2025 Technical Document

Underwater Research Robot Company

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Defiance

the 2025

UR^2 ROV Design

1. Abstract

At UR^2 (Underwater Robot Research Company), our innovative team of high school students has been building remotely operated vehicles (ROVs) since our founding in 2009. We designed and constructed an advanced ROV for this year's competition featuring an aluminum frame with PETG-CF 3D-printed skin for optimal hydrodynamics and durability. We engineered specialized tools, including a precision mechanical manipulator and pilot-positionable high-definition (HD) cameras, that provide comprehensive visual feedback. Our ROV is powered by six brushless thrusters, enabling precise maneuverability. A 15-meter tether connects it to our surface control station. These purpose-built systems enable our ROV to effectively document shipwrecks, deploy spotter buoys, and monitor invasive species and the impacts of climate change in the Great Lakes. Our technology also demonstrates capabilities relevant to marine renewable energy projects, where ROVs monitor environmental effects while supporting sustainable power generation—reflecting how student-engineered solutions address real-world underwater challenges.

2. PROJECT MANAGEMENT:

Our Company

Our company, UR^2, comprises students from grades nine to twelfth. Although we are young in age, most of our team members have been building ROVs since fifth grade. UR^2 has much experience. Our team comprises thirteen members; Our officers are a CEO, CFO, CDO, and CTO. They have Multiple responsibilities within the company. The CEO oversees all company operations and is also our lead software engineer. The CFO oversees company expenses, while the CTO oversee the development of our ROV hardware and subsystems, and our CDO takes care of all designed elements and manages all the team documents and due dates. Our company may be small, but we are motivated and passionate. With thirteen members, we share the load of responsibility. This is why self-reliance is one of the key traits we look for in people who want to join our company. Team members must be motivated and driven to get things done. When we bring on a new member, everyone is responsible for training and bringing them up to speed. We encourage our team members to explore their passions and pursue what they love. Our company starts meeting in August for strategic planning and ROV design. We developed a design criteria outline to give us some structure for our design decisions to follow. We started with three main objectives: Reduce the overall size and weight of the ROV. Develop a new operating system. Build a reliable vertical profiler, "Float."

What We Do:

- **Protecting:** UR^2 has partnered with the Thunder Bay National Marine Sanctuary and the NE Michigan Great Lakes Stewardship Initiative to support the mission of protecting and preserving our local freshwater resources.
- **Preventing**: Working with companies like Viking Cruise Line to develop substrate samplers that can be used in the Artic to take samples that will be used to create a data base of both biotic and abiotic factors to develop heath assessment of substrate ecosystems.
- **Preserving**: UR^2 has partnered with Alcona Community Schools and the Hubbard Lake Sportsman Association to use an autonomous surface vehicle with side scan sonar to identify historically interesting targets in Hubbard Lake and use our new photogrammetry technology to create 3D images of targets to research.

In the image above Kylie, team fabricator, shares with middle school students about STEM opportunities in marine technologies during a STEM event the team hosted at the Thunder Bay Marine Sanctuary in February of this year.

2. PROJECT MANAGEMENT:

The design team starts meeting in August for strategic planning and ROV design. UR^2 developed a design criteria outline to give us a structure for our design decisions. UR^2 started with three main objectives:

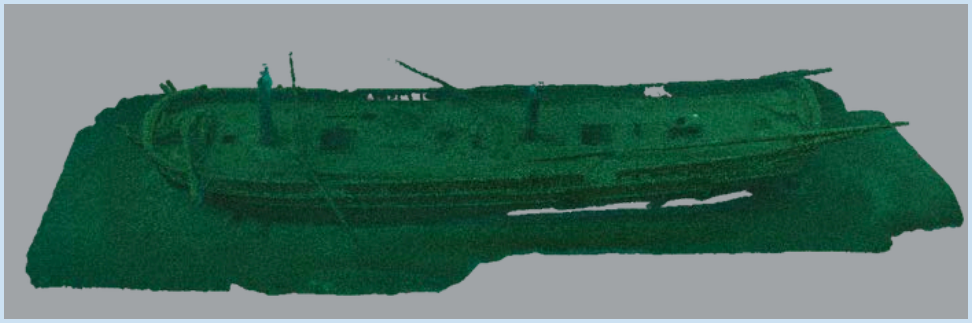
- Reduce the overall size and weight of the ROV.
- Develop a new operating system.
- Build a reliable vertical profiler "Float"

Our goal is always to develop a highly functional and innovative robot, but our company also needs to generate the resources to build a robot. Our company is always looking for ways to secure funding opportunities and develop partnerships to create projects. Leveraging our success at the 2023 World Championship, UR^2 secured two major projects working with Viking Cruise Lines and the US Naval Warfare Center at Crane. These partnerships provide us with world-class mentorships and opportunities to fund our ROV development.

UR^2 start officially meeting once a week on the second week of September. Our team creates a project plan to give us a timeline for completing components of the ROV. This year, UR^2 focused on our three goals and divided the team based on these goals. We partnered with the Alpena STARBASE program to train team members on using the CAD programs OnShape and Fusion 360. The team worked to develop a basic frame design, research possible changes in thrusters and operation systems. The team continued to prototype ROV ideas until the official mission tasks were released. Our goal is to have several options ready so that when the mission tasks are resealed, UR^2 can make adjustments and start building. At the release of the mission tasks, the team starts meeting twice a week. Once January comes, we are in full ROV season and meet three to four times a week until the Great Lakes Regional ROV Competition.

Our 2005 ROV design was developed through a collaboration with the Thunder Bay National Marine Sanctuary (TBNMS). The UR^2 Company has partnered with TBNMS since the early 2000s. Our most recent collaboration has been focused on developing educational material. Our team has used our 3D printer to create ROV frames and support equipment for years. The TBNMS asked if we could use our 3D replication skill to build 3D model of shipwrecks. Our first attempt was the wreck *Defiance*. Team members got to know the history and condition of the wreck that we chose to name this year's ROV design in honor of the shipwreck *Defiance*.

The image to right is a scan of the *Defiance* as she rests at the bottom of Lake Huron. She sank from a collision with another ship in 1854. Both vessels sunk shortly after the collision, and all crew members survived.



2. PROJECT MANAGEMENT

Keeping the Project on Task

UR² created a new team position of Project Manager for the 2025 season to help manage the project timelines and keep tasks on track. This addition to the organizational structure addresses the growing complexity of UR²'s project list and the need for enhanced coordination across research, development, and fabrication teams. The Project Manager role has comprehensive responsibilities, including timeline development, resource allocation, risk management, stakeholder communication, and progress tracking across all projects. By establishing this dedicated position, UR² aims to improve project delivery predictability, optimize resource utilization, enhance cross-functional collaboration, and ultimately deliver higher-quality ROVs such as Defiance and a reliable float.

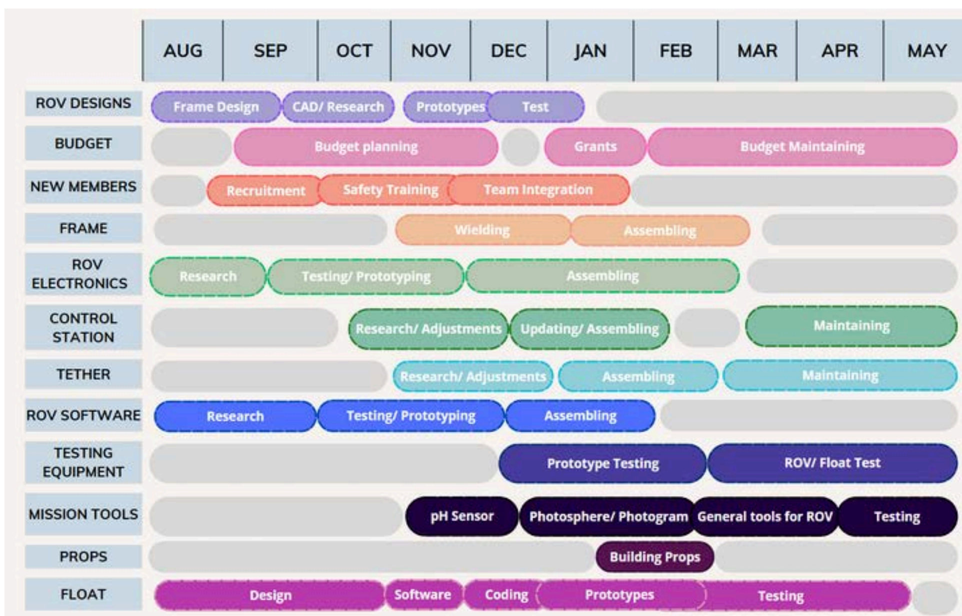
The first major task assigned to the new Project Manager was to create a master timeline for developing research projects, prototypes, and the completion of the Defiance vehicle and float. In previous years, the organization struggled, and many projects were left untouched and forgotten. Now, with someone overseeing everything and documenting progress, we have been able to meet deadlines and achieve our goals effortlessly. The Project Coordination Google Form was a significant factor in this success, which was distributed at the beginning of the year.

