringe is in place. A custom constructed collection vessel is attached directly to the pump. This prevents spills and greatly improves efficiency. The collection vessel detaches quickly to allow acidity, DNA analysis and dissolved CO2 testing to be conducted. After the sample has been collected, the pilot releases the syringe from the claw and the topside crew member uses the collection tubing to pull the device back to the surface.

"Line-of-sight" Notches and Pump with Collection Bottle
Photo Credit: N Scott

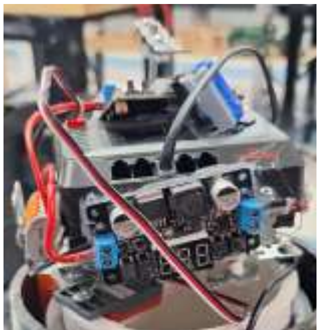
Payload and Tools: Power Plug Paddles

Power Plug Paddles (PPP)
Photo Credit: N Scott

BR Robotics custom constructed our Power Plug Paddles (PPP) to effectively grab, manipulate and insert the power plug into its socket. Grasping the metal hook on the connector has proven difficult, as it is very small and still allows the plug to rotate, making inserting it extremely difficult. Our solution was to bypass the metal hook and grab the plug directly. Our claw, however, does not have the ability to pick up objects directly off the seafloor. We designed our PPP's to extend the reach of our claw all the way to the seafloor and we custom designed them to be a perfect fit for the size and shape of the connector.

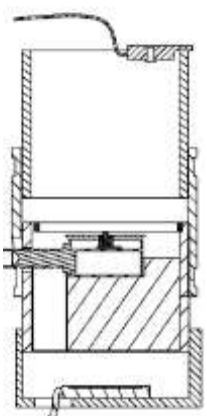
Payload and Tools: VESCO — Vertical Environmental Survey Collecting Omnibus

In 2025 VESCO 2.0 made a monumental leap from its predecessor. 2.0 is now powered by a buoyancy engine, significantly improving efficiency and battery life, has a custom built pressure/light sensor and has the ability to wirelessly transmit data when at the surface. Each of these features was lacking in VESCO 1.0. VESCO 2.0 is powered by 8 D alkaline batteries, providing 12 volts to the system. A voltage convertor reduces the voltage to 7.6 volts before entering the VEX cortex and an additional voltage convertor reduces the voltage to 5 volts prior to entering the LED puck light. A Vex 393 motor is attached to the VEX cortex and actuates a lead screw which raises and lowers the syringe to control the buoyancy of the float. A VEX light sensor is also attached to the cortex and gathers data on the light level provided by the LED light. Finally a wireless micro SD adapter is plugged in to the VEX cortex. All data gathered by the light sensor is saved to this card which creates its own wireless network. We can then access this network when the float returns to the surface. A 1.25amp cartridge fuse ensures that the system does not overdraw the capacity of the batteries. Our custom pressure/light sensor is one of BR Robotics' greatest innovations this season. Our team was set on using the VEX EXP system to control VESCO 2.0 as it is highly capable and reliable and our team has extensive experience using and coding this system through out PLTW Engineering classes. VEX however, does not produce a pressure sensor and aftermarket sensors are not compatible with the VEX system. We had to try to make something work with the sensors that VEX produces. After months of trial, error and testing, BR Robotics was finally able to devise an innovative and effective solution that converted water pressure to light that could then be measured and read by a VEX light sensor. An analog water pressure gauge was installed and a specially shaped lightweight cover was attached directly to the gauge's needle. The LED puck light was installed under the pressure gauge and a VEX light sensor was installed above the pressure gauge. As VESCO descends, the pressure increases and the needle on the gauge moves allowing more light to reach the light sensor. The reverse happens as VESCO ascends. The light sensor records the changing light levels as a percentage between 0 and 100. This data is recorded by the Cortex and stored on the wireless SD card. Through extensive testing at known depths we were able to use linear regression to create a formula that would convert the light values into kPa and depth. Another significant innovation on VESCO 2.0 is the ability to turn the float on and off and start and stop the program through the 2.5cm pressure relief opening. This greatly speeds up deployment and decreases the chance of leaks as all fasteners can be properly tightened well in advance.



