Hydro_04 Technical Report

MAY 24, 2019

UNIVERSITY OF RHODE ISLAND
KINGSTON, RI

ROV TEAM:

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Austin Clark………………………………………...…….. Structure Leadership
Hunter Claudio……………………………………..……. Structure Leadership
Karla Haiat………………………...………………………………...... Control
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URI Hydrobotics

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Acknowledgements

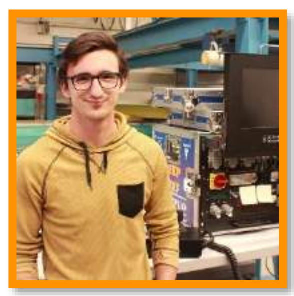
URI Hydrobotics would like to thank the MATE competition, as well as our Team Sponsors who help us create an environment and product that encourages advancements in Marine Technology.

Abstract

URI Hydrobotics set out this year, like every year before it, not only to fulfill the standards outlined in the MATE Competition handbook, but to seek the betterment of the next generation of engineers. After calculus and physics, between class and studying, URI Hydrobotics took what the company loves to do and sent the team into the field. Just like the many that came before those on the team today, the group that graduate from this team will possess skills of the classroom combined with familiarity of hands-on work. The team's objective is and has always to educate and enable the very people who will be the difference in the world of engineering to come.

This year has been a practice of perseverance. Twelve-hour meetings, multiple re-designs, and the end cap of the electronics housing coming off underwater two and a half days before qualification brought URI here. This team has been through many changes in the few years since its founding, and this year was a continuation of the development that URI Hydrobotics is undergoing to become a better and stronger group of people. Had standards been lower, or work ethic weaker, the team you see before you would not exist today. Veteran members paved the way for new undergraduates, and through much patience and guidance this robot built a team better than any year before.

Jackson Sugar
Team Captain



Team

URI Hydrobotics is comprised of ambitious undergraduate students that strive to design, manufacture and build a ROV to compete in the MATE competition's explorer class. As a student run organization, we not only compete at the world level but also strive to educate students in the fundamentals of building underwater robotics systems. Every year poses new challenges and learning opportunities, even for the most experienced veterans on the team; this allows everyone to further their own knowledge as well as to help each other learn in the process. We have a dedicated team of upperclassmen that work to keep the team in a functioning order and help direct students' endeavors. As a group, we project an atmosphere that allows undergraduate engineers to invest in educating themselves, while developing practical and professional skills.

Design Rationale

Project Management

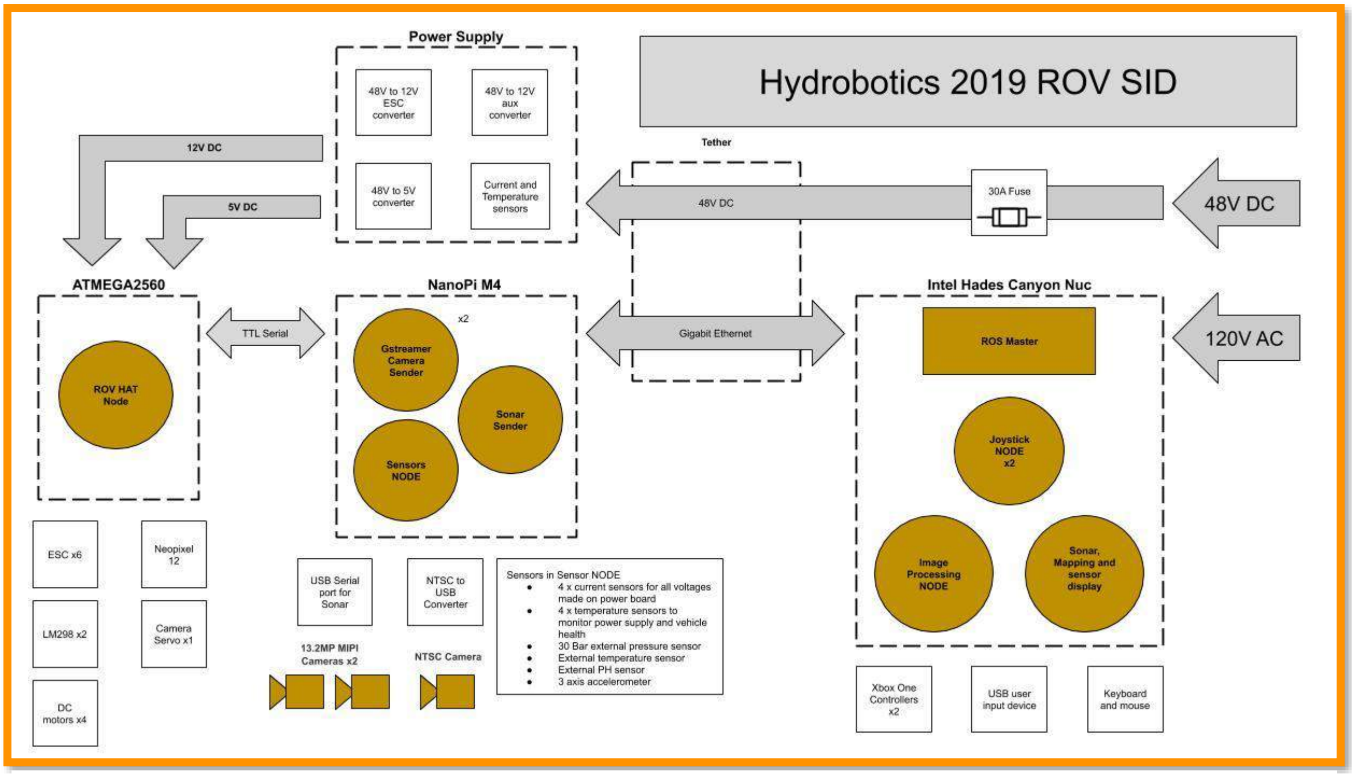
URI Hydrobotics is branched into two focuses, one on the mechanical development of the ROV, and the other on the control operations. This structure allows the company to focus on the larger aspects of education, design, and development that come with each side of the team. Though every member of the company is involved in and understands both the mechanical and control sides of the team, this setup provides the opportunity for more specific leadership and mentorship within each branch.