Project Coordination Google Form

These are the first couple of questions that members will answer every Saturday:

- What is your name and job title
- What is the name of the project
- Give a detailed outline/summary of the project
- List all steps that went into completing the project so far
- Was the start date or the project
- Was the end date or the project
- How did your project correspond with the MATE mission?

UR² Project Planning



UR²s new Project Manager, Myah Rondeau, has overseen the 2025 season timeline spanning research, prototyping, and production of the Defiance vehicle and the float. The build schedule runs August through May, with parallel development tracks, clear milestones, and detailed tasks to ensure successful completion by year-end. This includes MiSTEM projects such as the Viking sediment sampler, freshwater acidification research project, STEM outreach projects such as Brick Build Competition. Additionally, we have supported and mentored several area ROV teams.

3. DESIGN RATIONALE

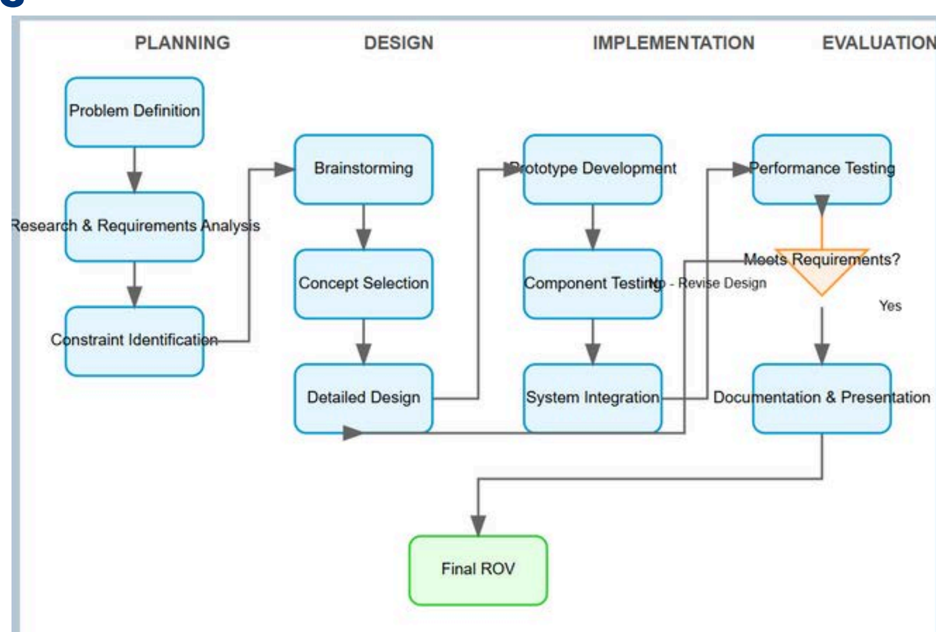
Team leadership started meeting in August and started creating a check list of items that we thought we need to keep, those that needed to be updated, and items that needed to change. Last year's ROV design worked well, but we had hardware failures that caused the ROVs operations to be unreliable. We created the following help guide our design rationale.

2024/2025 Build Agenda	Reuse	Update	Change	Brainstorm
Control Station	X			Look for an improved aesthetic look. Worked well, but doesn't need better functionality.
Ground Control Software			X	Implementation of ROS or look at Cockpit
ROV Operation Software		X		Update BlueOS or change to ROS
Enclosure		X		Keep Pi/Nav Board, but assign Pico
Grabber	X			Basic maintenance and cleaning
Camera	X			Keep the current cameras, but reduce the number to two.
Frame			X	Total rebuild. We want a solid metal frame.
Tether		X		Change the main power conductors, keep the Ethernet cable.
Thrusters			X	Change the thruster configuration to a six-thruster vector system.

Our last three designs featured 3D-printed frames, either fully printed or using a hybrid approach. We experimented with various materials, including carbon fiber and ABS, but the results have been mixed. None of these frames have lasted a full season without requiring repairs. This year, we will use a solid aluminum frame in our design.

Engineering Design Process

Before developing a new design, we start by identifying constraints, determining what needs to be researched, and examining potential problems. One significant issue became apparent right away: we wanted a solid aluminum frame but aimed to avoid prefabricated materials like Vex or VersaFrame. To achieve this, we needed a team member with welding skills capable of working with small aluminum stock. This requirement raised further concerns regarding the complexity of the frame, as it would depend on our ability to weld the components together.



ROV Engineering Design Process

3. DESIGN RATIONALE

Innovation

The Defiance design pushed the creativity and imagination of our design team this year. Designing, prototyping, and testing was the backbone of this year's design. We learned and implemented a new ground control system that provides great control and configuration to meet the needs of the pilot and the task. Our Raspberry Pi system provides a budget-friendly solution for reliable processor control. The code and Navigator collaborate to interpret analog input from the joystick into the required electronic speed controllers for the T200 thrusters. This year's design can manage the thrusters, camera, and manipulator with an Xbox Controller. This streamlined and compact system enables our robot to operate efficiently and swiftly. UR^2 can customize our control program to meet specific mission needs by experimenting with various programming commands.

Defiance is our most dependable and robust design our company has created. It has over 7kg of lift capacity and weighs less then 7kg out of the water. It has a solid aluminum frame with a PETG-CF outer covering.

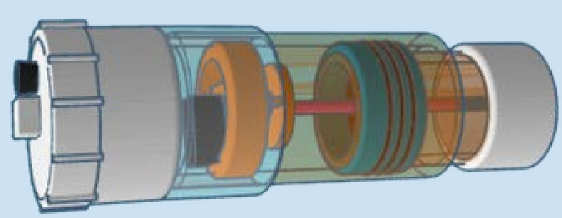
Our company collaborated with US Naval Surface Warfare Center mentors to better understand the Defiance operational system. In the fall of 2024, UR^2 engaged with coders to grasp essential Python control and command code. Applying these lessons, we developed Raspberry Pi control for our vertical profiler. This process allowed us time to draft basic code to steer the vertical profiler's functions.

Problem Solving

Our general approach to problem solving involves researching the issue first, developing a prototype, evaluating the results, and repeating the process until we achieve the desired outcome.

The float has been a consistent learning opportunity for us. With each prototype we developed, we discovered not only what we had learned but also how much we still needed to figure out. This year, we created four floats focused on reducing displacement, lowering power consumption, and simplifying control. Each prototype had its successes and contributed to our final design.

One solution we needed was the mechanics. To decrease displacement, we had to modify our actuator for more efficient operation. Our solution involved changing the linear actuator movement. In our previous builds, both the actuator and the plunger moved. However, this year, we fixed the actuator in place, allowing only the plunger to move, which simplified the mechanics significantly and reduced overall size.



Our first float design to change the mechanics worked, but it created too much internal pressure when placed in the water, making the displacement difficult to control. The required depth hold for this year's task needs more precision. As the plunger traveled up, it kept blowing the relief valve. The solution was to reduce the size of the plunger or increase the size of the float. Our goal was to decrease the displacement. We redesigned the entire float body to decrease the plunger size.

3. DESIGN RATIONALE

Design Decisions

Another critical design constraint is the budget. Our company has allocated nearly six thousand dollars for design and testing expenses. We have raised two thousand dollars to develop the prototype and four thousand to design the MATE. This budget includes creating a functional prototype ROV with new thrusters and a control system.

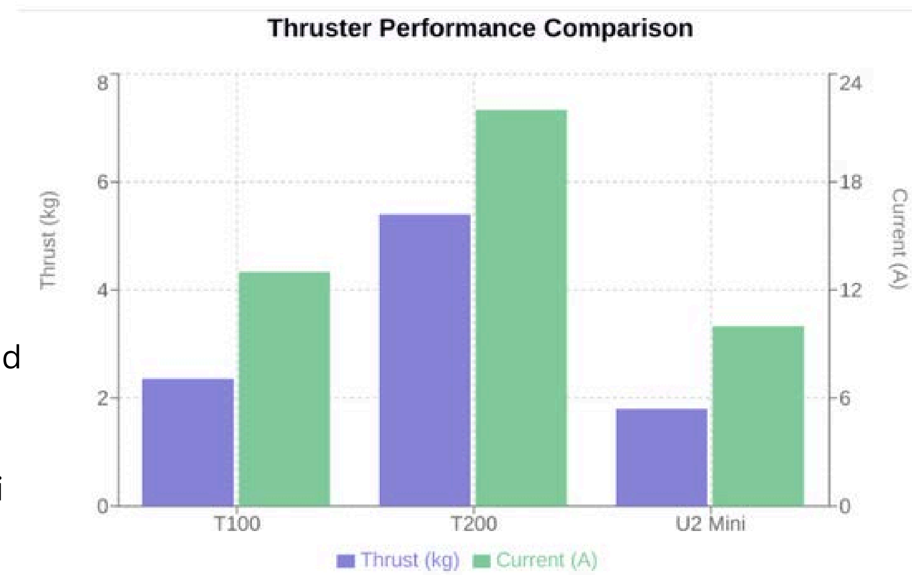
As we work to maximize our budget, we carefully consider the various factors involved in building an ROV from scratch. This includes deciding which parts to purchase, which parts to attempt to manufacture ourselves, and what components to reuse. Our goal is to develop an ROV that surpasses last year's performance.