VESCO 2.0 Cortex and Control Interface
Credit: N. Scott

VESCO 2.0
Credit: N Scott



CAD Section View
Credit: M Griffin

Pressure Senor Concept Model
Credit: N. Scott

P = x-17.727 / 21.5

VESCO Pressure Formula
Credit: D Lanuti

Build vs. Buy, New vs. Used

Choosing how to source components for Tigershark was of critical importance. Components can be purchased commercially, custom built in-house or reused from an earlier model. Each choice comes with its own pros and cons. Making wise sourcing decisions can mean the difference between success and failure and can significantly affect both the final cost and functionality of the project. Brother Rice Robotics spent considerable time ensuring we had a complete understanding of the sourcing tradeoffs for each critical component on Tigershark. We then discussed, debated and voted democratically on where/how to source each component. The tradeoff matrix that outlines our sourcing decisions can be seen in figure R.

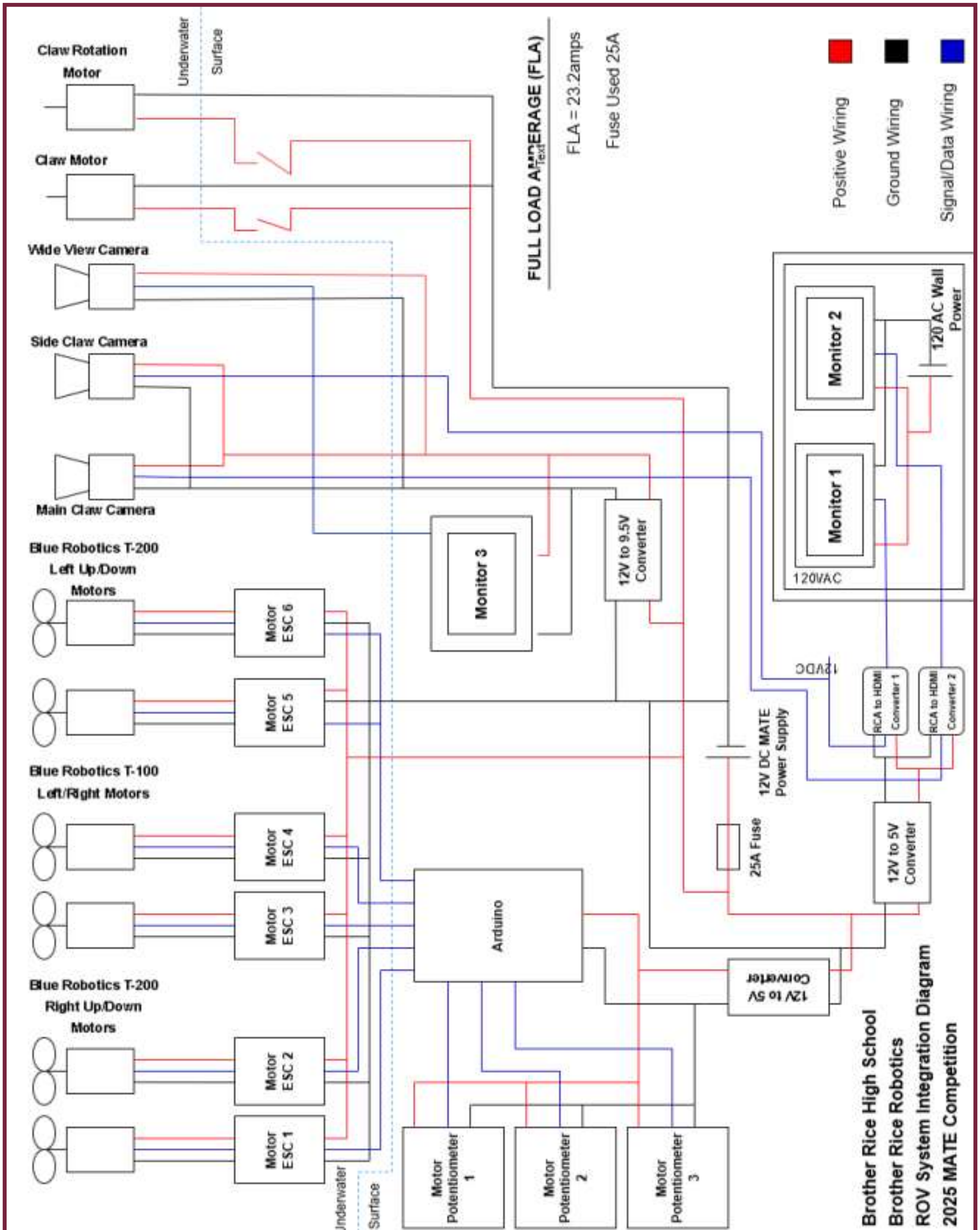
	Build		Buy		Reuse		
Component	Pros	Cons	Pros	Cons	Pros	Cons	Final Choice
Claw Gripper	Can customize exactly	90deg rotation is complicated, time consuming, realiability	Saves time, reliable	Costly, not customizable	Saves time and money	unreliable	Build
Thrusters	Exact customization	significant requied knowledge, waterproofing, reliability	Save time, reliable, compatable with existing T200's	Costly	Cant, the old T-200 is broken		Buy
Water Tight Enclosure (WTE)	Exact customization	significant requied knowledge, waterproofing, different buoyancy profile than WTE #1	Saves time, reliable, same buoyancy profile as WTE #1	Costly	Saves time and money	Existing WTE is not large enough to neatly contain all the required wiring	Re-use
Topside Control Box (TCB)	Exact customization	Time consuming, added cost for new materials	Saves time and more reliable	Costly, non-customizable to our exact components	Saves time and money	Some shortcomings will have to be changed/updated	Re-use
Task Specific Tools	Exact customization	Time consuming, reliability, water proofing	Would save time and increase reliability but these exact tools do not exist for purchase		This part does not currently exist in our inventory		Build