Graduating leadership of the control portion of the company put a heavy emphasis on education of company members this year in order to prepare future members and ensure successful longevity of the team. URI Hydrobotics is moving towards involving more general members in the process of control development, and the team is now prepared to include more members in future software design and development. The hard work of senior members in setting the team up for success is greatly appreciated and will be used for years to come.

The other branch of the team, focused heavily on the mechanical portion of the ROV, created a system this past winter that drew all members into the design process. Each member of the team, new or old, was tasked with choosing one aspect of the competition and creating a comprehensive design that would set out to complete the task. Over the University of Rhode Island's two-and-a-half-week J-Term, each member became familiar with their chosen task using the MATE Competition Manual and created a design. Biweekly team Google Hangout sessions provided an opportunity for the whole team to check in despite a portion of members having returned home for a period and some having stayed in Rhode Island for classes. During these meetings, members would present their drafts and receive feedback, hear suggestions, and ask questions in order to improve their designs. Utilizing the University's J-Term in this way allowed the team to get jump start on the design process and the company was able to go into more formal prototyping and development once members returned to school and were finished with winter classes. Projects completed by new team members included the metal detector and cannon catcher, and new members contributed to many other aspects of the competition, including the micro ROV and manipulator.

Hydro_04 Mission Solutions

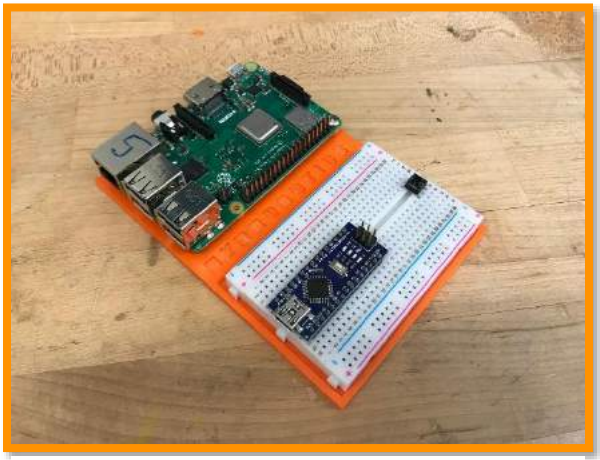
Control System



1-Overview of ROV SID

In seasons past, the electronics and software of the ROV where handled by one or two members of the team, totally undercutting the collaborative process and educational goals of the team. This year the company took a different approach teaching how the ROV works by narrowing the focus of the curriculum by establishing standard methods for control and communications with the ROV. The company designed custom hardware kits and delivered a multi-part lecture series to actively demonstrate the lessons learned in class from simple circuits and motor control to interfacing Linux based computers and AVR microcontrollers with the ROS network. Lectures also covered topics such as control rational, PCB design and GUI programming. Though the company was not successful in incorporating other members in the design and programming process, the company did finish the year with a ton of great documentation, reference material and a generalized control system to be used for years to come.

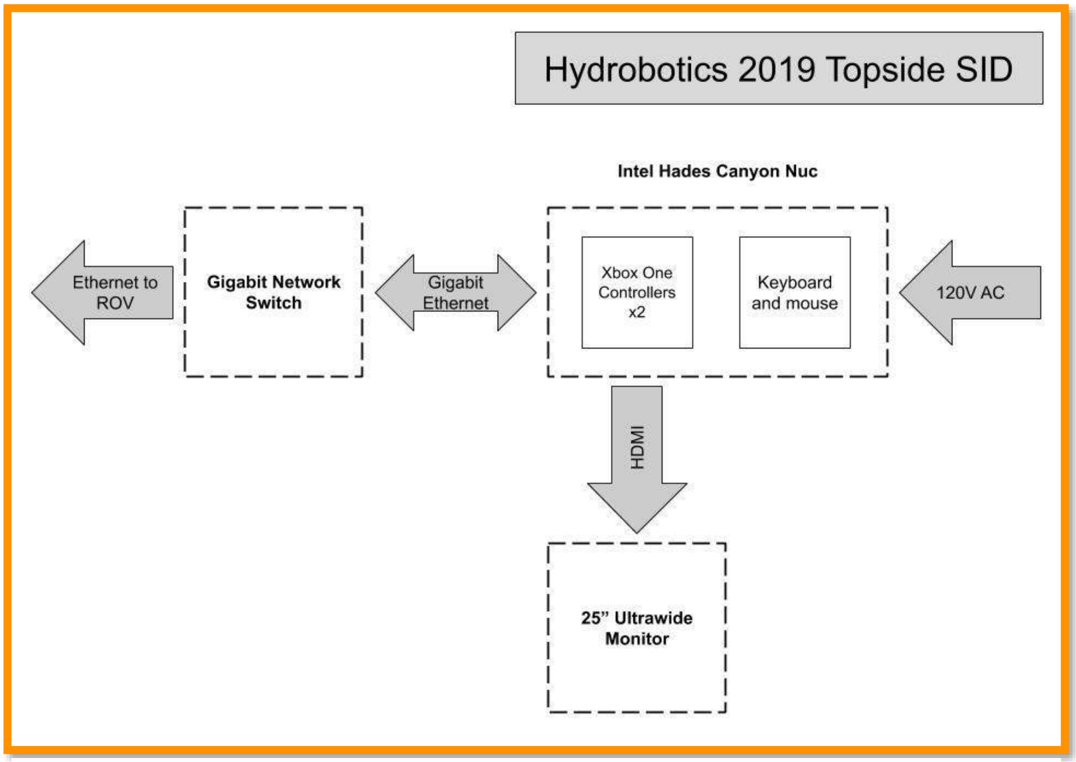
2-Hands on tutorial series for control and software development