While funding is a limiting factor, it must align with the design's requirements. As we agreed, the frame rebuild will not be restricted by cost; it is a crucial element that needs improvement. To make informed decisions, we need to consider the placement of six thrusters in a vector format, as the frame will need to accommodate them appropriately. We needed to research the thrusters to avoid redesigning the frame.

Thrusters

Our team has been working with the Blue Robotics T-100 for a few years. Last year, we chose a smaller thruster with lower power requirements; however, this decision resulted in a loss of overall power. Given the location and depth requirements for this year's Worlds, we felt it was necessary to reevaluate our thrusters.

The design team conducted a comparative study of the thrusters we used, focusing on reliability. We analyzed the Blue Robotics T200, T100, and the ApiSqueen U2 Mini. We have not designed an ROV with the T200 before, but we have discussed them with other ROV teams that have used them. The T200 emerged as the most powerful option, delivering an impressive 5.4 kg of thrust at 22A, making it ideal for large, demanding underwater vehicles. In contrast, the Blue Robotics T100 offers a balanced middle ground, providing 2.36 kg of thrust with a 13A current draw—suitable for medium-sized ROVs. The ApiSqueen U2 Mini, on the other hand, is the most compact option, delivering 1.8 kg of thrust at 10A, making it perfect for lightweight, space-constrained underwater vehicles. Each thruster has its advantages: the T200 excels in raw power, the T100 offers versatility, and the U2 Mini prioritizes efficiency and size.

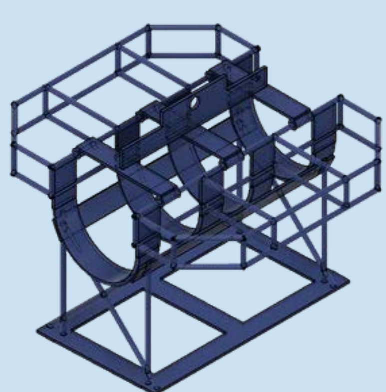


Comparison of thrust and power consumption for underwater thrusters

3. DESIGN RATIONALE

Our decision was primarily based on the size of the tank and the need for increased power to move vertically in the dive tank at Worlds. We needed to reduce the size of the ROV to fit through the one-meter opening required for operation at the surface and to navigate around the shipwreck without causing damage.

We chose to use two T200 vertical thrusters to take advantage of the additional thrust they provide, and we selected the U2 Mini as our horizontal thrusters. The U2 Mini helps keep the ROV's size down while still providing the necessary control and agility. This combination of thrusters allows us to maintain a manageable power requirement for operating all six thrusters, ensuring we stay below the required limit of twenty-five amps for power consumption. We used six thrusters and set them in a vectored formation to ensure our ROV is efficient underwater to help us navigate around the shipwreck and capture the Medusa Jellyfish.



Defiance frame design

Frame

This year, we decided to take a new route in building our ROV frame. Unlike past years, we decided to make our frame out of aluminum. The use of new material brought many new challenges. These challenges included finding a space to weld the frame, thin material to work with, and design flaws. Our first challenge was finding a space to weld the frame. Our team collaborated with a welding professor at Alpena Community College. With the barriers of Alpena Community College's hours, we contacted Superior Fabrication, who allowed us to use their facilities to finish welding the frame. Our second challenge was working with the thin materials. This was a challenge because the heat from welding kept melting the pieces, which caused us to keep purchasing new material. We reassessed this problem by learning about different settings on the welder. We save more material once when we found, learned, and update the settings. Our final challenge was design flaws. This was a challenge because some of our pieces could not be put together as designed. We were able to take a step back and figure out new ways to put the ROV together.

This was our first time using the materials, and we did not realize the need for a welding station or how the material needed to be welded together. The team's Fabricator began welding the base together, but the crossbeams, as shown in the design drawing, would not weld together as intended. She would have to stop what she was doing and meet with the design team, and we would have to work out a solution. It became frustrating because what the design team wanted and what could be done were not the same. Our welding mentor informed us that this happens frequently in production. What the engineer designed and wants is not always possible based on the materials being used. The design and build team kept working together and we completed the frame, but it took us much longer than we thought it would.

"We worked on the frame for nearly two months because of all the changes, but it was fun" - Kylie Gagnon
The image above is Kylie Gagnon welding the frame.

3. DESIGN RATIONALE

Buoyancy

Buoyancy and ballast are among the most critical factors in the performance of our ROV. When it comes to having excellent control, precise movements, or being able to return to the surface while carrying assets quickly, having the correct buoyancy for the job is essential. Buoyancy was always something we considered after the ROV hit the water. So that is why we did extensive research beforehand on the parts we used, such as our aluminum frame, to keep it lighter than our previous year's designs. We wanted to take advantage of this. The enclosure will displace 2.54 liters of water when fully submerged, providing approximately 2.54 kg of buoyant force. If we start with positive buoyancy of the enclosure and then keep working toward neutral buoyancy, our ROV should be close to neutral when completed.

Another advantage for our ROV is our neutrally buoyant tether, which reduces the pull, furthering the amount of control we have operating Defiance. We are also going to add foam on the surface attached to the tether to lessen the drag even more. Factoring in all of the parts allows us to assess if we need to add ballast or buoyancy and we discovered that Defiance would be slightly negatively buoyant. With this information we knew how much to add to make our ROV ideally slightly positive.

Buoyancy Calculations

Parts	Water Displacement (cm^3)	Weight in air (g)	Weight of water displaced (g)	Net Buoyant Force (kg)
Newton Gripper	203.6	529	203.6	-325.4
Thrusters	871.74	850	871.74	-0.89
External Cameras	47	84	47	−0.363
Enclosure	2,078.3	2,334	2,074.2	-259.8
Total Frame	1,030.23	2,598	1030.23	+794
Total	4,230.87	6,395	4,226.77	+207.547

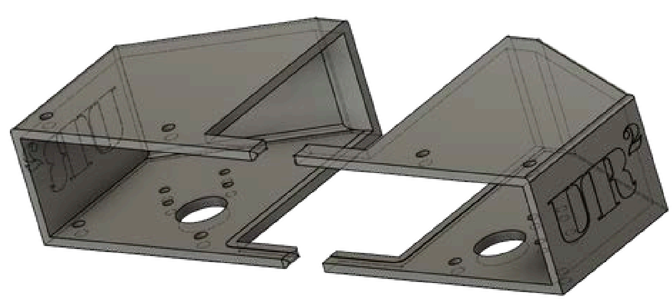
Frame Calculations

Parts	Weight in air (g)	Water Displacement (cm^3)	Net Buoyant Force (g)
Aluminum Frame	885	316.6	+ 0.085
Plastic Covering	807	598.1	+ 0
Steel	906	115.53	+794

Developing a plan to calculate the overall buoyancy of the ROV prior to building the ROV was a challenge. We developed several tables to help keep track of the data.

Did it Work

We got close. Those of us that worked on developing the calculation and predicting total displacement felt that we had done our job. We did create a contingence plan because we felt the ROV would be slightly negatively buoyant when completed. When the skin for the frame was created we allowed room to add buoyance so it would be hidden and not seen. The frame covers space to tweak the the buoyancy.



When we designed the frame covers, we left space to hide the wires to keep the design clean and free from potential snags. This space also provided room to hide the foam needed to trim the buoyancy.

3. DESIGN RATIONALE

Sub Surface Electrical System

The Blue Robotics acrylic enclosure guarantees Defiance's underwater safety and efficiency due to its sturdy and watertight design. It is versatile for various underwater tasks with dimensions of 100mm by 1000mm and a depth rating of up to 100m. Its electronics are securely housed inside, so it is primed for dependable performance in aquatic environments.

Defiance features two electronic speed controllers (ESCs) connected to two T200 brushless thrusters for vertical movement within the enclosure. The four vectored U2 horizontal thrusters contain waterproof ESC that are outside the enclosure. This helps with cooling and space in the enclosure. These ESCs receive their Pulse Width Modulation (PWM) signal from the Blue Robotics Navigation board, guaranteeing seamless integration and operation. The Navigation Board interfaces with a Raspberry Pi 4 processor running the Blue Operating System, offering advanced functionality and control for Defiance's underwater tasks.

Defiance is equipped with an HD camera with a 170-degree view, mounted on a single servo to regulate the camera's vertical scanning. This feature allows the pilot to adjust the camera position downwards or upwards by an additional thirty degrees of view. The enclosure also houses leak detection sensors that are placed throughout the enclosure to make sure all enteral electronics stay the same.

Surface Electrical System

Defiance's surface operations and command control are powered by the HP EliteDesk 800 G3 Mini Business Desktop, which operates on a Linux-based system. This compact topside computer is small enough to be held in one hand, making it ideal for operational needs. Its portable command-and-control system can easily fit in your pocket, providing added convenience. The HP Elite Mini can be powered by a standard AC outlet or a 12V DC supply, ensuring seamless transitions for remote operations.