Frame	Exact customization	Time consuming, troubleshooting required	Saves time, troubleshooting not required	Unessisary cost, tough to find a purchased frame that meets our exact specs	Already built and ready to go	Will not fit the new design, and is starting weaken at the joints after 2 years of use	Build
Tether	Exact customization	Time consuming and costly	Saves time, confident there will be no issues	Significant cost, may not have the amount and gauge of wires we desire	Tether worked well in '24	Needs mods for an additional camera and bilge pump motor and will also need a new sheath	Re-use
Cameras	Exact customization	Lack the knowledge and skills	Saves time, confident there will be no issues	Costly	Worked great in '24	None	Re-use

Build, Buy, Reuse Tradeoffs and Decision Matrix
Figure R: Credit: O Roa

Field Reparability

BR Robotics understands that down time is extremely costly, both at MATE '25 and in the field for our customers, the GOC. We went to great lengths to ensure that Tigershark limits ROV downtime by being highly reparable in the field. The entire claw assembly can be removed, making changing motors or replacing other vital claw components easy and efficient. Our TCB is completely removable for ease of repairs. Every wire and component in our TCB is secured through a snap or screw connector. This means that any damaged wire or component (voltage convertor, HDMI convertor, Arduino, etc.) can be replaced in just a matter of minutes. We also took care to ensure that all wiring and components in our WTE are also easily and quickly replaced. Wire and components in the WTE are connected using screw and snap connectors and we have customized our ESC's to include three phoenix connector ends. If a spare ESC (with connectors) is on hand it will take longer to open the WTE than it will to replace a damaged ESC. Finally in the event that a thruster fails, we have used Blue Robotics Wet Mate Connectors to install and seal our thrusters to the WTE. This makes replacing a thruster a breeze and the ROV could be back up and running in no time. At MATE '25 BR Robotics will have all these replacement components on hand so that a failure will hopefully not spell disaster for our ability to compete. We would also advise any of our GOC customers to have ample spare components on hand so that they too can make use of Tigershark's high degree of field reparability.