3-Development station used in tutorial series

Topside

The Hydrobotics topside box was designed to be reused from year to year as a cost saving measure. The simple layout consists of a small form factor computer (Intel Nuc), a gigabit network switch and a 25-inch ultrawide monitor all housed in a Pelican Air 1605 case. All components are powered by a single 120 AC power connection. The Linux computer handling user inputs, machine learning and sensor outputs communicates directly with the ROV over an ethernet LAN connection.

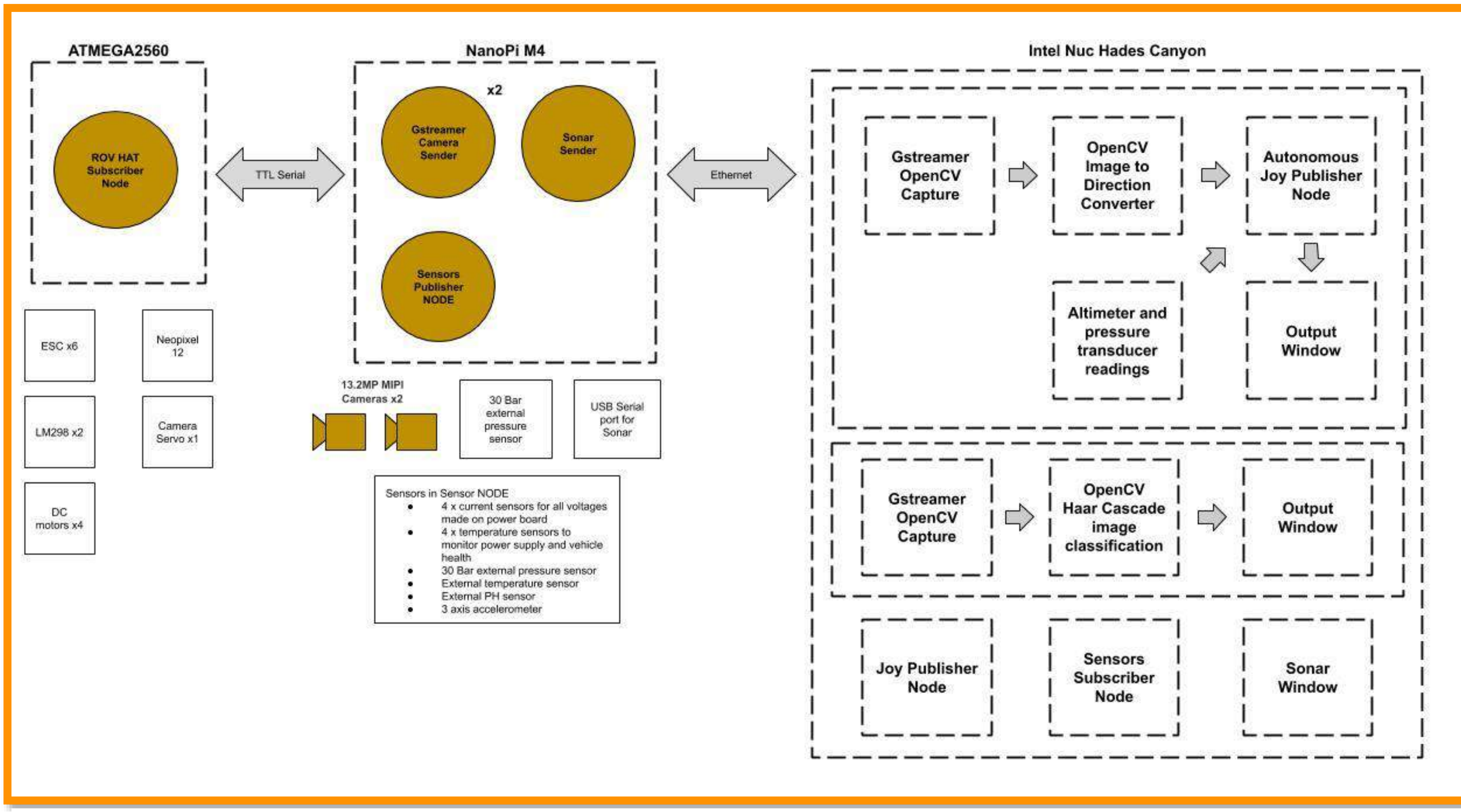


4-2019 Topside SID

5-Using topside at a local seaperch ROV competition

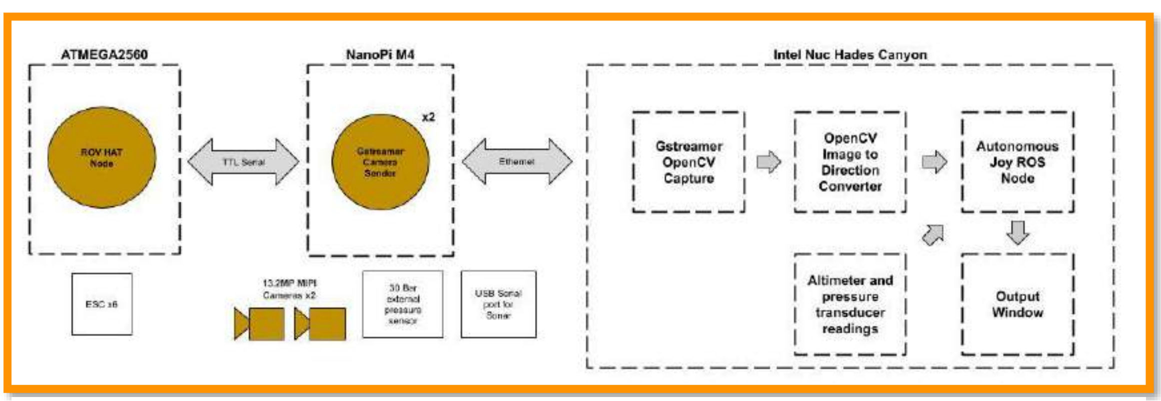
Software

Like all other control related aspects of the Hydro_04, the software infrastructure is also meant to be easily taught. As noted in previous sections, the team decided to transition to a ROS based control system to better prepare undergraduates for industry. Keeping the software as streamlined as possible proved less difficult than predicted. The publisher-subscriber relationship between interconnected devices on the ROS network allow for incredibly flexible access to all system data from any device attached. Leveraging this to our advantage the control system can be boiled down to two publisher-subscriber interactions on the ROS network. The joy ROS topic publishes all joystick inputs from topside and is subscribed to by the ATMEGA2560. All values published to joy operate devices connected to the microcontroller. Similarly, the sensor publisher sends all data from the NanoPi to the topside sensor subscriber to be interpreted and used as need be. Outside of the