We designed Defiance to be lightweight and compact to facilitate easy storage and transport at the control station. To enhance Defiance's mobility, our team developed a mobile control station. This mobile surface control station is a complete 12V system, capable of housing its own 12V battery or sourcing power from another 12V system. The station is built on an aluminum dolly, allowing for easy transport from a vehicle to a ship. It features a 19-inch LCD screen that provides a clear video feed from the ROV, making piloting straightforward and efficient.

Our mobile surface station was originally built to control our design prototype to make it easy to move around and take to the pool. The pilots liked it so much that we kept it to run our MATE ROV design, Defiance.

3. DESIGN RATIONALE

Control Station

The UR2 design team drew inspiration from their time aboard the vessel Octanist, a cruise ship that comes to Alpena during the summer, shifting their focus from a control box to a control station. This year's mission requirements prompted reevaluating their traditional approach to designing a control box for their ROV. With the need for additional hardware support for photogrammetry on the surface control side, they recognized the necessity of rethinking their control box setup. By hardwiring Defiance's tether to a control box and exploring new possibilities for topside controls, the team aimed to leverage Defiance's upgraded machine vision to its fullest potential.

The Defiance control station is a self-contained mobile unit.

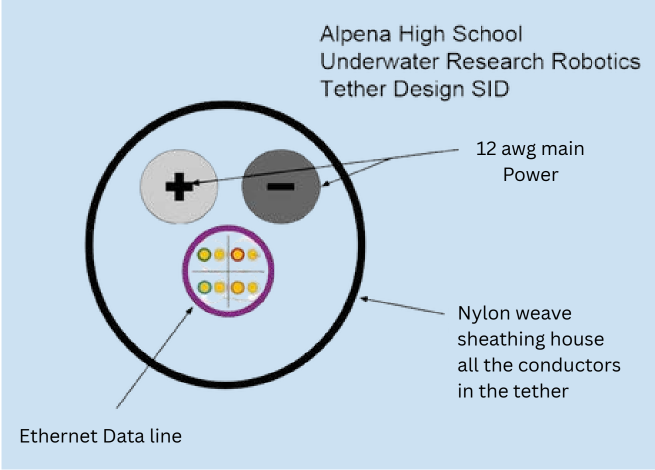
During their time on board the vessel Octanist, they observed the control station used by the ROV pilots for their submersibles. This experience led them to repurpose an older desktop workstation that was slated for recycling by the school district. The sturdy, mobile workstation, crafted from durable welded steel, provided valuable insights into expanding the pilots' monitor access beyond the limitations of a standard control box.

When we created the Defiance prototype, traveling with the large control station was impractical. Therefore, we built a second, smaller, and more mobile control station that could easily fit in the back of a car for transport to the pool for testing. This mobile control station became our go-to solution.

Tether

Defiance has stood out as our improved ROVs to eliminate the hardwired connection to the surface control box, simplifying operations by removing the need for a three-person team to manage the ROV as a single unit. We reduced the number of conductors by sixty-six percent compared to our previous ROVs by removing the extra hardwires needed for cameras. Previously, each additional camera necessitated the integration of two power wires and a signal wire, improving the pilot's visibility and increasing the tether's weight. You can find detailed information about our tether SID in the appendices of this report. Additionally, we research different strands of wire in the conductors and the exterior coating to reduce the twisting and rigidity in the tether.

Tether SID



3. DESIGN RATIONALE

Tether Protocol

Our progress in tether technology began with enhancing Defiance's photosphere capabilities for mission tasks. With guidance from mentors at the US Navy Warfare Center, we collaborated with Deepwater Exploration, experts in underwater cameras. With technical assistance from Deepwater Exploration, UR^2 utilized companion software tailored for Blue OS, allowing up to nine cameras to stream over a single network connection. This software enabled us to integrate more cameras without extra wires in the tether, which now only requires three wires. By mastering video streaming, UR^2 improved our capacity to incorporate more cameras for mission success and reduced the tether size by fifty percent.

The detachable tether from the control box has significantly simplified its management. This modification reduces tether twisting, resulting in smoother ROV operations. It also allows for easier maintenance and replacement of the tether, reducing downtime and increasing the efficiency of our operations. See appendence for tether protocol.

Gripper

The mission requires the ROV to lift and connect many devices, leading the design team to consider building or buying a gripper. Our current gripper is on its third competition and would need to be rebuilt and upgraded; the team decided to purchase a new Newton gripper from Blue Robotics. We integrated the gripper into the Defiance framework and mission design. The gripper can open its jaws to grasp objects up to 6.2 cm in diameter, featuring plastic jaws secured with custom aluminum screws for a corrosion-resistant and lubrication-free mechanism. A linear actuator, powered by a geared brushed motor and lead screw, drives the jaws, connected to a brushed ESC on Defiance's onboard computer. Control of the gripper is managed through an Ethernet connection to the surface and operated with an Xbox controller. The gripper is suitable for depths of up to 300m.

A stationary gripper was not working well in our initial operation test with the mission props. We need to be able to change the position of the grippers based on the task. The gripper design can rotate 360 degrees to reposition as needed, with the pilot adjusting its position using a programmed servo signal sent through the Ethernet connection from the surface to Defiance's computer. This flexibility allows Defiance to efficiently complete tasks like turning a valve 360 degrees. By purchasing the gripper, the team saved design time and could focus on more challenging tasks.

Image of the claw UR^2 uses.

Camera

This year's ROV build, Defiance, introduces two groundbreaking UVC-compliant cameras featuring innovative patent-pending technology. These cameras, with HD USB output and an IP69K waterproof rating, are equipped with a cutting-edge Sony sensor and a unique 4-layer PCB for exceptional vision in low-light conditions. This is helpful as we compete in a 5m dive tank, and the conditions tend to be darker to see. We also only use one Camera that focuses on the claw

3. DESIGN RATIONALE

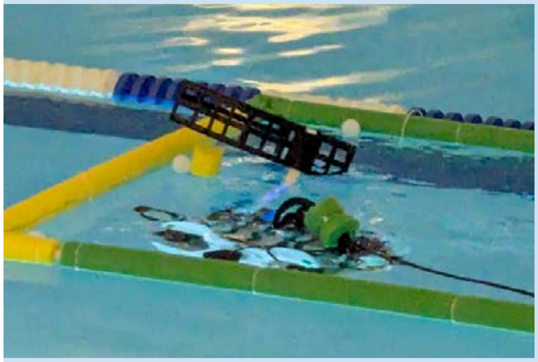
Mission Task Devices

To help develop mission tools, we invested in new 3D replication equipment. This change allowed us to create significantly lighter components, improving the ROV's maneuverability and enabling us to adapt and print new designs quickly for further testing.

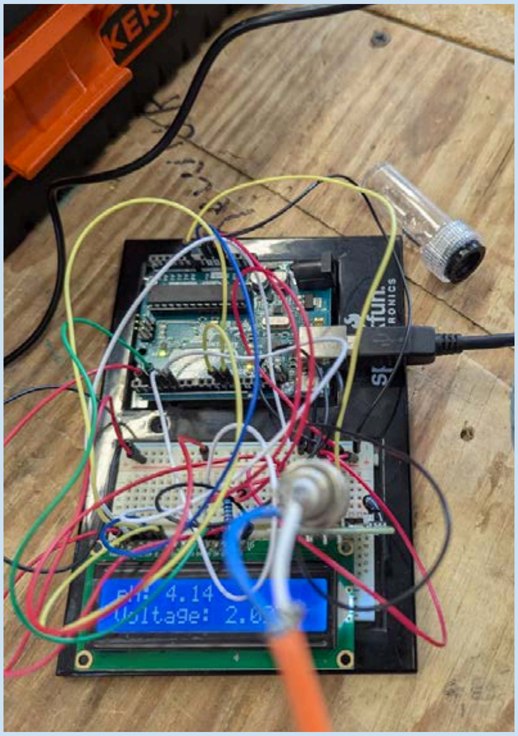
We initially tested the fish capture device using the ROV prototype we constructed to develop the control system. By using Fusion 360, we meticulously tailored the basket size to match the jaws of this year's MATE ROV design. This careful planning ensured that we would have a fully functional capture device ready for testing as soon as the MATE ROV was operational.

Collecting lake acidification data presented an additional challenge of collecting the sample in situ. We had a head start on this task because the team is collaborating with NOAA and MTS to develop a freshwater acidification project using a float in open water. Our current design utilizes an Arduino-based pH meter. The design question was to mount the sample on the ROV or build an independent sampler. The team developed an independent sampler by extending the sample length to ten meters. This would allow the pilot to place the pH sampler and leave to continue other tasks, while the surface crew could recover it after completing the test. Additionally, the task required that a water sample be removed and brought to the surface for additional testing. The design team used the ROV to deliver the pH sample, attached a tube to recover it, and pumped it to the surface.

The ability to iteratively test and redesign our prototypes has provided invaluable insights to our team, benefiting us not only as competitors in the MATE ROV competition but also as contributors to collaborative research projects. Utilizing the engineering design approach has brought us closer to developing practical and effective solutions, equipping us with the knowledge and skills necessary to tackle similar challenges in the future. Our experience in this project exemplifies the importance of innovation, teamwork, and a rigorous testing process in achieving our research goals.



