Kingsport Technologies

Dobyns-Bennett High School

Kingsport TN, US

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Abstract

Kingsport Technologies (K-Tech) is a student-led organization affiliated with Dobyns-Bennett High School in Kingsport, Tennessee. K-Tech strives to develop innovative ROVs aligned with the United Nations' 17 Sustainable Development Goals and fulfill customer needs.

To contribute to a cleaner environment, K-Tech produced an ROV, Monarch, named after the endangered butterfly. Monarch is made to preserve marine life by incorporating a range of systems, including photogrammetry and a rotary manipulator. It is designed to construct and repair projects for solar energy infrastructure in marine environments as well as remove large obstacles that may impede missions. Additionally, an autonomous buoyancy engine provides data from various depths and feeds it back to the main control center. Monarch then uses this data to better accomplish its missions.

Monarch features a modular frame that is entirely 3D-printed using recyclable filament. This allows for easy customization and modifications while reducing Monarch’s environmental impact. Using recyclable plastics instead of metal alternatives also optimizes the weight to strength ratio and reduces the size of the ROV, granting greater maneuverability and control.

In addition to its focus on design, K-Tech is committed to sharing its robotics and engineering experience with the community. The company hosts regular STEM outreach nights for local elementary schools, YMCA, Scouts, and other programs, inspiring others to develop new solutions to environmental problems.

Figure 1: Completed ROV, Monarch

Figure 2: STEM outreach to elementary school

Project Management

Kingsport Technologies follows a hybrid of engineering and business principles. The company is split into several subgroups—Electrical Design, Mechanical Design, Missions and Tools, and Documentation—to break up the overall mission into easier tasks. An experienced company member leads each group, and the CEO oversees each lead. This allows the company to focus on efficiency and productivity by facilitating cross-team communication and cooperation.

Electrical Design writes software and assembles all electrical hardware both onboard the ROV and in the control box. Mechanical Design models and designs the frame using CAD and assembles it to incorporate all necessary elements developed by the Electrical subgroup. Mission and Tools focuses on designing, building, and programming the vertical profiling float as well as additional mission-specific components, such as the deadlift hook. Documentation focuses on K-Tech's finances, sponsors, community outreach, and technical documentation.

Subgroup Name	Subgroup Leader	Additional Member
Electrical Design	Zack	Samuel, Bre, Caroline, Eric
Mechanical Design	Charles	Jakob, Eesha, Lyle
Mission and Tools	Samuel	Bre, Jackson, Jakob
Documentation	Natalie	Abby, Jackson, Eesha, Emily

Table 1: Team Member Assignments

In order to integrate these groups, K-Tech emphasizes the importance of open communication and organization. The company uses Slack, an instant messaging program, to ensure all members can contact each other outside of in-person meetings. Meetings are held every Wednesday from 3:00-5:00 pm, with additional meetings being announced through Slack. K-Tech also utilizes Google Keep, where the CEO assigns specific tasks and deadlines. This structures every meeting with an intuitive flow of small goals and accountability to maximize efficiency.

Timeline

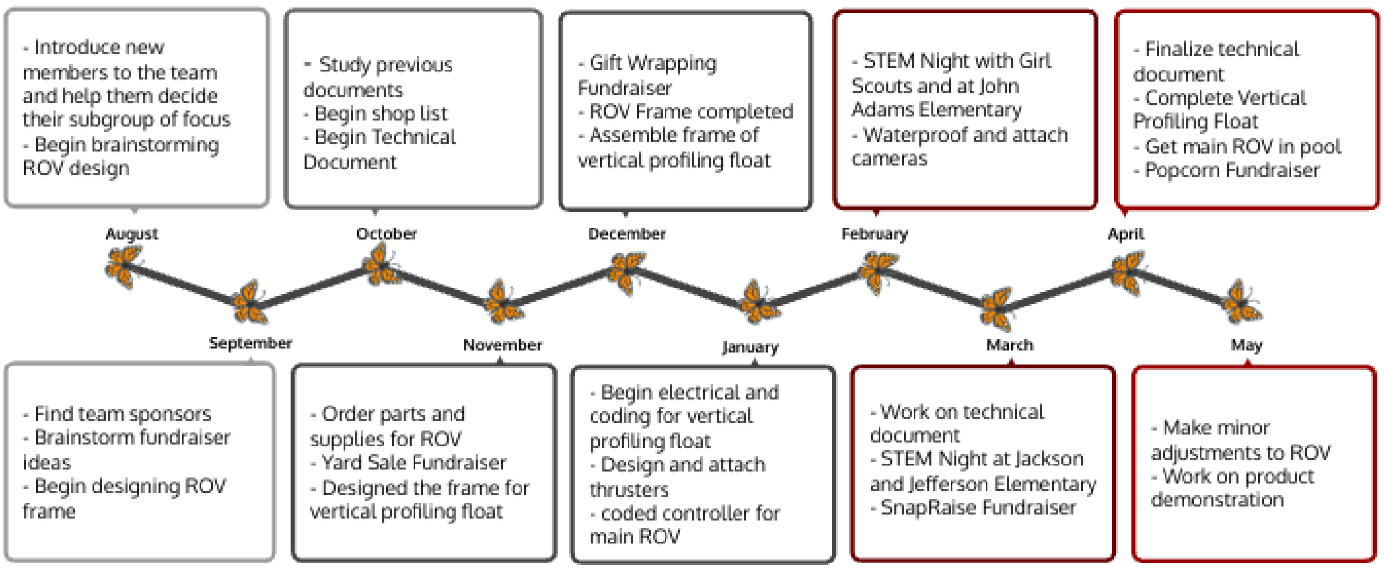


Figure 3: Timeline of company goals.

Safety

Kingsport Technologies prioritizes safety by creating safety procedures and enforcing them. Before pool testing, Monarch and members must meet the safety requirements for personal, equipment, and operational safety below.