System Integration Diagram (SID)



Tigershark System Integration Diagram
Figure S: Credit: M Griffin

Safety

TIGERSHARK

Safety is a top priority at BR Robotics. Team members are trained how to safely use the tools and materials required to build Tigershark. Team members underwent training on how to safely use drills, hand-saws, belt sanders, hot glue guns, soldering irons, and heat guns. We had training on how to properly clamp materials as well as training on how to properly and safely use electricity. We have a designated cutting/drilling table and a designated "hots" table in our shop. Care is taken to ensure the shop and all work tables stay neat and organized. When in the pool area we ensure that at least two team members are always present. Running and roughhousing on the pool deck is never allowed. Team members are trained to know where the life preservers and AEDs are located. As an added bonus to ensure the safe operation of Tigershark by our customers we have created a safety procedure checklist (Fig. T) that is included with Tigershark. Users should follow this checklist during setup, operation and take down of the ROV, to ensure the pilots/crew and all ROV components remain protected. Tigershark comes equipped with numerous, built in, onboard safety features, these were discussed earlier on page 9 and in figure H.

Brother Rice Robotics

Updated: 5-14-25

Tigershark ROV Operational Checklist

Pilot and Crew Considerations
☐ Ensure that all individuals have closed toed, grippy footwear
☐ Ensure that all individuals minimize loose/baggy clothing
☐ Ensure that all individuals understand their roles and responsibilities

Pre-powerup Procedure
☐ Visually inspect the operating area for potential hazards
☐ Position the cart within 3m of the water
☐ Chock all 4 cart wheels
☐ Ensure that all wires are properly connected to the TCB
☐ Adjust monitor positions
☐ Plug the power strip into a 120v outlet
☐ Grab front and back of ROV frame to remove from cart
☐ Place ROV near the waters edge
☐ Visually inspect the ROV for damage/issues
☐ Remove tether from cart spool and coil neatly near ROV

Powerup Procedures
☐ Turn on the power supply
☐ Listen for the correct motor chime pattern
☐ Ensure camera feeds are working
☐ Perform a motor functionality test
☐ Perform a claw functionality test
☐ Adjust camera angles on ROV if needed

Launch Procedures
☐ Use the lift handle to lower ROV into the water
☐ Submerge the ROV and tilt backwards to fill the BRVs
☐ When BRVs stop bubbling release the ROV

Retrieval Procedure
☐ Use lift handle to remove ROV from water
☐ Place ROV on waters edge
☐ Grab the back of the ROV and tilt forward to drain BRVs
☐ Grab the front and back of the ROV frame and place on the cart
☐ Coil the tether on the cart spool
☐ Ensure that both controllers are hooked on the cart
☐ Tilt the monitors down into their traveling positions
☐ Remove the 4 wheel chocks

Continual Maintenance of the operating area
☐ Ensure that the operating area is well organized and free of tripping hazards
☐ Ensure that all tools and equipment are placed on/in their designated positions
☐ Continually ensure that excess tether is neatly coiled on the ground