During a recent ROV competition, we tested our ROV prototype to evaluate our new surface control system. Additionally, we used the ROV to test the fish capture devices designed to capture floating ping pong balls, which were used to simulate fish species for this year's MATE task.



Our pH sampling device is a good example of build vs buy. We had plenty of odds and ends that we used to develop the sensor that works well with no impact on this year's budget.

3. DESIGN RATIONALE

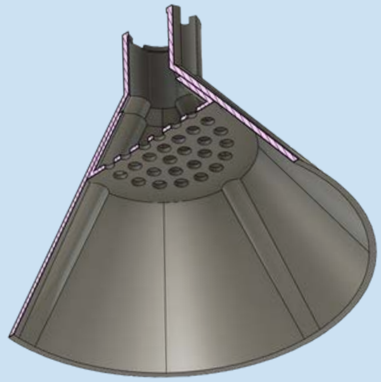
Mission Task Devices

Task 2.2 involves the collection of various marine species and their safe return to the surface. This task simulates research, focused on minimizing their stress and ensuring their well-being during the collection process. The design team at UR^2 has been working diligently to develop and prototype multiple innovative solutions for completing thses tasks.

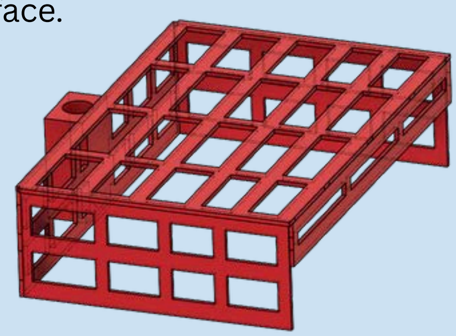
The first requirement in our project is the removal of polyps from their environment. To tackle this challenge, the team designed a specialized grabber featuring a large surface area. This unique design enables pilots to capture polyps more quickly and securely, which is essential for efficient collection. To enhance the effectiveness of the grabber, we attached two large, flexible suction cup-style pinchers to its jaws. This feature allows operators to function with less need for pinpoint accuracy, making the process of removing polyps less stressful for both the pilots and the organisms.

The second species requiring capture is the medusa jellyfish. Capturing jellyfish presents its own set of challenges, as these creatures are delicate and need to be maintained in their natural environment as much as possible during retrieval. To accomplish this, the design team experimented with various capture devices that would allow us to capture the jellyfish while still surrounded by water, which is crucial for its survival. The capture device we ultimately developed allows the jellyfish to be pulled to the surface without disturbing its in-situ environment. Our initial prototype was created using a two-liter soft drink bottle cut in half, featuring a handle for easy operation. While this concept was innovative, we quickly discovered that the design lacked durability and was too flimsy for practical use.

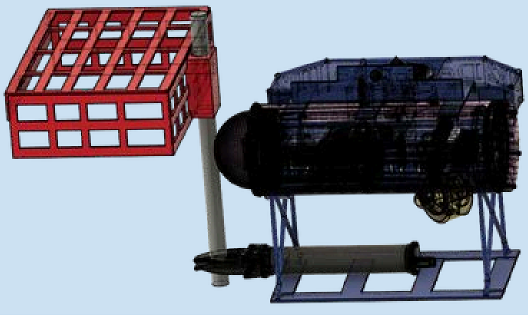
Throughout the project, we conducted extensive testing on the fish collection device as part of Task 2. Our initial prototyping efforts involved using PVC piping and plastic netting. While these early concepts successfully functioned, we soon realized that they were heavy and clumsy for the ROV (Remotely Operated Vehicle) to handle effectively. Seeking a better solution, we shifted our focus to 3D printing adjustable capture baskets.



Medusa Jelly Prototyping: Our initial idea was not structurally strong enough, but the concept was solid. We searched Thingiverse for ideas on a funnel that would retain water and help control the jelly. We decided on a funnel design that would allow water to flow through while keeping the jelly positioned until reaching the surface.



Prototyping the fish capture device using Fusion 360 allowed us to make size comparisons to see how the concept would fit into this year's ROV design.

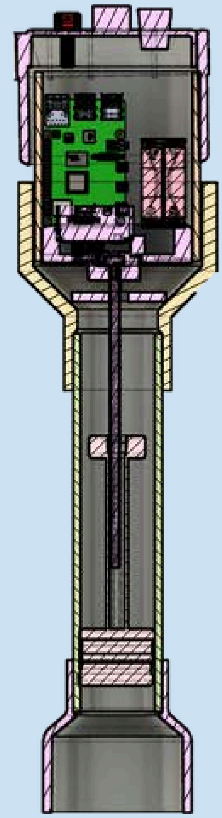


Mission Task Devices: Float

UR[2] has spent the past four years developing a Profiling Float called Perseverance, or Percy for short. The Float is designed to autonomously descend to desired depths to collect data on depth, pressure, and temperature, completing two vertical profiles per mission. Measuring 76.2 cm in length with a circumference of 7.62 cm, Percy is constructed from PVC pipe that tapers down to 5 cm to accommodate its syringe mechanism.

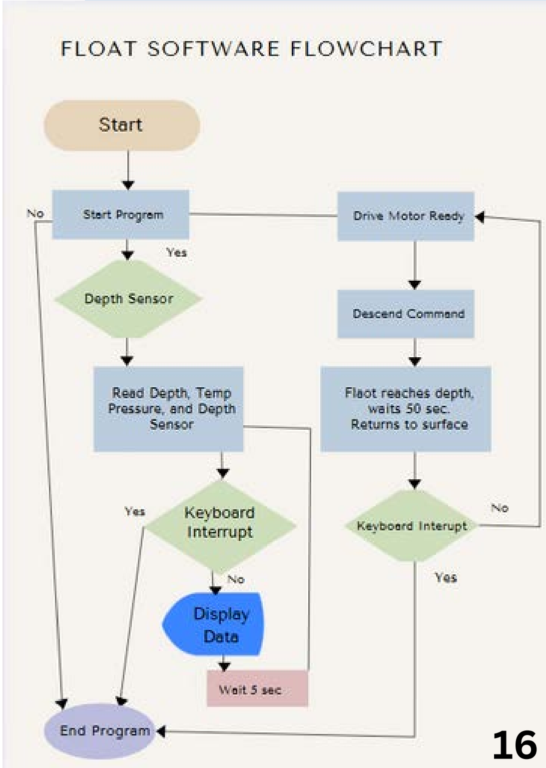
Powered by Python code on a Raspberry Pi, Percy employs a motor and linear actuator to control the syringe plunger for water collection during its descent. A pressure sensor gathers data during its dive. Percy can go to any desired depth as its program reads the pressure sensor and will stop, collecting data for 5 seconds at any depth the user wants.

Once the Float has reached its desired depth using the pressure sensor, the actuator lowers the syringe, allowing it to ascend. Upon surfacing, the Raspberry Pi reconnects via Wi-Fi and sends the collected data to our topside computer. From there, our computer generates an in-depth graph of the collected data.



This is a cross-section of our float design showing all of the interior components.
Below is our flowchart showing the process of the program.

Earlier versions faced significant buoyancy challenges, requiring an additional 2.2 kilograms of weight to sink, which resulted in a bulky design. To overcome this, the team minimized the internal chamber size, developing a smaller syringe, and reconfigured the interior layout. The 2024 FLOAT, the original software design, followed a "tower" structure, with components stacked vertically and leaving significant air gaps along the sides. This layout resulted
in unused and inefficient space. By reorganizing the internal arrangement to pack components more efficiently, the team successfully reduced the FLOAT's overall length and size, creating a more streamlined and compact design. Developing the software for this year's mission task was just as challenging as designing the float. The software needed to stop the float at a specific depth and create a feedback load, but it just wasn't working. To solve this problem, we created a float using a neutrally buoyant tether to collect feedback data as it descended. To align the buoyancy displacement needed to stop at depth, we developed software that allows control of the actuator using the arrow keys on the keyboard. This setup enabled us to track and control the descent, as well as refine the software for managing the float.



New vs Reused

UR² carefully and methodically sourced components for Defiance by evaluating features from our previous ROVs to determine the most effective approach for each part, whether to buy, build, or reuse components. To streamline this decision-making process, we compiled our findings into a detailed table (Figure below), allowing us to organize and compare our findings clearly. We determined that a part is a quality reused item if it has been in use for only one season, is typically a reliable reused item, and meets budget demands. For the years that our revenue has been down, we will go deeper into our reused parts.