<u>Safety Checklist</u>

- All equipment properly waterproofed
- No exposed sharp edges
- Hazardous/caution labels marked
- All analog cameras have power filters
- All power within a 30 amp limit
- Tools are a safe distance away from the pool
- A certified lifeguard is by the pool at all times
- Organized subgroups abide by all pool guidelines

Safety Procedures

- Ensure everything is shrouded
- Adhere to CDC's COVID guidelines
- Double-check that wires are properly connected to control box before poolside practice
- Abide by all pool guidelines
- Maintain attentive and professional behavior
- Put away all materials and tools in correct area after five
- Use protective equipment when working with resin
- Do not touch resin and epoxy until fully cured
- Two Members of the team are CPR certified, with at least one on active watch while the ROV is being operated poolside

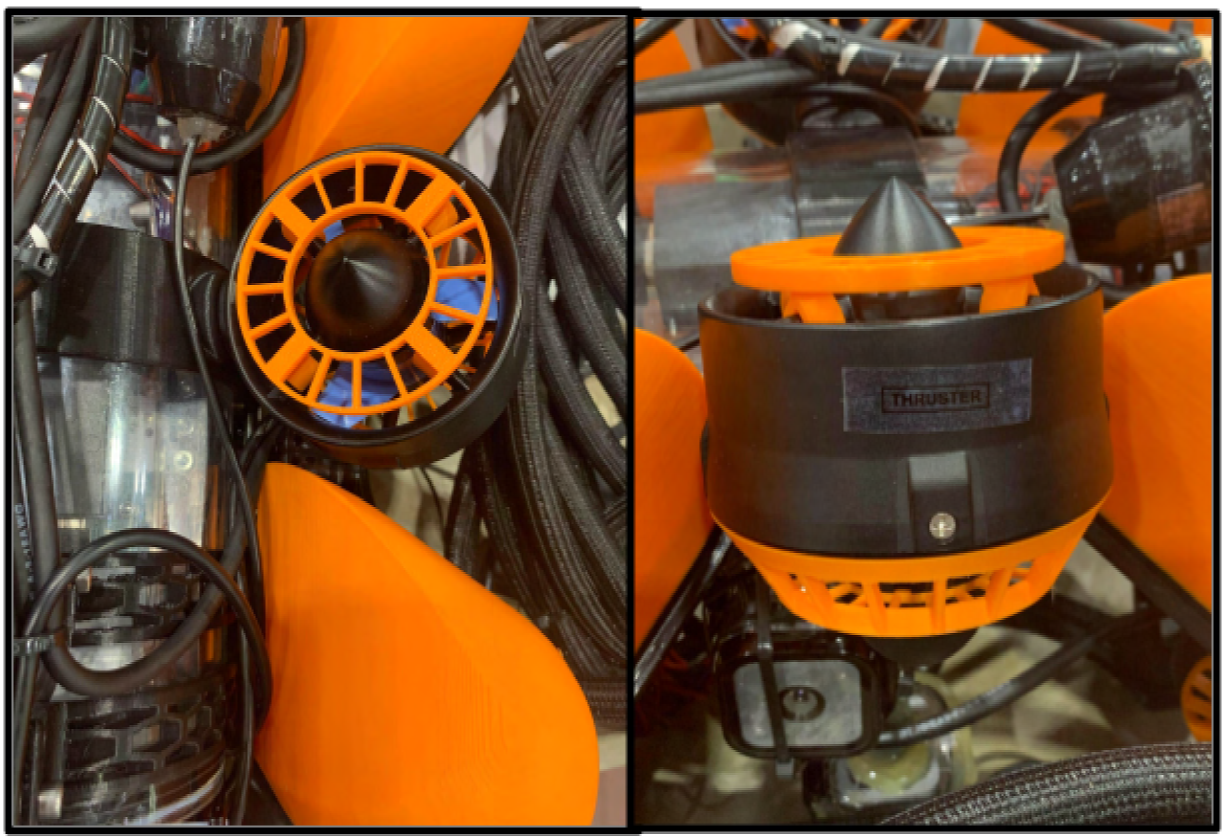


Figure 4: Thrusters on the ROV are properly shrouded.

Electrical and Structure Safety
K-Tech is aware of possible safety concerns in regards to using electrical tools. Therefore, the company enforces an attentive and cautious work environment while building. K-Tech trains all members in proper handling and maintenance of equipment before assembly begins. Members additionally follow the electrical safety procedures listed below. Team members maintain professional behavior and demonstrate appropriate use of tools throughout meetings.

Electrical and Structure Safety Procedures

- Use safety glasses when power tools are in use
- Connect all wires to correct gauges
- Ensure no exposed wiring and or fuses
- Unplug tools when not in use
- Be cautious about possible emergencies
- Allow proper time for organizing work area
- Ensure personal items are a reasonable distance away from work area
- Ensure wires are properly connected to control box
- All power has required voltage, no outlets are overpowered
  - All materials are correctly put away after use

Design Rationale

Engineering Design Rationale

The design process for K-Tech's Monarch ROV involved careful consideration of various factors. One of the first steps in designing Monarch was deciding whether to use aluminum V-Slot rails or a 3D printed frame. A polymer frame is cheaper, lighter, and allows for more design flexibility, while aluminum is more rigid and better for simple frames. K-Tech chose a printed frame because it provides more options in materials. This allows the Mechanical Team to tune each part to synergize with the material's properties and bought components. The Electrical Team then compiled a list of all the components needed on Monarch, including T200 thrusters for movement and an acrylic capsule for electronics. By figuring out which components were needed before choosing the frame material, the Mechanical Team could make a more educated decision on what met each mission's needs the best. In the design process, to decide which material was best, emphasis was placed on rigidity, toughness, and environmental impact because it addressed most of the weak points related to past materials K-Tech had used. After researching a series of common filaments, K-Tech decided on Tough PLA because of its slight flexural properties, and its similar toughness to ABS.

Properties	**Tough PLA**	**PLA**	**ABS**
Flexibility	Slightly Flexible	Brittle	Rigid
Toughness	Very Tough	Tough	Very Tough
Ease of Print	Easy	Easy	Difficult

Table 2: Comparison of different filaments and their properties.