ROS network we employ gstreamer to rtp (real-time transfer protocol) both camera's sensor data to topside. Lastly the sonar streams data using UDP (user datagram protocol) from the NanoPi's usb port to the topside computer for analysis. All systems are initialized with a single autostart shell script from topside.



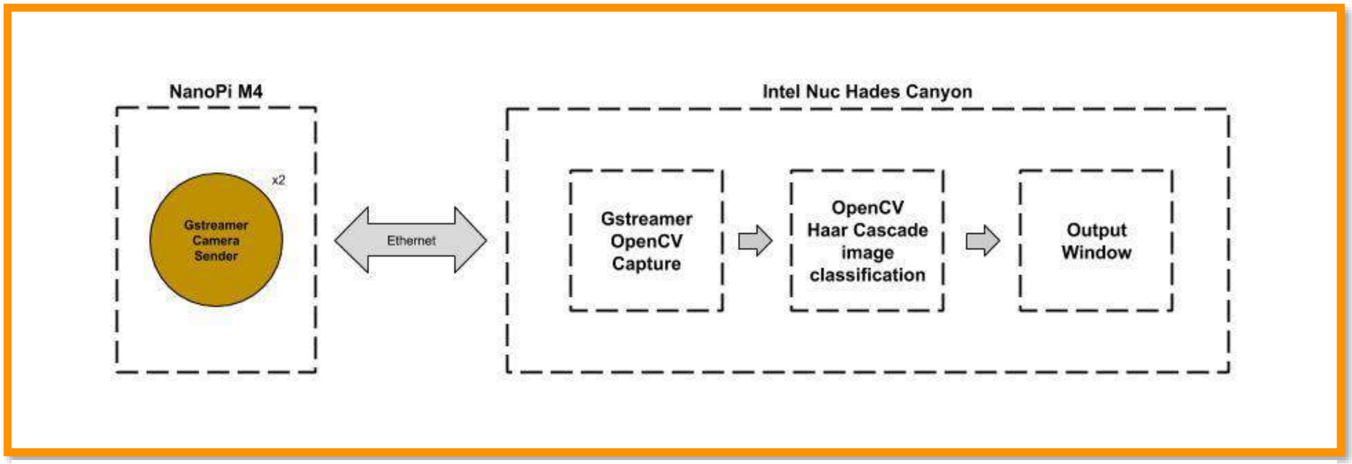
6-Detailed software breakdown

To complete task 1a, autonomous inspection of the dam foundation, the company opted to use OpenCV (Open Computer Vision) libraries as gstreamer has built in functions for capturing live video for external scripts. The company captures image data from one of the two 13.2MP MIPI cameras and send the live feed via gstreamer to topside over ethernet. Once the image data is attained, the company samples the feature-based object detection classifier scans at 10Hz. These scans generate two data outputs. The first is the direction the ROV should travel to continue the course and second is the presence of the blue simulated crack with bounding box and measurement in the output window. The team attains the direction vector by using bounding box scans of the left and right side of the bottom facing camera image data. Once the team has a direction, it is combined with the pressure transducer and altimeter data to fully resolve x, y and z movement while completing the task. Lastly the data is published to the motor control topic on the ROS network. These inputs travel over ethernet from the topside computer to the NanoPi M4 Debian SBC; then are echoed over TTL serial GPIO pins to the ATMEGA2560 Microcontroller. That outputs PWM to our ESCs, which in turn moves the ROV.