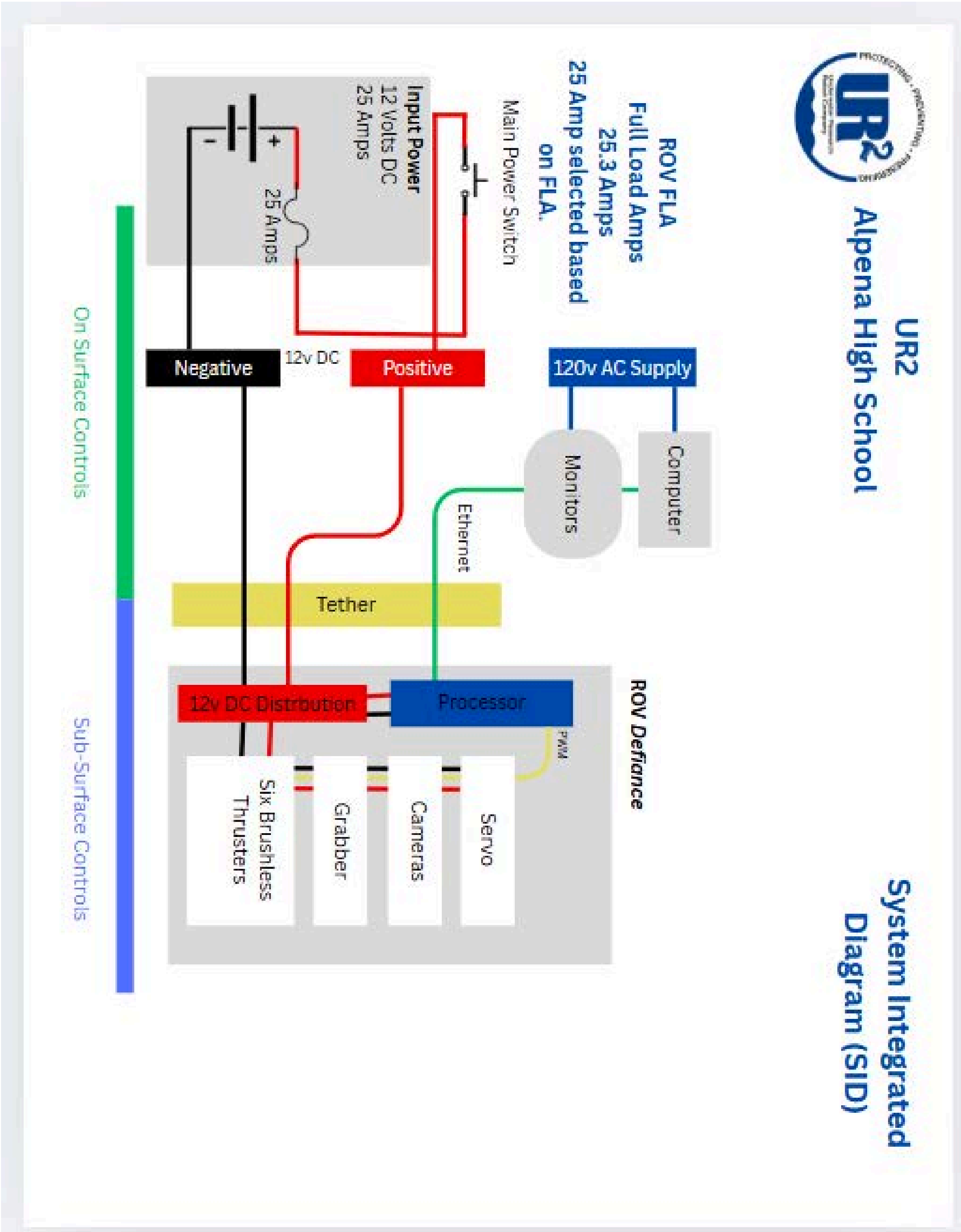
Components Name	Build		Reuse		Buy		End Decision
	Pros	Cons	Pros	Cons	Pros	Cons	
Thrusters	Customization	Challenges to water proof, longer testing period	Saves money, trustworthy Product, already know how it works, and wired up	Having to take apart 2024 ROV, ESC issue, not supper reliable	We know the quality of the thruster, provide longevity through the 2025 season	Costs money	**Buy**
Claw	Customization, creating exactly what needed for mission	Challenges to water proof, Longer testing period, Take longer to make	Saves money, Trustworthy Product, Already familiar with the part	Having to take apart 2024 ROV, several stripped Screws	Provide longevity, durable	Costs money, same part we have already	**Buy**
Frame	Customization, creating exactly what needed for mission	Takes a long time and would have to test the efficiency	Saves time troubleshooting, Saves money	Frame will have to be updated and has cracks from last years	Saves time, Durable	Non customizable to our tasks	**Build**
Top side control Desk	Exact customization,	Time consuming and costly for new desk and materials	Saves Time and money, Good condition, Durable	Nothing major just a couple adjustments and add ons	Durable, saves some time	Cant customize	**Reuse**
Tether	Exact customization	Time Consuming	Worked well in 2024, Neutrally buoyant	Has a small amount of damage that needs to be repaired	Reliable and durable	May not have the right amount of wires or gauges needed	**Reuse**
Encloser	Exact customization, Can make it smaller then what we have	Would have trouble sealing, costly to prototype with different materials	We know it works, seals, already customized, and reliable	Taking apart 2024 ROV, having to remove all the electronics from the year before	Little work to get it assembled and sealed	Cost money, have to add customizations to it	**Reuse**

Build vs Buy

Building our components and parts is the best economic decision we can make because developing our own parts is cheaper than buying. Buying comes down to is it faster for us to buy the item or do we have the time and resources to develop our own. One item is the Newton Gripper. Our team has developed many mechanical grippers. Many on our team have been building grippers since fifth grade. It comes down to reliability and time. Developing and testing a gripper requires time and our team would rather invest our time in developing other parts of the ROV. The Newton Gripper is easy to service and we understand how it works. We have repaired them and reconfigured the gripper for different tasks. Recently, we finished this year's ROV and were testing when the gripper stopped working. We had a spear that we replaced it with, but we took the old one apart and discovered that a capacitor on the ESC broke. We removed the ESC and wired directly to the motor and the grabber works like a traditional analog gripper.

Our pH sensor used in task two was build from years of spare parts. We had a left over pH sensor from a research project last year and several Arduino boards we used on last year's ROV prototype that we turned into a pH sampling device. We created a case by using filament left over from the Defiance to create a case to hold all the components.

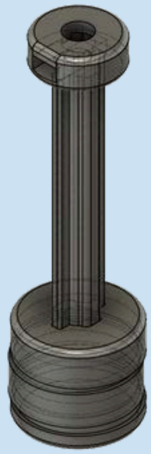
4. SYSTEM INTGRATED DIAGRAM



5. CRITICAL ANALYSIS

Testing

While functional, the 2024 MATE Float had several notable flaws: it was fragile, oversized, and depended on a 500 cubic centimeter syringe for buoyancy control. During our design sessions in October, we created a list of changes we wanted to implement, including designing a smaller float and utilizing 3D printing technology to create a compact and efficient syringe.



The float plunger is printed from PETG-CF.

Testing various components of the float required multiple prototypes of different elements. To reduce the overall displacement of the float, we designed our own plunger to fit into a two-inch schedule 40 PVC. Initially, we created a solid plunger, but we encountered issues with sealing the O-ring, as it was either too tight or did not seal properly. To address this, we broke the plunger down into smaller parts to eliminate the rough edges caused by the support material.

Vectoring the thrusters not only enhanced the ROV's operational capabilities but also increased cost efficiency. Instead of investing in new propulsion systems, we optimized the layout of our existing components to improve movement. To test the position of the thrusters and the new control system, we built a prototype of the ROV.

We conducted tests at three different levels. First, we used our small tank in the workshop to evaluate operations in shallow water. Then, we took it to the local pool to test it in deeper water. Finally, we tested the prototype at the Square One UIVD (ROV competition). The success of our prototype at Square One reflects our commitment to iterative design and practical innovation in robotics.

Troubleshooting

Creating the aluminum frame required a whole new skill set and Kylie Gagnon, team fabricator, spent the summer and fall learning how to weld aluminum so the team could develop a new ROV frame. Developing new code for the control system and learning new systems made this year difficult, but the results are something we are proud of. This year's design has been a challenge and we made it work.

Another area we built upon from last year was fixing our limited movement from the 2024 season: We wanted this year's design to make precise underwater adjustments, especially moving laterally to the left or right. This issue led us to vector the thruster placement, allowing the ROV to move sideways like a crab. We arranged six thrusters in a vectored configuration to maximize movement and allowing smooth lateral movement. This setup directly influenced the ROV's overall design.

In preparation for the Square One Tournament, our team engineered a prototype for MATE that introduced key innovations to enhance maneuverability, functionality, and overall performance. One of the most significant modifications we made was vectoring the thrusters, which enabled full 360-degree movement. This upgrade dramatically improved our control of the ROV, allowing it to navigate tight spaces, maintain underwater stability, and complete tasks with greater precision. By strategically repositioning and angling the existing thrusters, we boosted agility and responsiveness without adding extra hardware or complexity.