With the chosen material, a holistic approach was made toward piecing together all subsystems instead of manipulating each component about the frame. While designing the frame around the components takes longer due to needing to know which components were going on the frame, experience from previous years meant most of the components needed were acquired before missions came out. This enabled K-Tech to have an ROV ready with future compatibility of additional accessories.

Innovation

This year, K-Tech has developed its most advanced ROV. Monarch is assembled using 3D printed components, allowing K-Tech to be less reliant on other companies for parts. Since a vast majority of the ROV can be manufactured on-site, the need for bought components is reduced.

This year, Monarch's tool system has been completely revamped. Instead of creating multiple different tools with separate mounting points, K-Tech established a standardized mounting system with a quick lock and release mechanisms for quick tool interchangeament. Monarch utilizes this standardized system to create different tools with a common mounting point to allow for easy organization and systematic resurfacing. Monarch has several tools including a custom hook for the deadlift task, a linear actuated claw, light module, and fish fry basket.

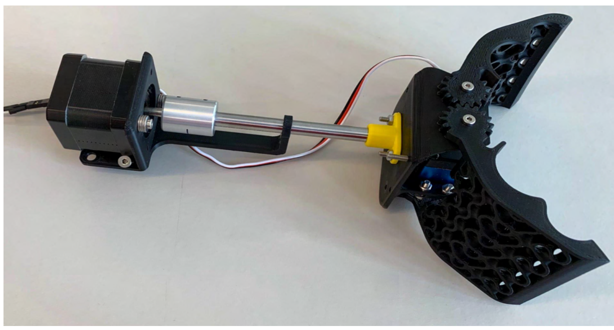


Figure 5: The manipulator and the linear actuator system

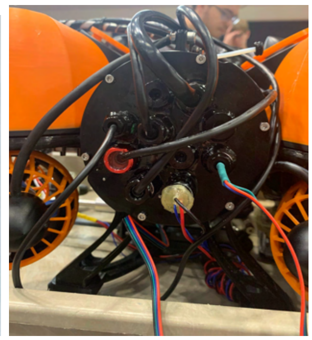


Figure 6: Capsule with wetlink penetrators

In addition to the standardized system, K-Tech has also modified their strategy for waterproofing this year. The 4″ electronics capsule now locks into place using an integrated locking mechanism which prevents external pull on either side, all of the wires are potted using reusable wetlink penetrators for greater interchangeability and modification, and a waterproof case is used for all our servos to prevent waterlogging.

Problem Solving

K-Tech began the year with structured brainstorming sessions for three meetings. In this planning stage, members of the company were broken into subgroups based on their preferences. Members were tasked with researching the benefits and downsides of various mechanical and electrical aspects, such as deciding whether to have a metal or 3D printed frame, then further

Figure 7: Charles working on code for the claw.

exploring the details of construction. Monarch's design decisions were made through group voting after subgroups presented their research, with the majority vote determining the final choice.

Figure 8: Aiden, Bre, and Jim weighing the ROV.

K-Tech consults with engineers from Eastman Chemical Company and local businesses in order to collect a greater understanding of mechanical and chemical processes in the construction of Monarch. Chemical engineers assist in the design of the 3D printed frame and waterproofing techniques since they have a greater knowledge of sealants and plastic characteristics. These mentors enable K-Tech to maximize efficiency of testing and reduce costs with better alternatives.

When problems arise in testing, K-Tech follows a pattern of isolating the problem, researching alternatives, constructing prototypes of the new solution, and finally testing the new alternative. This cyclical process ensures a constant flow of redesign and improvement. K-Tech is constantly innovating and redesigning, unafraid to change even fundamentals to improve.

Systems Approach

To get the most efficient ROV as possible, K-Tech prides itself on making each subsystem cohesive and responsive to each other.

<u>Mechanical and Electrical</u>
The Mechanical Design and Electrical Design teams worked together to decide the positions of the vertical thrusters on the frame. The teams decided to use a gyro on the ROV capsule and angle the vertical thrusters to allow for pitch. By considering integrated electronics with the frame, the mechanical and electronic features are able to be balanced on the ROV.

<u>Mechanical and Mission</u>
Another consideration was how each mission would impact the mechanical features of the ROV. Each mission was considered holistically and how the weight impacts the level. Different weights were placed on the base of the frame to allow for offsetting of

the general weights of each payload. The gyro from the electrical system also allows for the thrusters to use varying forces to help offset the weights from missions.

Vehicle Structure

In addition to the aforementioned benefits of plastic, another advantage of polymers is the ability to design components into any form needed for each subsystem. The V-slot rails are easier to assemble, since everything is pre-standardized; however, with a printed frame, the end result is much more compact and allows for more unique shapes. The cost of aluminum versus any filament was also a consideration. With aluminum, the Mechanical Team had to buy rails at a preset length, and then either cut them down or fasten them together. This presented a challenge of needing to overbuy to have enough for the frame. Simulations found that 3D printing was much more cost effective since the printer only uses the amount of filament required, with a little excess for supports. V-slot rails are stronger and more rigid than plastic, but are also much heavier. Since a large focus of Monarch is weight, K-Tech chose plastic, which provides enough strength while greatly reducing weight.

Figure 9: Comparison of metal V-slot rail and 3D printed part.

Vehicle Systems

<u>Frame</u>

Monarch's frame is tough PLA, which allows for a greater range of limit testing in terms of thickness, curvature, and lattices. The Mechanical team designed each piece of the frame to be able to withstand environments and situations mimicking the real world, including drop testing, the loads from assembly, and pressure from 12ft and deeper. A custom gyroid was created for the wings of the frame, which allows for vertical water displacement and reduces drag when resurfacing. Another benefit of this is the weight reduction and increased strength from printing out a solid piece. These lattices were built into load bearing components on the frame such as the vertical thruster bracket. This helps distribute the weight evenly towards the center of the ROV so that the capsule bears more of the weight instead of the print. Due to the underwater pressures, shear forces were also considered so every line was turned into a curve and every angle was flattened. This made it so the forces applied on the ROV are distributed evenly across the entire frame. Finally, a standardized screw was chosen for every component on the frame so that assembly is much easier, and cost was minimized through bulk buying.