7-Software breakdown for task 1a

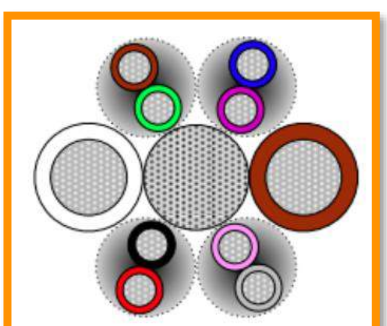
To complete task 2b, determining benthic species, the company opted to use OpenCV (Open Computer Vision) libraries as gstreamer has built in functions for capturing live video for external scripts. The company captures image data from one of the two 13.2MP MIPI cameras and send the live feed via gstreamer to topside over ethernet. Once the image data is attained, multiple feature-based object detection classifier scans are performed. These classifiers are called Haar cascades. Using a combination of edge, line and corner features each Haar cascade scan will count the number of features that most represent the generalized input data. Once every scan is complete the totals and shapes are easily displayed in the output window.



8-Software breakdown for task 2b

Hardware

The tether is an off the shelf Igus CF-211.010 chainflex cable of 15 meters in length. This cable was donated to us via the Igus YES program targeted at academic projects. The CF-211.010 is a continuous flex cable comprised of four 23 gauge twisted pairs for ethernet and two 17-gauge wires to deliver 48VDC to the robot. The total resistance of the tether is .506 Ω. The ROV's minimum input voltage is 18 V, yielding a theoretical maximum current of 60A! Thus, the ROV has been configured to not exceed the 30A limit set by the competition with 30A fuses installed within 30 cm of the power input and physically on the power distribution board.

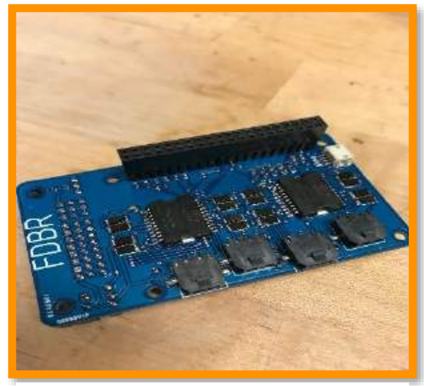


9-Igus Chainflex-211.010

The Hydro_04 bottle houses all necessary electronics for ROV control. Our central flight computer, NanoPi M4 SBC (single board computer), handles all data both in and out of the

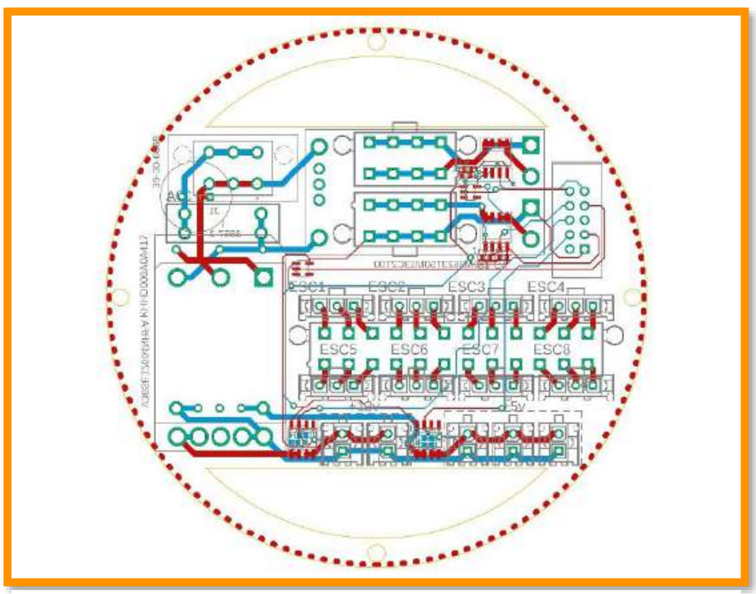
ROV. Running a custom Debian build for the RK3399, the SBC is responsible for interfacing with the ROS network, ROV HAT, collecting and distributing sensor data ranging from pressure and altitude to internal temperatures and power supply output currents. The computer also connects and streams our two MIPI cameras back to topside. All devices are then powered by a custom-built modular power supply