6. SAFTEY AND OPERATIONS

Content

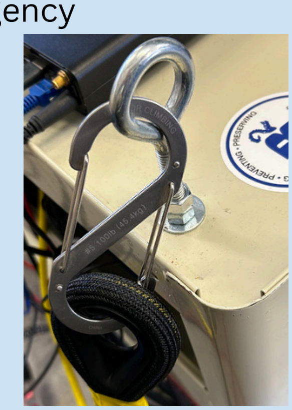
At UR^2 , safety comes first—always. We take every necessary step to protect our team members, mentors, customers, and the public. We provide comprehensive training to every team member to prevent accidents and ensure safety at every stage of their work. We maintain a safe and supportive learning environment by consistently implementing and following strict safety protocols. Our team follows a "check twice" policy and encourages everyone to reference our safety checklist regularly(see appendices).

Before working on equipment or handling parts, every team member completes a rigorous ten-hour OSHA health and safety class. This training helps ensure a safety culture and significantly reduces the risk of accidents. Additionally, we have two certified lifeguards on deck at all times.

We extend our commitment to safety beyond the team—to the ROV and our working environment. Defiance features two strain relief systems that prevent the tether from being forcefully disconnected. The first strain relief is on the back of the ROV and is a simple carabiner clip that clips onto a cable thimble. This setup attaches to all the wires from the enclosure, preventing strain. The second strain relief is connected to the side of the control station so the tether is securely attached. The ROV also has an in-line fuse positioned 30cm from the PowerPoint. In addition, all thrusters have a 3D-printed guard over them so that no fingers can enter the vicinity of the propeller. Finally, all of the ROV's edges are rounded, so there is no risk of anyone cutting themselves while picking up or working with the frame.

Team members showing off their OSHA certification cards.

Strain reliefs at both ends of the tether. We use the carbine clips for quick removal in case of emergency



Safety Procedures

Our motto is simple: a safe company is a happy and productive company. We adhere to this principle every time we meet, build, and launch. When working in the makerspace, all team members are required to wear safety goggles and closed-toed shoes. Additionally, team members with long hair must tie it back when using tools or machinery such as hand drills or drill presses. When team members are using equipment in the practice tank, they must ensure the floor is dry and remove any standing water that could create a slip hazard. A "Wet Floor" sign must be displayed during all tank activities. All 120V service in the practice tank must be connected to a GFI plug or adapter. This requirement also applies to all 12V power supplies. Finally, any team member can call a stop work order if they believe a safety issue has occurred. All work must cease until the situation is assessed and resolved.

7. ACCOUNTING (BUDGET & COSTS)

During our first month of practice in September, we review and discuss the budget. We use the costs from our 2023, 2024, and 2022 ROV builds to estimate expenses for the 2025 model. At the same time, we itemize reusable components—such as our enclosure and tether—and factor them into the projected budget. UR^2 takes a detailed and proactive approach to financial planning. For the development of Defiance, we created a comprehensive Profit & Loss (P&L) analysis. This includes all expenditures over the one-year development period, unit costs for manufacturing each production ROV, and revenue projections based on current market pricing. (See Appendix the full report)

UR^2 2025 Predictions:

	Price of ROV	Price of Control Box	Total
2022	$2,980.00	$1,300.00	$4,280.00
2023	$2,860.00	$1,000.00	$3,860.00
2024	$2,809.00	$1,200.00	$4,009.00
Predicted Cost of 2025	$2,883.00	$1,166.67	$4,049.67
2025 Cost	$2,857.03	$1,056.00	$3,913.03

	Reused Parts	New Parts	Total of ROV
2022	$1,090.00	$3,190.00	**$4,280.00**
2023	$1,260.00	$2,600.00	**$3,860.00**
2024	$1,490.00	$2,519.00	**$4,009.00**
Predicted Amount	$1,280.00	$2,769.67	**$4,049.67**
2025 total	$ 1,563.00	$ 2,350.00	**$3,913.00**

At the beginning of the season, we developed a detailed table comparing the costs of our ROVs from the past three seasons. Enabled us to analyze spending trends to make an accurate prediction of the 2025 ROV. By calculating the average price of our ROVs from before, we estimated that the 2025 ROV would cost approximately $4,049.67. This prediction played a crucial role in our budgeting process. A realistic budget projection helped the team make informed decisions throughout the season.

Ultimately, the total cost of our 2025 ROV came to $3,918.00. Our original prediction was only $131.67 higher than the final cost. In addition to predicting the overall cost of the ROV, we also examined the reuse of parts from previous seasons. We reviewed data from previous years to estimate how much of our budget could be offset by reusing components rather than purchasing new ones. Based on the average amount of reused materials, we predicted we would save $1,280 by repurposing existing parts.

However, as the season progressed, we exceeded this estimate. Our final tally revealed that we had reused approximately $1,563 worth of parts. This significant increase was primarily due to our strategic decision regarding the control station. Historically, UR^2 has built a brand-new control station each year. However, since last year's control station performed exceptionally well, we decided to reuse parts for the 2025 season, resulting in a highly reused component.

To manage our funds responsibly, we require team members to submit a Purchase Request before any purchases of tools, hardware, or equipment. The proposal must be reviewed and approved by our CEO, CFO, and Head Coach before any team funds are used. Furthermore, maintaining a detailed and accurate record of all purchase requests, approvals, and expenditures is critical for transparency and accountability within the team. This system helps prevent unnecessary or duplicate purchases but also gives us a clear understanding of how our budget is being used across various projects and team needs.


2025 Purchase Request

Name:
Date:
Budget Request Cost:
Task Description:

	Items and quantity	Price	Link of Item	Item Approved	Approved By (CEO,CFO, Mentor)
1.					
2.					
3.					
4.					
5.					

8. CONCLUSION

The development of this year's ROV design, Defiance, commenced a week after the last World Championship. We established a design criterion outline to guide our design choices in achieving our three primary objectives. As a team, we aimed to decrease the ROV's overall size and weight, create a new operating system, and construct a dependable vertical profiler. Our team is proud of what UR^2 accomplished this year, and UR^2 is already building ideas for next season.

Furthermore, our team has made a positive impact in the community by engaging with over five hundred elementary students, three hundred middle school students, and mentoring three high school ROV teams. Additionally, we have continued to provide a research platform for local stewardship conservation working with dozens of community partners.

Community and Project Partners

Acknowledgements

Underwater Research Robotics would like to express our gratitude towards the people who made it possible to compete in the MATE ROV competition. Our team would like to thank MATE and Marine Technological Society, sponsors of the MATE 2025 compositions for making everything possible. We would also like to thank the following for supporting us and contributing to our successes:

- STARBASE Alpena for providing 3D printers, and Steve Tezak for providing mentoring advice
- US Naval Surface Warfare Center Crane: Debra Walker for her help in mentoring our ROV frame
- Seafloor: Marcos Barrera provided mentoring advice for the FLOAT
- Robert Thomson and Paul Coleman for mentoring our team
- Thunder Bay National Marine Sanctuary for providing laboratory workspaces and networking opportunities
- Alpena Public Schools for donating various supplies and other resources
- Marine Advanced Technology Education provides opportunities and helps us grow
- MISTEM provided ample amounts of funding, making it possible for us to complete
- The volunteer divers who made it possible to practice and compete in NOAA’s dive tank
- NOAA staff members that make our competitions and many out reach programs possible

References

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All pictures of team members used in this technical documentation were taken by Lydia Thomson and Sarah Rabbideau.

9. APPENDICES

Underwater Research Robitics (UR2)
Statement of Account

	PY 2024	CY 2025	CHANGE YOY	Percent Change
Revenues				
Contributions / Donations	$ 12,000	$ 750	$ (11,250)	-94%
Total Contributions	**$ 12,000**	**$ 750**	**$ (11,250)**	**-94%**
Fundraising				
Popcorn Sale	$ -	$ 1,000	$ 1,000	N/A
Total Fundraising	**$ -**	**$ 1,000**	**$ 1,000**	**N/A**
Grants and Awards				
State 99h Grant	$ 6,000	$ 4,500	$ (1,500)	-25%
MISTEM Grant	$ 5,000	$ 1,976	$ (3,024)	-60%
Samsung Award	$ 2,500	$ 2,500	$ -	0%
Total Grants and Awards	**$ 13,500**	**$ 8,976**	**$ (4,524)**	**-34%**
Total Program Revenue	**$ 25,500**	**$ 10,726**	**$ (14,774)**	**-58%**
Expenses				
Robot Development				
Robot Prototype (Square One)	$ 1,000	$ 500	$ (500)	-50%
Robot Prototype (Viking)	$ 1,000	$ 500	$ (500)	-50%
Robot Parts (Defiance)	$ 3,000	$ 4,000	$ 1,000	33%
Robot Parts (Float)	$ 500	$ 500	$ -	0%
Total Robot Development	**$ 5,500**	**$ 5,500**	**$ -**	**0%**
Research				
Water Acidification Research Project	$ -	$ 300	$ 300	N/A
Total Research Expense	**$ -**	**$ 300**	**$ 300**	**N/A**
Equipment				
Test Equipment	$ 500	$ 300	$ (200)	-40%
Total Test Equipment	**$ 500**	**$ 300**	**$ (200)**	**-40%**
Outreach				
Mentoring	$ 800	$ 1,400	$ 600	43%
Workshops	$ 600	$ -	$ (600)	N/A
LEGO Competition	$ 1,500	$ 1,500	$ -	0%
Total Outreach	**$ 2,900**	**$ 2,900**	**$ -**	**43%**
Other				
Apparel	$ 500	$ 1,000	$ 500	100%
Travel	$ 12,000	$ 1,100	$ (10,900)	-91%
Competition Fees	$ 665	$ 870	$ 205	31%
Total Other Expenses	**$ 13,165**	**$ 2,970**	**$ (10,195)**	**40%**
Total Program Expenses	**$ 22,065**	**$ 11,970**	**$ (10,095)**	**43%**
Total Change in Net Assets	**$ 3,435**	**$ (1,244)**	**$ (4,679)**	