Camera Based Design

Figure 10: A waterproofed camera.

An important aspect of the design process was considering what missions K-Tech planned on doing. As the Mechanical Team decided which missions had the highest realistic success rate, they found that most of the missions were camera based. This led to changing the frame to be more optimized for camera compatibility. The electronics tray within the capsule was raised to allow for more flexible camera placement and an additional 5 camera placements that can provide 6 unique angles based on the field of view of the USB cameras.

Claw

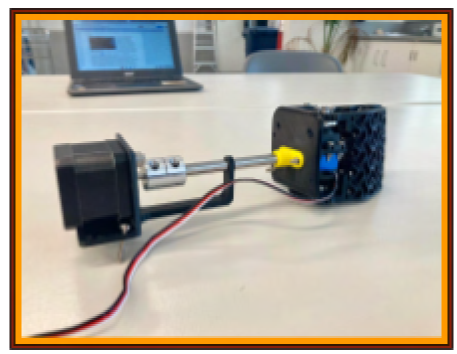


Figure 11: Manipulator attachment of ROV.

As with the other subsystems of Monarch, every aspect of the manipulator was given much deliberation. After considering everything from hydraulics to laser cut metal claws to simple hooks, K-Tech decided on a 3D printed two prong manipulator with enough surface area to support attachments and payloads. The 3D printing allows for interchangeability of different manipulators given the environment for the mission and allows for much greater hydrodynamics and balance. Since the manipulator is printed, the print settings were modified to make each side neutrally buoyant so they do not affect buoyancy calculations. A gyroid based lattice for the prongs was integrated within the claw frame because of its ease of water transmission and its stability and ability to print without supports. The prongs also feature a built-in PVC connection with 2 PVC molds supporting pipes between 1 inch to ½ inch. This was chosen because most of the missions required either of the 2 types. The connections also allow for better grip of any addons needed. The manipulator is able to continuously rotate thanks to a 30 kg servo in a waterproof case.

Control/Electrical Systems

The control system for this year's ROV is built around an Arduino Due located in the ROV's capsule. The Arduino Due was chosen for this year's ROV due to its native USB port and abundance of PWM-enabled pins.

Most Arduinos use the ATmega 16U2 as a USB-to-serial chip, meaning the actual main microcontroller does not directly interact with the USB bus. The Due, in addition to the normal "programming" USB port that runs through an ATmega 16U2, has a "native" USB port that connects directly to the microcontroller chip. This means the Due can act as a USB host and be directly connected to the controller, the DualShock 4. In addition, the Due can be programmed through this native port, meaning the same tether cable used to transmit the controller signal can be used to program the ROV from the surface. In fact, the entire design philosophy for our tether was to minimize the amount of cables. The current design only uses 3 cables (18 total conductors).

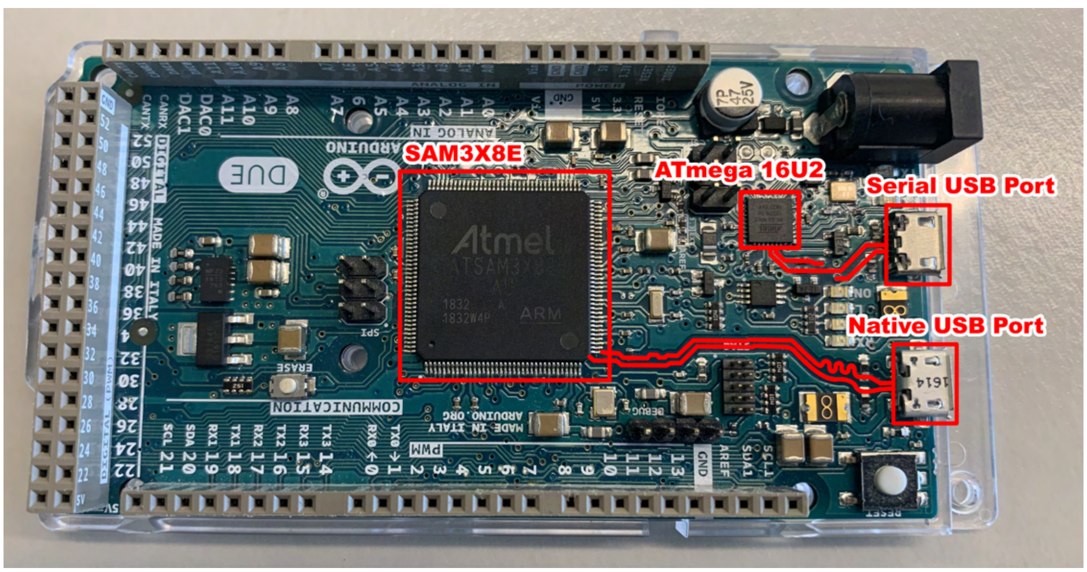


Figure 12: Arduino Due with labeled USB ports, microcontroller chips, and related traces

At first, an off-the-shelf USB-over-ethernet active extender was used to transmit the controller's USB signal to the capsule. However, this extender has fixed "host" and "device" ends. If the Electronics team wanted to both program the ROV (surace-side host, ROV-side device) and drive the ROV (surface-side device, ROV-side host) with the same cable, an extender that allows for configurable host and device ends was needed.

Opening the off-the-shelf extenders revealed that they used the same PCB layout with different configurations of resistors to set the mode of the extender chip, the UIC4102CP. A custom schematic was then created for the extender based around the same chip, but with a set of DPDT relays to control the chip's mode based on the position of a switch on the control box. This circuit was built into the larger control box PCB and an altered version was placed in the capsule.