11-Top view of the 2019 ROV HAT



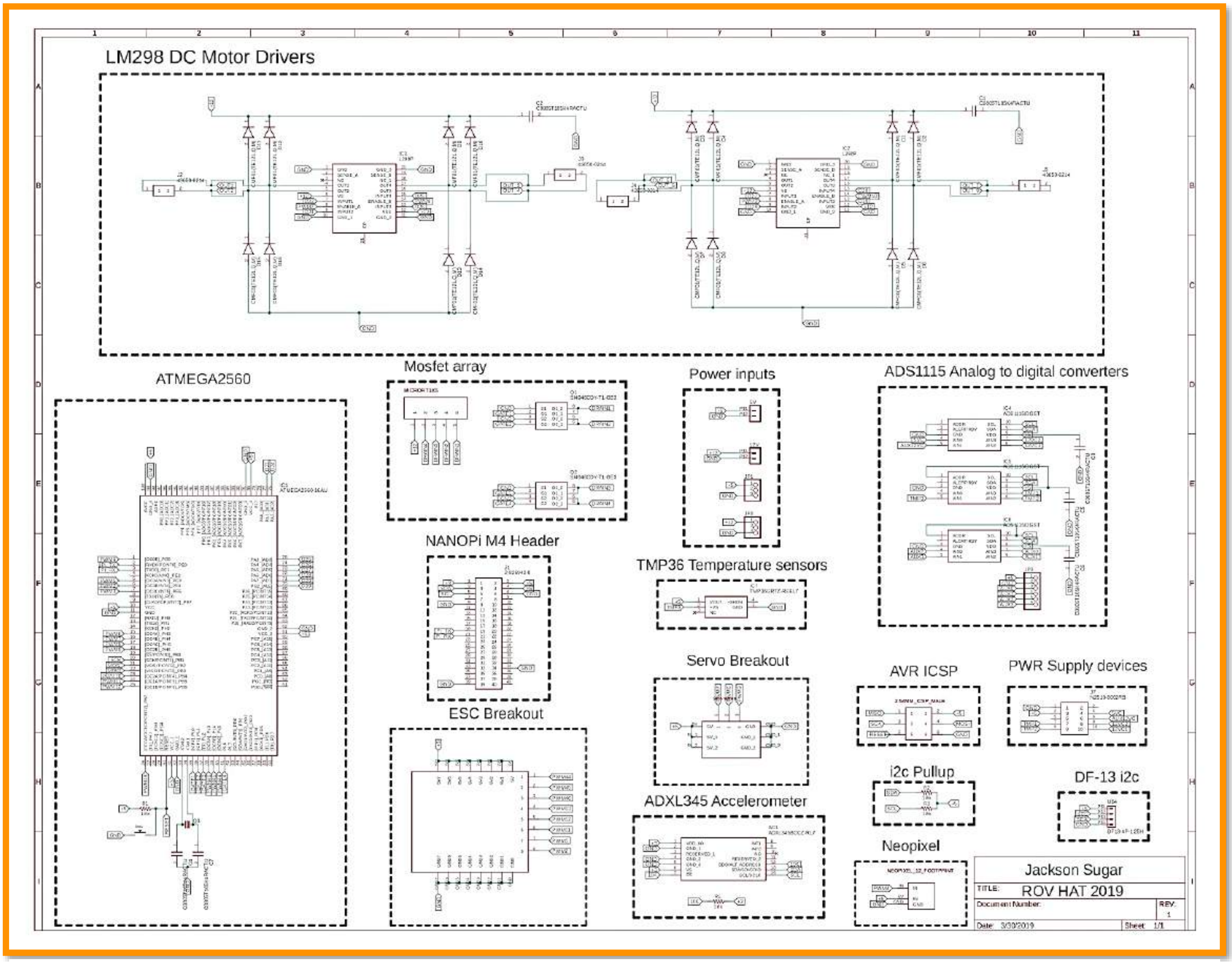
10-Bottom view of the 2019 ROV HAT

The ROV HAT was designed with future competitions in mind. An ATMEGA2560 AVR (Alf and Vegard's RISC) microcontroller is responsible for control of 4 MOSFET channels, 8 ESC PWM (pulse width modulation) lanes, 3 servo PWM lanes, 4 full-bridge DC motor controllers and the 12 LED neopixel status ring. The AVR communicates with the NanoPi via the TTL serial GPIO pins in order to connect to the ROS network. Other devices on the HAT include the DF13 connector for the pressure transducer and 3 four lane analogs to digital converters connected directly to the NanoPi via i2c. The design this year uses only a fraction of the HAT's capabilities.



***12**-Eagle CAD of the power distribution PCB*

The power distribution PCB was designed to miniaturize and improve previous years' approach to modular power supply designs. This is done by incorporating current and temperature sensors for all power outputs and adding dedicated ESC output distribution to better organize connections to the end cap. The power board houses three isolated DC to DC converters, 5V, 12V and a high wattage 12V supply for ESCs only. This allows us to ride out any possible brown we may experience during ROV operations without any power outages to the control system.