On Deck Operational Safety Checklist
Figure T: Credit: O Roa

Testing Methodology

Every part of Tigershark has been rigorously tested for functionality and reliability. Early in the build each component was tested as efficiently and effectively as possible. An example of this is the evolution of our claw manipulator. After completing the mechanical changes to the drive train of the claw it would have been inefficient to have immediately attached the claw to the ROV and wired it up to it's motor. Instead, we conducted multiple rounds of intermediate testing and made many adjustments and changes along the way with the performance data we collected. First we tested it by simply moving the claw by hand. We looked for issues, felt for smoothness and friction and got a general sense of how the claw and lead screw were working. Next we attached the claw motor and wired it up to its switch and operated the claw with it clamped to the workbench. This helped us determine if the speed was appropriate, if gears were slipping and if the motor was strong enough to do the work we envisioned. This round of testing led us to add a 52:1 gear reduction to both slow the claw rotation speed and increase torque. Finally we attached the claw assembly to the ROV as designed, "dry" tested it on the bench to ensure it was still working and then took it to the pool to "wet" test it. Nearly every component on Tigershark went through a similar testing process. Once all systems were working as desired it was time to put the entire ROV through its own round of testing in the pool to ensure that each system was functioning harmoniously with each other system. The pilots and crew then put the ROV through its paces, practicing each MATE '25 task, spending extra time on the most difficult tasks, brainstorming strategies to make each task simpler, determining an "order of events" (the best order to complete tasks in order to earn the most possible points during the pool demonstration) and then practicing this routine until they were confident and competent in their roles.

New Claw Bench Test
Credit: N Scott

Troubleshooting Strategies and Techniques

In engineering, problems are the name of the game and troubleshooting is the tool used to solve those problems whenever they arise. At BR Robotics we have honed our troubleshooting expertise over many seasons, and have condensed this knowledge into a 5-step troubleshooting procedure that can be seen in figure U on the next page. Effective troubleshooting requires that the engineer does not make assumptions or jump quickly into isolation or solutions. This will assuredly waste time, effort and most likely money on a solution that at best might only partially fix the issue. When an issue arises that needs troubleshooting we first spend considerable time observing and analyzing the issue and work hard to gather actual data that can be used to design a solution and to allow us to measure how effective our solution is. Next we study what ROV systems might be contributing to the issue. We use all this data and information to plan the most effective way to begin isolating components to find the problem. Isolating components is the fourth step and while it is highly effective it is also very time consuming and the ROV is out of commission during the entire isolation process, slowing down the build and pilot/crew training.

During the isolation phase we find creative ways to bypass individual components in a systematic way until the ROV begins to work properly. That component is then identified as the issue and must be repaired, modified or replaced (step 5). We spent considerable time troubleshooting a thruster control issue this season. All four of our Up/Down thrusters began to work erratically. After gathering data about the issue and determining what systems might be involved, we determined that it must be an electrical signal issue. We chose to start at the beginning of the signal pathway which is the controller. We swapped to a backup controller and got the same results. We swapped in a spare Ethernet cable and got the same results. We traded out and reconnected the signal wires from the Ethernet port to the Arduino and even re-downloaded our code, thinking it may have been corrupted. Nothing fixed the issue. The four Up/Down motors are controlled by a single potentiometer on the controller. That signal is fed to the Arduino which maps it the to proper PWM signal and sends that down the tether to the ESC's. During our build we chose to simplify our signal pathway by running a single signal line to the WTE and then splitting that signal to the 4 motors. We surmised that splitting the signal may be the issue. We chose to avoid any signal splitting by changing the Arduino code to send out the identical PWM signal for Up/Down control on 4 separate lines. These lines already existed in our tether, so this was not a major issue. This fix finally solved our thruster issues.

BR Robotics Troubleshooting Procedure		
Step	**Title**	**Action**
1	Observe and Analyze	Gather as much quantitaive and qualitative data about the issue as possible
2	Determine the System/s	Based on the data determine what system/s might be involved in the issue
3	Brainstorm/Plan	Brainstorm possible causes and a plan to isolate and confirm the issue
4	Isolate	Remove/bypass systems/components to confirm what the issue is
5	Repair/Innovate	Repair the issue or innovate an improvement that fixes the issue

Brother Rice Robotics Troubleshooting Procedure
Figure U: O Roa

Prototyping and Testing

Prototyping and testing is key to BR Robotics keeping customer costs as low as possible and meeting project deadlines. We strive to find the fastest and cheapest ways to bring our ideas to life. This often starts with a paper sketch that is studied and modified significantly before any prototype is created. We often create a physical, full size model of the component from paper/cardboard and check for feasibility and fit. We then model the component in CAD using Onshape[8] and often 3D print a prototype with our Makerbot 3D printers[9] when applicable. We continue to iterate as many versions as needed until the component is working as desired, and passes all the tests that it needs too. Images of our prototyping process including our VESCO pressure/light sensor, ROV frame, claw and thruster guards can be seen in the images below.