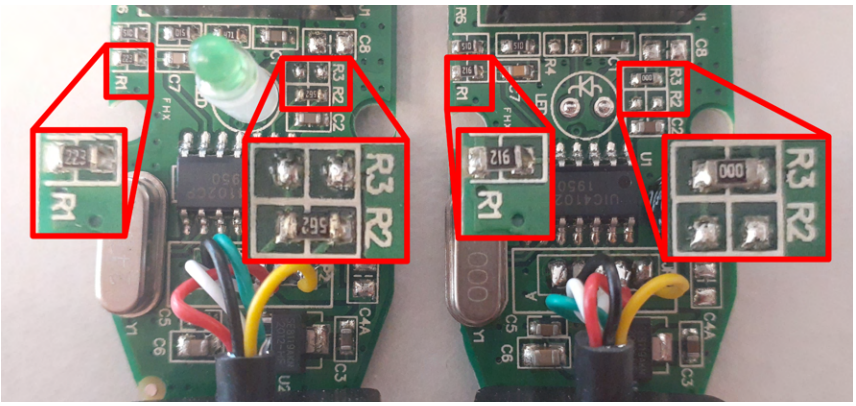


Figure 13: The host and device ends of the off-the-shelf USB extender, with different resistor configurations setting the mode of the UIC4102CP chip.

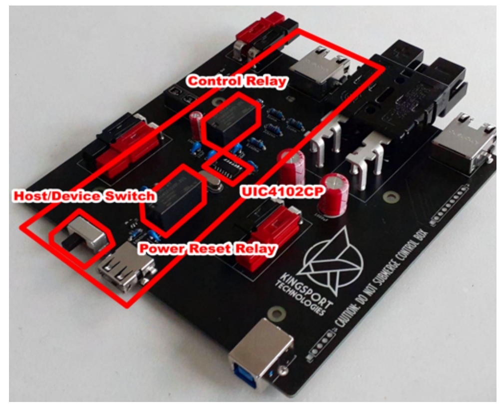


Figure 14: Control box PCB with configurable active USB extender highlighted and important modifications labeled.

Unfortunately, the official USBHost Arduino library only has built-in support for keyboards and mice. The Electronics Team developed a version of the USBHost library with custom HID parsing and logic to support the controller. K-Tech made the decision to release the improved custom library to the world to help other teams with the same issue.

The control box consists of a single custom PCB containing three separate circuits. The first circuit handles power delivery for the ROV. It contains an Anderson PowerPole port for connection to the power supply, a fuse, power switch, watt meter, and two 1000uF electrolytic capacitors to stabilize the power. All power distribution is done onboard the ROV. The second circuit is the configurable active USB extender discussed above. The third circuit is simply some port breakouts for IO alignment with the USB extended hub used in the camera system.

The onboard capsule contains the Arduino Due along with two custom PCBs, electronic speed controllers, and the camera system. The first custom PCB is the altered USB extender discussed above. The second PCB is in charge of power distribution and providing IO for the various servos and electronic speed controllers on the ROV. It also contains a 6-axis gyroscope/accelerometer (MPU-6050) and a humidity sensor (DHT-20). The use of these custom PCBs avoids creating a rat's nest of wires in the capsule, conserving room in the already cramped space.

The tether management procedure is as follows:

1. Inspect tether before deployment for abrasions, cuts, or kinks.
2. Use an on-deck member to tend slack on the tether.
3. Always stand at least two feet away from the edge of the pool.
4. Always have a secondary member help pull the ROV up in case of emergency shutoff.

Propulsion

Monarch is propelled using six T-200 thrusters. T-200 thrusters were chosen for their performance, allowing for better movement. Although other thrusters were cheaper and used less power, missions can be completed faster with the T-200s. Four of these thrusters are positioned in a vectored format to allow for horizontal movement in all directions, with power output for each thruster being determined by custom code. Two additional thrusters were placed at 45 degree angles vertically in the top-middle of the ROV to allow Monarch to change its depth in the water. The 45 degree horizontal angle was chosen so that the water flow from the vertical thrusters would not interfere with the frame of Monarch, and so that the ROV can tilt when unbalanced. Each thruster is encased in a shroud that was printed in Tough PLA. All gaps in the shrouds are less than 12.5mm to ensure a safe environment when operating the ROV.

Buoyancy and Ballast

As designs for the frame progressed, buoyancy was kept in mind for how it would affect balance. The four wings are positioned on the frame above the horizontal thrusters at each corner. These wings have buoyancy capsules filled with air to offset weight centers such as the forward claw and rear camera.

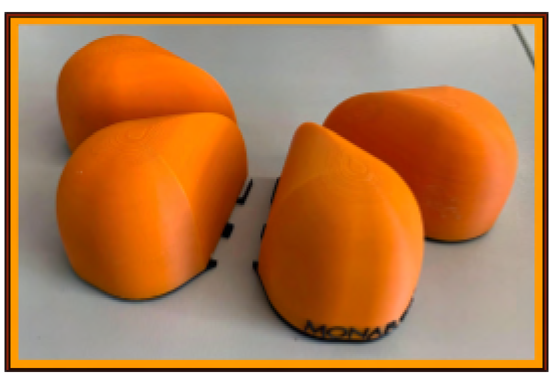


Figure 15: Buoyancy capsules.

The buoyancy capsules were printed with a stronger setting compared to other components on the frame to prevent any collapse or release of the air from the water pressure. The design for each capsule was parametrically made so that simulations could determine the appropriate height to reach neutral buoyancy. This allowed for greater efficiency in the design process and reduced downtime between design and print.

Payload and Tools

An issue K-Tech had in previous years was whether to create one tool for every mission, or to have multiple different tools on several mounting points across the ROV. After reviewing the different missions and planning out when we would resurface, K-Tech decided on a standardized tool system with two mounting points for maximum efficiency. The mounting system also has a quick release system consisting of a block slide in and lock held in place by spring. This allows for a quick twist and release pool side for tool changes. A standardized mounting system also makes designing new tools much easier, by only needing to design the specific tool part, and not worry about how it mounts to the ROV.

<u>Fish Release</u>
For Task 2.5 (fish fry release and rehabilitation), a container was designed that could be easily fitted into the claw. The container has an open top and 3 barrels that can be gripped by the claw in the case the standard handle is unavailable. This container can have a wider base so that it can be set down on the pool floor in the rehabilitation area while Monarch completes other missions. The barrels and handle also allow for ease of the claw to rotate, which lets the fish slide out and into their new location.