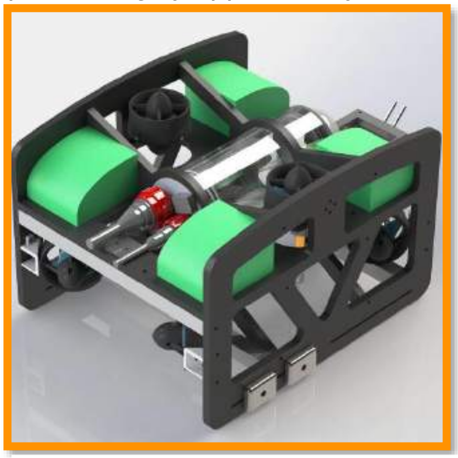


13-Eagle CAD schematic of the 2019 ROV HAT

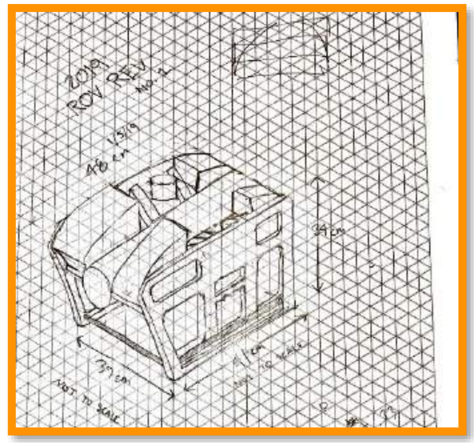
Structure

ROV Frame

For the 2019 frame, design considerations focused primarily on a stability, with high adjustability and modularity. Two design iterations for the frame were produced by two groups within the team, both focusing on a two, side hull-panel and one mid-panel design, and differentiated in how they provided shear and lateral support. The final design was primarily comprised of five high density polyethylene (HDPE) panels that would be fastened together in an "H" configuration. The panel layout for the ROV had to accommodate mounting for the ROV's syntactic foam, stainless steel ballast, the planned six thruster configuration, and bottle. Two panels acted as side hull panels and a mid-panel was perpendicularly connected high in the frame between, which allowed for a large amount of undercarriage space for payload. A key feature of the frame was two customized X-brace panels, which slotted into the mid-panel around the ROV's bottle. These panels served the purpose of placing the bottle of the ROV as high as possible to increase the height of the vehicle's center of volume. The X profile of these panels largely opposed any shear forces acting on the ROV, and overall provided rigidity in the system.



15-Solidworks CAD drawling of the 2019 ROV



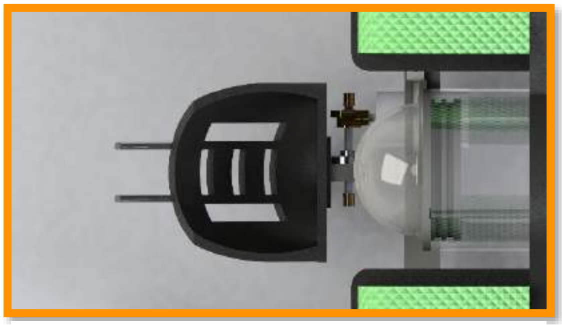
14-Early parametric drawling of the 2019

The ROV has intervals in the water where it would be equipped with the cannon retrieval device, Micro-ROV platform, or with an open undercarriage to allow for a secondary downward facing camera to complete the line tracking portion of the competition. This required a lot of the mounting to the undercarriage to be easily accessible and detachable. Thus, the cannon catching and Micro-ROV platform would both be designed to fit within the lateral HDPE supports at the base of the ROV and mounted using a configuration of thumbscrews and routing clamps.

In order to ensure the stability of our ROV once manufactured, a trim table was be developed in correspondence to the ROV solid model. This would be a vital part of the design process as it would directly affect the placement of components on the finished frame. The trim table summed the centers of mass and centers of buoyancy for all the vehicle's components in relative coordinates, which would be used in order to determine if our design was stable. The company ballasted and added foam to align the center of mass in the center of the vehicle and the center of buoyancy directly above, as high as possible. This is typical to increase the righting moment and overall stability of the vehicle. The company also adjusted simulated ballast in the solid model in order to attempt to bring the net upward acceleration due to buoyant force as close to zero as possible (neutrally buoyant). Even with a precise trim table, it was understood that the ROV would need to be tested before the vehicle was stable enough to drive. This was accounted for in the design of the hull panel. The lateral and vertical slots can be used in order to fine-tune the position of the 180-gram stainless steel units of ballast and Blue Robotics T100 thrusters that were mounted. This allowed the four vector thrusters to be perfectly aligned with the center of mass so no unnecessary moments would be generated, and ballast could be added incrementally and positioned precisely.

Manipulator

The primary manipulator of the ROV platform was designed to have as few points of failure as possible while still being easily controllable. With all competition props that needed to be interacted with, the added challenge of delivering multiple loose props to designated zones such as the trout and grout warranted a large manipulator design that could act as a vessel capable of a dumping motion. The manipulator was manufactured to overshoot the volume of grout that needed to be delivered and was mounted with two static aluminum pins that would be able to catch corrugated plastic or fix to a 310 U-bolt with ease. The container of the manipulator was designed to be manufactured by bisecting a HDPE pipe at a 45-degree angle in order to have the inclined contour for a controlled pouring motion.



16-Top view of the 2019 ROV manipulator

The rotating motion of the manipulator was driven by a 12-volt DC motor selected based on the max current that could be provided by the motor controller (2 amps). Here the motor was potted and mounted on the frames front lower lateral support using a vibration damping clamp that would prevent the motor from slipping and resist any vertical force. The position of this clamp was determined to keep the static pins and center of the manipulator in line with the ROV's front camera. This mechanism utilized a 50 teeth worm-gear system and axle which the manipulator would rotate about using a set screw to prevent slip. This system yielded many benefits due to the nature of worm gear systems being non back drivable so if the motor can't support the load, it would dump its contents. Crucially, worm-gearing systems are inherently high torque and low rotation speed which would allow good control over the system.