Examples of Prototyping Process
Credit: N Scott

Project Accounting

TIGERSHARK

BR Robotics began the 2024-2025 season by estimating and projecting costs. After determining the amount of seed money BRHS was willing to contribute the team made projections as too how much would need to be spent on each ROV system. These projections can be seen in figure V. The team emphasized the need to cut costs wherever possible so as not to go over budget as the team had no leftover funds from the year before. Throughout the build, costs were recorded, including reused parts, so a total ROV cost and the '25 final budget, could be determined, see figures X & Y. BR Robotics has standing donors ready to cover travel expenses if the team is successful enough to make it to the World Championship. Our proposed travel costs can be seen in figure W.

Type	Budgeted Amt.	Description (as of 10/08/24)
Donation	2000	Yearly seed money for our program
Electronics	200	May need misc electrical supplies
Bouyancy	0	Shouldn't need anything
Propulsion	250	Enough for 1 replacement motor
Materials	200	May need misc structural supplies
Fasteners	25	May need misc fasteners
Adhesives	50	May need misc adhesives
Tether	0	Shouldn't need anything
Camera	200	Need a new LED camera
Claw/Tools	250	Total rebuild
Vesco	625	Estimate of VESCO cost
Misc	200	Slush fund for any overages
Total	2000	

Proposed Project Costing 24-25
Fig. V
A Kmak

Regionals	Category	Amount
	Travel (rental/gas)	100 (gas only)
	Lodging	0
	Food	0
	Activities	0
	Entry Fee	250
	Total Expenses	100
*** BRHS will cover the gas and fee for regional attendance*		
World Champ	**Category**	**Amount**
	Travel (rental/gas)	1000 (gas only)
	Lodging	5000
	Food	500
	Activities	500
	Entry Fee	250
	Total Expenses	7250
*** Donors are lined up to cover WC expenses if we make it*		

Estimated '25 Team Travel Expenses
Fig. W: A Kmak

Type	Amount
BRHS Donation	2000
Total '25 Costs	1843
Balance	157

Simplified Final Budget for 2025
Fig. X: A Kmak

Component/System	Source	Description	Cost
Thrusters	Reuse	3 T-200 & 2 T-100 & 4 ECS	1200
Thrusters	New/Build	2 T-200 & 2 ESC	250
Frame	New/Build	VEX Aluminum	40
Frame Fasteners	New/Build	VEX bolts, crown nuts and lock nuts	22
WTE 1	Reuse	Blue Robotics 4" x 15" Acrylic	400
Tether	Reuse	12g MTD wire x 2, ethernet x 1, 20g x 2	125
Tether	Reuse	12gauge MTD, Ethernet, 20gauge x4 for claw	100
Tether	Reuse	Velco protective sheath	58
TCB	Reuse	Box, wires and connectors	50
TCB	New/Build	Arduino screw topper and distribution blocks	55
ROV Cameras	Reuse	1 LED and 1 intfrared fishing cameras	285
New LED Camera	New/Build	1 LED fighing camera	143
Camera Feed	Reuse	VGA to HDMI convertors	50
Large monitors	Reuse	24" computer monitors	93
Drone controller	Reuse	Repurposed drone controller with 3ft. ethernet	40
Claw controller	Reuse	3D printed box and 3 way switch	9
Thruster Shrouds	Reuse	3D printed	15
Claw manipulator	New/Build	2 bilge pump motors, VEX metal/Claw and lead screw	100
Cart	Reuse	Cart was repurposed into the new cart system	90
Electronics	Reuse	Arduino and 4 voltage converters	50
Paint	Reuse	Orange and black latex left from 2024 build	25
Stickers	New/Build	Warning labels from Stickeryou.com	45
Adhesives	New/Build	Hot glue sticks and waterproof epoxy	100
Zip ties	New/Build	Variety pack	12
Heat shrink	New/Build	Variety pack	17
Task Specific Tools	New/Build	Misc parts as needed	250
VESCO Electronics	New/Build	Vex cortex, wires, fuses, 393motor, connectors, 3 way switch	526
VESCO Housing	New/Build	PVC pipe, endcaps, PVC cement, rubber boot	105
VESCO Motor	New/Build	500 GPM Bilge Pump Motor	22
VESCO pressure sensor	New/Build	Pressure gauge, LED light, PVC, VEX light sensor	79
VESCO Interior	New/Build	Vex metal, HDPE, D Battery holders x 4	32
VESCO Batteries	New/Build	8 D Batteries and fuse	45
		Cost of new parts on Tigershark	1034
		Cost of reused parts on Tigershark	2590
		Cost of VESCO 2.0	809
		Total Cost of Tigershark	3624