9. APPENDICES

ROV Cost Breakdown
Underwater Research Robotics (UR2)

Category	Description	New or Reused	Quantity	Unit Price (FMV)	Total Cost
ROV Structure					
PEPG-CF	3D Printing Material	New	1	$ 40.00	$ 40.00
Aluminium	Quarter in. 0.25 Roundstock	New	8	$ 6.67	$ 53.36
Flat Bar	1 in. Bar for Structural Support	New	3	$ 10.83	$ 32.49
Hardware	Nuts and Bolts	Reused	1	$ 8.00	$ 8.00
Total ROV Structure					**$ 133.85**
Propulsion					
V2 Mini Thruster	Brushless Thrusters	New	4	$ 59.99	$ 239.96
Blue Robotics T200 Truster	Brushless Thrusters	New	2	$ 258.00	$ 516.00
Total Propulsion					**$ 755.96**
Enclosure					
Navigator Board	Navigation Used for Robot	New	1	$ 61.00	$ 61.00
DWE HD Cameras	Camera Used for Navigaiton	Reused	1	$ 400.00	$ 400.00
Low-Light HD USB Camera	Camera Used for Navigaiton	Reused	1	$ 110.00	$ 110.00
Camera Tilt System	Titls Camera	Reused	1	$ 62.00	$ 62.00
ESC	Speed Controller	New	2	$ 38.00	$ 76.00
Bar30 High-Resolution 300m Depth	Measures Water Pressure and Depth	Reused	1	$ 85.00	$ 85.00
Electronics Tray	Used to hold all electronics in the enclosure	Resused	1	$ 55.00	$ 55.00
Cast Acrilic Tube	8 Inch tube for eltronics to go into	New	1	$ 330.00	$ 330.00
Pressure Relief Value	Used to releif pressure from the enclosure	New	1	$ 30.00	$ 30.00
SOS Probes	Leak Sensors	New	2	$ 3.00	$ 6.00
Wiring	12AWG Wiring (Spools)	New	2	$ 39.99	$ 79.98
Total Electronics					**$ 1,294.98**
Tether					
Mesh Casting	Nylon Mesh Bindining and Protecting Cables	Reused	1	$ 53.00	$ 53.00
Fathom ROV Tether	Neutrally Bouyant Tether	Reused	1	$ 245.00	$ 245.00
Total Tether					**$ 298.00**
Mission Tools					
Agjewsoft	Softwear for Photogramitry	New	1	$ 50.00	$ 50.00
pH Sensor	pH sensor used for the MATE Tasks	New	2	$ 12.00	$ 24.00
Syringe	Pack of 10 Liquid Measuring Syringes	New	1	$ 9.99	$ 9.99
Newton Sedimate Sampler	A claw that help the ROV grab iteams	New	1	$ 290.00	$ 290.00
Total Mission Tools					**$ 373.99**
Miscellaneous					
Foam	2x4 foam	New	1	$ 0.25	$ 0.25
Total Miscellaneous					**$ 0.25**
Total ROV Cost					$ 2,857.03

Control Station Cost Breakdown
Underwater Research Robotics (UR2)

Category	Description	New or Reused	Quantity	Unit Price (FMV)	Total Cost
Acer Flatscreen TV	Monitor To Drive the ROV	Reused	1	$ 35.99	$ 35.99
Computer desk	Desk To hold all ROV Equiment	Reused	1	$ 150.00	$ 150.00
Duel TV mount	Holder for TV	Resued	1	$ 39.99	$ 39.99
Hardware	Nuts and Bolts	Reused	1	$ 8.00	$ 8.00
HDMI Cable	Cable for TV's	New	2	$ 5.99	$ 11.98
HP Micro Computer	Computer To Run ROV	Reused	1	$ 200.00	$ 200.00
Keyboard And Mouse	Imput devices	Resued	1	$ 16.95	$ 16.95
Memmory Foam Matt	Matt For Desk	Resued	1	$ 13.98	$ 13.98
NETGEAR 5-Port Gigabit Etherne	Internet Switch	Resued	1	$ 13.99	$ 13.99
Samsung Flat screen TV	Monitor To Drive the ROV	New	1	$ 500.00	$ 500.00
XBox Controller	Joystick For ROV	Resued	1	$ 65.99	$ 65.99
Total Control Station Cost					$ 1,056.87

Control Station Cost Breakdown
Underwater Research Robotics (UR2)

Total Cost of ROV	TotalCcost of Control Station	Total
$2,857.03	$1,056.00	**$3,913.03**

Disclaimer: UR^2 didn't have to account for traveling in the 2025 season as worlds, and our reginals is hosted in our hometown there, for we didn't have to include travel costs this year

9. APPENDICES

Tether Protocol

- Tether is stored under the control station in storage tub
- Check if topside tether carabiner is clipped to I-Bolt on control station
- Remove ROV end of tether from storage tub
- Make sure tether is not twisted or tangled
- Lay tether out on deck and avoid placing it in high foot traffic area
- Recheck connections on both ROV side and control station ends of the tether

Image: Back of control station

Saftey Checklist

Pre-Power	Yes	No	If No...
Area is clear of tripping hazards			Clear the deck of tripping hazards before moving on
All team members have proper PPE ☐ Safety Goggles ☐ Hair pulled Back ☐ Closed toed shoes			Obtain proper PPE before going near the ROV
Teather is free of tangles			Untangle tether and lay out on the pool deck
Strain relief is attached			
No visible damage inside the enclosure			Do not put ROV in water. Fix the damage first
The enclosure is sealed fully			Make sure the enclosure is sealed before placing in water
Thrusters are guarded and free of debris			Clear debris and attach guards
ROV Launch			
Control box powered on			Power control box and ROV on
Pilots keep hands off controls			
Payloader shouts "Hands on" before grabbing the ROV			
Rov placed in water and visually checked for leaks showed by bubbles			
If no leaks the payloader shouts "Launch" then lets go of ROV			
When payloaders hands are off ROV the payloader must shout "Hands off"			
Pilot shouts "Power on" and begins driving ROV			
ROV Retrieval			
pilot shouts "returning to surface"			
when ROV is at surface payloader			
Leak Detection			
Power down ROV and remove from water quickly			
Visually try and find the source and cause if the leak			
Verify location of leak			
Create an action plan to stop leak			
Carry out action plan Check ROV systems for damage			
Pit Maintenance	**Yes**	**No**	**If no...**
Pit is organized			Tidy up the pit.
All materials are put in the proper place and are not a tripping hazard			Place materials in proper places where they are not a tripping hazard.
Check that ROV and teather are put in proper location			Correct the location of the ROV and teather
Dry ROV and be ready for the next run			Take time to dry the ROV or place it in a space where it will dry in time for next run.

ROV Retrieval			
Pilot shouts "returning to surface"			
When ROV is at surface payloader shouts "Power off"			
Pilot indicates power has been shut off			
Payloader pulls ROV from water using tether restraint			
When ROV is on the pool deck payloader shouts "ROV on deck"			
Team prepares to pack up ROV			
Loss of Power/Communication			
Power off ROV then back on on ROV to regain power			
If still no communication pull ROV in via tether			
Check for leaks that could be the cause			See leak detection
If communication/ power is restored continue the run			

Safety Training Chart

Crew member Name	Job Title	Company Safety Training	10-Hour Osha Safety Certification	15-Hour Osha Safety Certification	Lifeguard Training Certification	First Aid Training
Lydia Thomson	CEO	☑	☑	☑	☐	☑
Sarah Rabbideau	Safety Officer	☑	☑	☑	☑	☑
Elizabeth Rabbideau	CFO	☑	☑	☐	☑	☑
Ray Johnson	CTO	☑	☑	☐	☐	☐
Taylor Widajewski	CDO	☑	☑	☐	☐	☐
Gus Wirgau	Pilot	☑	☑	☐	☐	☐
James Rawlings	Co-Pilot	☑	☑	☐	☐	☐
Kylie Gagnon	Fabricator	☑	☑	☐	☐	☐
Matthew Kowalski	Fabricator	☑	☑	☐	☐	☐
Benalli Gabara	Lead Mechanical Engineer	☑	☑	☐	☐	☐
Dawson Smolinski	Mechanical Engineer	☑	☑	☐	☐	☐
Alexa Blumental	Software Engineer	☑	☑	☐	☐	☐
Myah Rondeau	Project Manager	☑	☑	☐	☐	☐