<u>Deadlift Buoyancy</u>
One issue facing buoyancy is how the ROV reacts to payloads since with calculated neutral buoyancy, the ROV does not have any additional weight. This means that with heavier payloads, the ROV is unable to properly correct for the weight. For the payload capacity mission and the deadlift mission, a separate buoyancy system was created consisting of a deflated balloon and hose carried by the ROV down to the payload attached via a hook. The balloon is then inflated by a bike pump on deck to lift the payload to the surface.

Light Apparatus

To provide visibility and complete the photoresistor task, the Mission and Tools Team came up with a mountable flashlight that can be switched on and off remotely. The light is designed to illuminate the tube and light sensor. A cone was attached to the front of the light to block external light.

Vertical Profiling Float

K-Tech has designed a vertical profiling float, named Michael, capable of completing multiple vertical profiles and transmitting data wirelessly to the control station on the surface. The frame of Michael is a 4 inch inner diameter capsule cut down to 7 inches in length. One side is covered with a 5 port end cap, the other is sealed using Flex Seal. Michael is propelled by a buoyancy engine consisting of bi-directinal water transfer pump, a large green balloon, two disconnects, tubing, and a water reservoir. The bi-directional water pump sends water from the balloon to the reservoir, making the engine negatively buoyant to float to the surface. When Michael has reached its required depth, the buoyancy is then changed by moving water from the balloon to the reservoir and floating Michael to the surface. A Raspberry Pi Pico stores the code and communicates between all other electronics. A bluetooth module allows for a wireless transmission of Michael's travel times, which is tracked using a real-time clock. Michael is powered by two 9 Volt batteries, with a DC-DC Buck Converter lowering the voltage for the raspberry pi pico.

Cameras

Figure 16: Waterproof camera.

USB cameras were used instead of vehicle backup cameras from previous years, since they are easier to repair and replace. These cameras themselves are waterproof, being rated IP69K dust and water resistant. This allows for easy access to the camera, unlike in previous years where the camera was potted in epoxy resin. Although the USB cameras are more expensive, the higher quality video and compact mounting made them worth the investment. These cameras also do not reverse the video feed, making them much more intuitive for the driver. There are 4 main cameras on the ROV, one mounted on the claw for claw based missions, one on the rear rails for rear driving and downward view, one within the capsule for a more centered view of the front of the ROV, and one near the top of the ROV for a angled view of the front and of the claw for better driving.

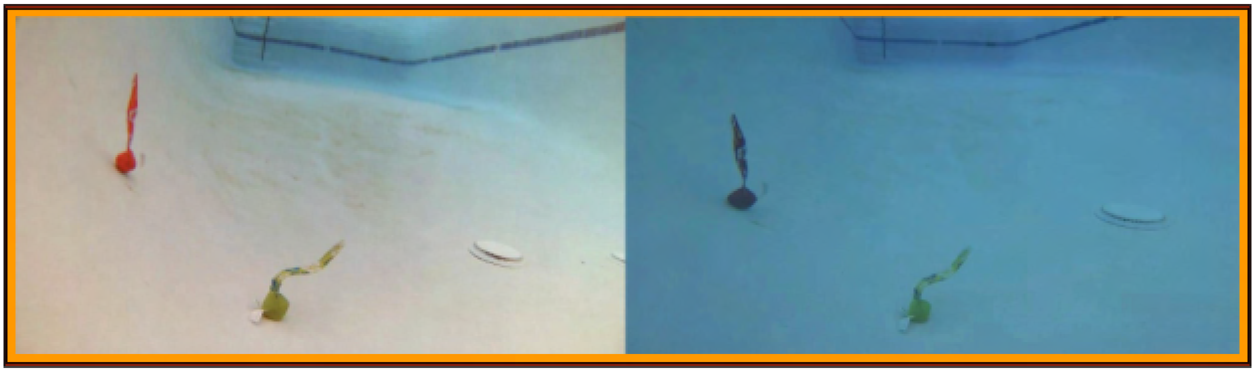


Fig 17: The advanced image processing onboard the waterproof cameras allow for superior image quality in the water.

Build vs. Buy, New vs. Used

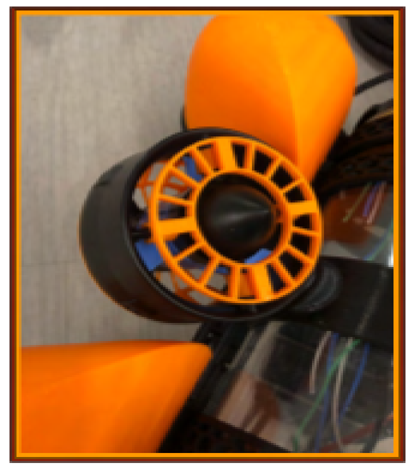


Figure 18: Reused T200.

With K-Tech's focus on efficiency, Monarch balances the outsourced professional components with its customized parts while also recycling costly components from the previous year's ROV. Since the company uses a 3D printed frame, K-Tech does not need to buy components for the frame except for the electronics, capsule, and thrusters. It was decided that a printed or on-site attempt at a waterproof capsule would be too much of a risk for the electronics inside. This means that the company was willing to invest in a professionally engineered water-sealed container. Other items that were purchased rather than built were four T-200s. Two T-200s are being reused from last year to limit waste and decrease one of the major costs of the ROV. These thrusters are a pivotal determining point in Monarch and paying for reliable, durable thrusters allows for higher functionality and reliability. The company also invested in new wetlink penetrators this year, designed to be easily removable. This was easier and more manageable than recycling last year's potting entries that required scraping out the marine resin. The wetlink penetrators were purchased due to their

Figure 19: Blue Robotics wetlink penetrators.

required precise machining and waterproof seals that were more reliable than the resin-potted cables of last year. In respect to the camera system, the cameras themselves were purchased along with rotary mounts and waterproof camera containers. The rotary mount is smaller than anything K-Tech could create and allows for a mounted camera inside of the capsule with 90 degree range of view. The waterproof mount for the exterior cameras fixes the previous year's leakage and destruction of the cameras by establishing a machined seal and rated container.