Itemized Budget for Tigershark and VESCO 2.0 for 2025 Season
Fig. Y: A Kmak

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R VROOM SERVICE

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	Brother Rice Robtics Tigershark Basic Troubleshooter
	ROV Not Powering on
1	is the ROV is plugged in to a 120v wall outlet?
2	is the 120v wall outlet and/or GFI working properly?
3	is the cart powerstrip on?
4	is the power supply plugged into the powerstrip?
5	are the front and back powersupply cords plugged in properly?
6	has the powersupply fuse blown?
7	If the ROV still will not power on the ROV will need intensive troubleshooting
	Thruster/control Issues
1	turn ROV off and wait 30 seconds to allow for residual power to leave the system
2	turn ROV on and see if same issues occur
3	turn ROV off
4	is the controller Ethernet cable plugged in securely on both ends?
5	are the 12v power and motor signal cords plugged securely into the back of the TCB?
6	are all signal wires form the controller Ethernet port to the Arduino secure?
7	are any 12v power wires inside the TCB loose or damaged?
8	is the 5v power conterter for the Arduino functioning properly?
9	is the arduino power light illuminated?
10	are an wires loose of damaged in the WTE?
11	If the thrusters still do not function properly the ROV will need intensive troubleshooting
	Claw Issues
	Claw not working at all
1	is the Ethernet cable from TCB to claw controller plugged in securely?
2	do all claw wires in the TCB appear connected and in good condition?
3	If the claw still does not function properly the ROV will need intensive troubleshooting
	Claw Working But Not Fully or Smoothly
1	check the claw geartrain, roataion geartrain and rotation cradle for damage/foreign objects
2	lubricate all black VEX bearings
3	If the claw still does not function properly the ROV will need intensive troubleshooting
	Camera Issues
	Claw Cameras 1 and 2
1	are the claw monitors plugged into the powerstrip?
2	are the claw monitors turned on?
3	ensure that debris is not covering the camera lens
4	are the exterior HDMI cables plugged securely into the TCB and both monintors?
5	are the 2 cam power plugs and 2 yellow signal plugs attached securely to the back of the TCB?
6	are the white signal convertors in the TCB powered on?
7	are the internal HDMI cables plugged in securely?
8	If the camera still does not function properly the ROV will need intensive troubleshooting
	Navigation Camera
1	is the navigation camera monitor turned on?
2	is the cam power on the backside of the TCB securely connected?
3	ensure that debris is not covering the camera lens
4	If the camera still does not function properly the ROV will need intensive troubleshooting
	Water Tight Enclosure Leak
1	are all endcap bolts and all cable penetrators tight?
2	remove the endcaps, clean, dry and re-seat endcap gaskets
3	remove enclosure flanges, clean, dry and reseat all flange gaskets
4	reassemble WTE