Testing and Troubleshooting

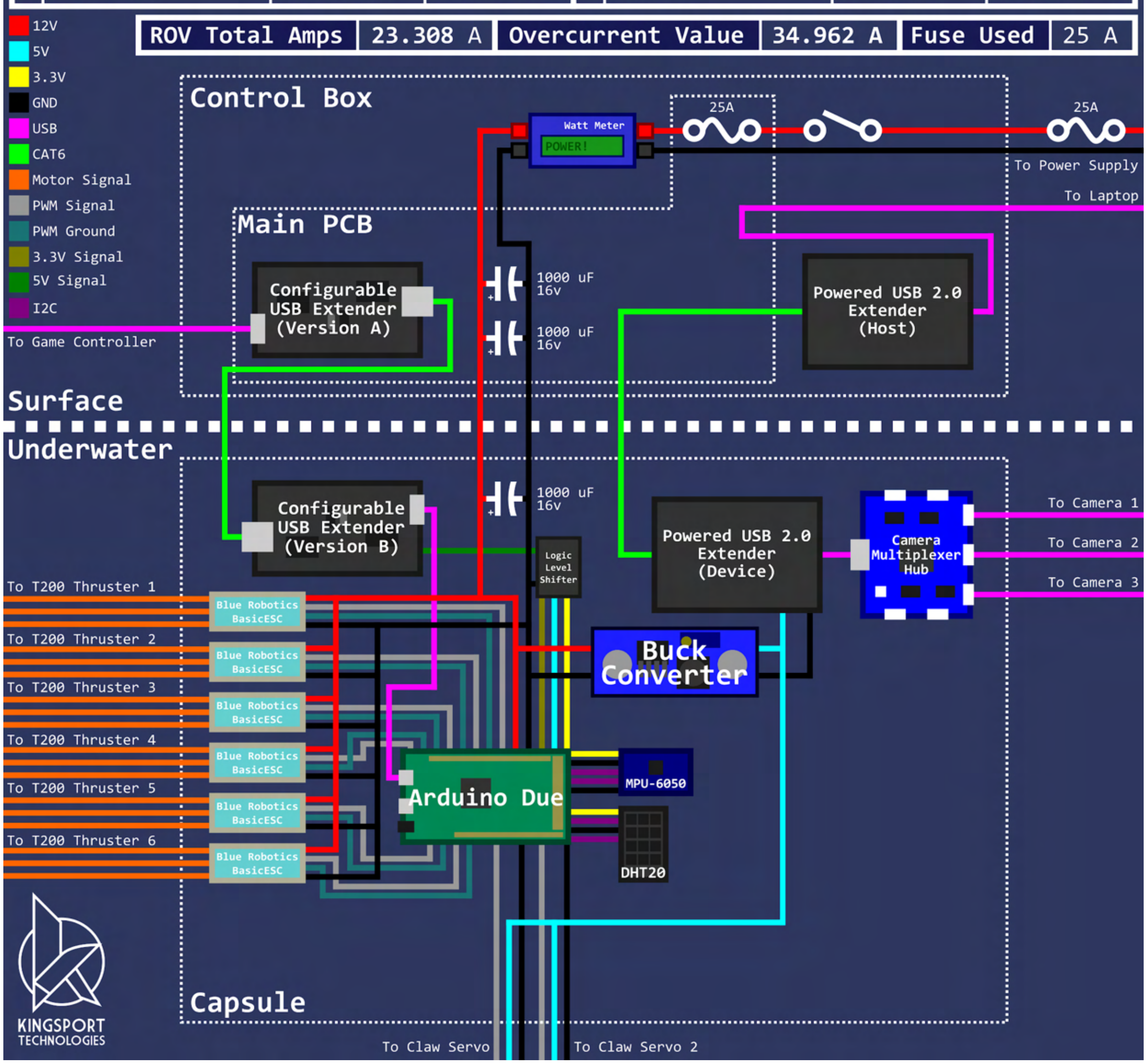
The testing of Monarch can be divided into two phases: the testing of individual subsystems and components and the testing of the complete vehicle. The initial testing focuses on each subsystem's functionality, including the propulsion system, the camera system, and the control system.

The complete vehicle testing involves testing the entire vehicle's performance as a cohesive unit. The testing includes evaluating the vehicle's maneuverability, speed, and stability in different water depths and pressures, which is crucial in identifying any potential design flaws and ensuring the vehicle is safe. If the ROV malfunctions, troubleshooting techniques include identifying the root of the problem and developing a solution based on the problem. After a solution has been developed, the ROV can be retested in order to ensure the problem has been fixed. For example, complete vehicle testing was used to test Monarch's overall buoyancy by placing the ROV in water. This helped identify that it was positively buoyant, so the company changed the height of the buoyancy capsules to make Monarch neutrally buoyant. This approach helps in identifying potential design flaws early on and modifying the design to address these issues.

Prototyping also helps in identifying potential design issues so they can be modified easily. Prototyping techniques like 3D modeling in CAD help the company to evaluate the functionality and reliability of each component and subsystem before integrating them into the final product. For example, the buoyancy capsules were put through a series of prototypes and trials, including using spray foam as a filler, leaving printing supports in the empty space, and finally settling on modifying the print to be completely enclosed and hollow. These techniques allow for assessing the usefulness of different design options to determine which option best meets the project's requirements. Through the use of prototyping, testing, and troubleshooting, the company can design components, identify potential problems, and adjust the components to ensure the greatest possible vehicle performance.

SID

#	Product	Amps Per	Amps Total	#	Product	Amps Per	Amps Total
1	Arduino Due	70.80 mA	70.80 mA	6	BasicESC	76.89 mA	461.34 mA
1	Conf. Extender	34.99 mA	34.99 mA	3	Camera	250.00 mA	750.00 mA
2	Servo	0.97 A	1.94 A	6	T200	3.34 A	20.04 A
1	MPU-6050	10.00 mA	10.00 mA	1	DHT20	0.98 mA	0.98 mA



Budget and Accounting

Budget

Dobyns-Bennett High School MATE-ROV Team Budget 2022 - 2023			
Expenses:			
Category:	Description/Example:	Projected Cost:	Budgeted Value:
Capsule:	Pressure Relief, Acrylic Plastic, End Caps	$400.00	$400.00
Electrical	Cables, Raspberry Pi, Monitor	$400.00	$400.00
Frame	Screws, Heat Inserts	$270.00	$270.00
Programming	Capacitors, Resistors	$200.00	$200.00
Propulsion	Stepper Motors, Thrusters	$650.00	$650.00
Visual	Cameras, Camera Mounts	$1,660.00	$1,660.00
General Supplies	Zip Ties, Screwdrivers	$400.00	$400.00
General	Competition Fee	$200.00	$200.00
General	Apparel	$150.00	$150.00
Travel	Gas, Food, Flights	$16,000.00	$16,000.00
Income			
Type	Source	Amount	
Donation	Advanced Anesthesia Solutions	$500.00	
Donation	Anonymous	$6,000.00	
Donation	Anonymous	$6,000.00	
Fundraiser	Gift wrapping	$750.00	
Fundraiser	SnapRaise	$4,018.80	
Fundraiser	Yard Sale	$1,067.25	
Fundraiser	Cornucopia	$111.00	
Fundraiser	Water Bottles	$1,678.00	
Sponsorship	Kumon	$200.00	
Sponsorship	Streamworks and Ballad Health	$1,000.00	
Totals:			
Total Expenses:	$19,963.45		
Total Income:	$21,325.05		

Project Costing (Purchased items)

Category:	Product	Source:	Individual Price:	Quantity:	Item Total:
Capsule	Cast Acrylic Plastic - 300 mm	Blue Robotics	$216.00	1	$216.00
Capsule	Watertight Enclosure End Caps	Blue Robotics	$26.00	2	$52.00
Capsule	O-Ring Flanges - 100 mm (4")	Blue Robotics	$43.00	2	$86.00
Capsule	Pressure Relief Valve	Blue Robotics	$28.00	1	$28.00
Electrical	WetLink Penetrator(6.5LC)	Blue Robotics	$50.00	1	$50.00
Electrical	Wetlink Penetrator(5.5LC)	Blue Robotics	$12.00	2	$24.00
Electrical	Raspberry Pi Pico	Amazon	$11.99	1	$11.99
Electrical	DC-DC Step Down Buck Power Converter	Amazon	$10.49	1	$10.49
Electrical	Buck Converter Power Volt Transformer (12V/24V to 5V 3A)	Amazon	$10.99	1	$10.99
Electrical	GearIT 12/2 Marine Wire (100 Feet) 12 AWG Gauge	Amazon	$79.99	1	$79.99
Electrical	Servo	Amazon	$31.00	3	$93.00
Electrical	Servo Horn	Amazon	$11.00	1	$11.00
Electrical	50 ft 10 Gauge Wire	Amazon	$28.13	1	$28.13
Electrical	Raspberry Pi Pico	Amazon	$14.50	1	$14.50
Electrical	Motor Controller	Amazon	$15.99	1	$15.99
Frame	Screws and Nuts (Complied Total)	McMaster			$161.54
Frame	Buoyancy Foam	Amazon	$39.99	1	$39.99
General	Assorted Zip Ties	Amazon	$12.79	1	$12.79
General	10-Piece Screwdriver Set	Amazon	$14.99	1	$14.99
General	Soldering Iron	Amazon	$49.99	1	$49.99
General	Robots for STEM Nights	Amazon	$24.49	4	$97.96
Propulsion	Nema 17 Stepper Motor	Amazon	$55.00	1	$55.00
Propulsion	T200 Thruster	Blue Robotics	$210.00	2	$420.00
Propulsion	Basic ESC	Blue Robotics	$36.00	2	$72.00
Visual	Low-Light HD USB Camera	Blue Robotics	$99.00	2	$198.00
Visual	USB to Ethernet Box	Amazon	$55.99	1	$55.99
Visual	Low-Light HD USB Camera	Blue Robotics	$99.00	2	$198.00
Visual	Camera Tilt System	Blue Robotics	$64.00	1	$64.00
Visual	Mount for USB Camera	Blue Robotics	$4.00	1	$4.00
Visual	Camera Mount	Amazon	$12.99	3	$38.97
Electrical	Circuits and Components for Control Board (Compiled Total)	DIgikey			$129.05

Electrical	USB 2.0 Extender Hub	Amazon	$49.99	1	$49.99
General	¼ Inch Hose	Amazon	$12.59	1	$12.59
Electrical	Bluetooth Module	Amazon	$18.99	1	$18.99
Electrical	Pico	Amazon	$12.99	1	$12.99
Electrical	4 Relay Board	Amazon	$12.99	1	$12.99
General	Reservoir	Amazon	$31.34	1	$31.34
Visual	Underwater IP Camera Marine	Amazon	$250.00	1	$250.00
General	750 GPH Drill Pump	Harbor Freight	$14.99	1	$14.99
Electrical	Servo	Blue Trail Engineering	$90.00	2	$180.00
Visual	USB Machine Vision Camera	DeepWater Exploration	$279.00	3	$837.00
General	Tapered Heat-Set Inserts	McMaster-Carr	$10.35	2	$20.70
Frame	6mm to 25t Spline Coupling	ServoCity	$6.99	3	$20.97
Electrical	USB Extender	Amazon	$156.55	1	$156.55

Project Costing (Reused items)

Category:	Product	Source:	Individual Price:	Quantity:	Item Total:
Electrical	Basic ESC	Blue Robotics	$36	2	$72
Propulsion	T200 Thruster	Blue Robotics	$210.00	2	$520.00

Totals:

Project Costs:	
Capsule:	$382.00
Electrical	$910.64
Frame	$222.50
Propulsion	$547.00
Visual	$1,645.96
General Supplies	$255.35
Travel	$16,000.00
Total Income:	
Donated:	$12,500
Fundraised:	$8,656.25

Sponsorships:	$1,200
Net Totals:	
Total Spent:	$19,963.45
Total Income:	$21,325.05
Balance from Previous Year:	$3,422.18
Final Balance:	$4,783.78

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