Manipulator Design Rationale

Net Torque acting on manipulator downward (worst case scenario): 72Ncm (this number is a close estimate by weight of manipulator and weight of grout at the center of mass' distance away from axle)

-This torque must be overcome before the manipulator can start upward rotation

-Motor provides 10Ncm of continuous rotational torque at 200rpm

-Gearing selection was using a 50 teeth worm gear

-A baseline scenario was using a 50 teeth gear at 60% efficiency (this would be considered very poor efficiency)

10Ncm * (50) * (0.6) = 300Ncm upward

Far overcomes downward torque and will allow for upward rotation

Gearing ratio - this is just however many teeth there are (worm gears advance one tooth every screw rotation)

Efficiency

We also calculated a much worse case scenario with a 30 teeth worm gear set to determine at what minimum efficiency the manipulator could overcome the downward net torque.

72Ncm * (1/30) * (1/e) = 10 Ncm

e = 24%

Angular velocity calculation

(200rpm)*(1/50)*(1/60sec)*(360deg)=~24 deg/sec

Cannon Catcher

The cannon catcher that can be seen in use on this year's robot was designed without the use of electrical input. The system stands alone and can be attached and removed from the robot as seen fit. A progression during the design process, both sets of arms on this cannon catcher are curved to accommodate the shape of the cannon that it will pick up. Having not been given a size for the cannon, the arms are highly adjustable and remain open to receive the cannon until the robot is lowered over it, triggering them to snap closed and grip the cannon during the robot's ascent. The cannon can be removed and if needed the cannon catcher is manually reset upon surfacing.

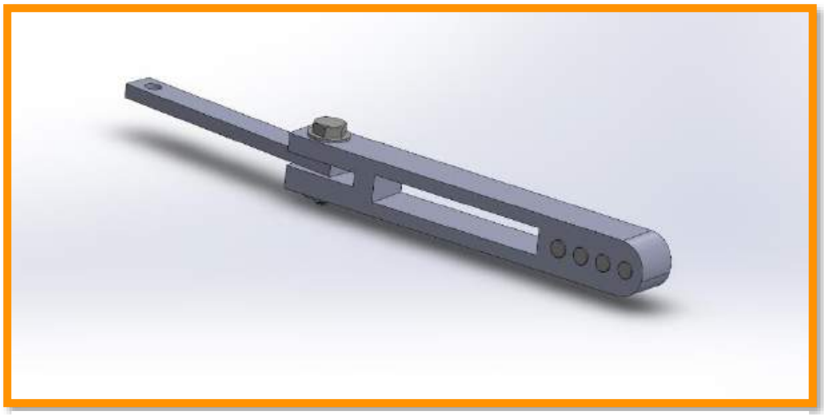
17-Solidworks CAD of the 2019 Cannon Catcher

Pneumatics

The third task of the competition tasked companies to lift a cannon from the bottom of the pool to the surface. For the ROV to complete this task, it was determined that a lift bag was required. This was attached to the center of the ROV in order to keep the center of mass in line with the center of buoyancy once the cannon was retrieved and the lift bag deployed. This would prevent any moments from being created that could jeopardize the positioning of the cannon or the ROV during ascent. In order to lift the device, a pneumatic air system was needed to fill the bag as the company did not have access to an air compressor. A bike pump was used to fill the airbag manually. The airline was run to the lift bag from the bike pump via the tether operator managing a separate line.

Metal Detector

A simple, analog metal detector was designed to identify and mark the location of metal cannon shells and nonmetal debris in the third task. The metal detector is 3D printed and has one point of attachment to the ROV. There is screw that fastens the magnetic head to the arm, which allows for controlled movement. The ferrite ceramic magnet mounted to the end of the arm is strong, corrosion resistant, and will pull the arm towards metal debris to indicate the material. With water flow in mind, the shape is streamlined, allowing water to move through the slits in the mounted arm.



18-2019 metal detector

19-Temperature and ph sensor penetrator

Temperature & Ph

A high-density, 3D printed mount was designed to measure the temperature and the acidity of the water in the second task. Two laser mounts were added in the later iterations of the design to allow the ROV pilot more accuracy when driving the probe to certain areas of the competition field. The temperature probe communicates over one wire, and the pH sensor gives off an analog signal.

Safety

URI Hydrobotics holds each employee to high safety standards during the construction and operation of our remotely operated vehicles. We understand as a company that the assessment and control of risk prevents workplace accidents and injuries. A variety of procedures are used in the machine shop and during deployment to prevent incidents, such as mentor supervision, the implementation of personal protective equipment (PPE) and safety features built into the ROV as required by MATE.

All employees are taught machine shop safety by faculty from the University of Rhode Island and are required to sign a safety waiver regarding their understanding of machine shop protocol after training. Although employees should recognize that there is no substitute for sound decision making and common sense. First and second year students are mentored by upperclassmen when operating heavy machinery, and lathes can only be operated under direct supervision from university faculty. Surrounding employees with more experienced personal mitigates risk and prevents accidents. PPE such as glasses, respirators, closed-toed shoes, and hearing protection are used depending on type of operation and material.

Situational awareness is an important factor in workplace safety. Implementing safety features onto the ROV not only makes extra points available during competition, but also creates additional risk mitigation apart from the common sense and training of the employee. From an electrical perspective, Anderson Power pole connectors, fuses, and built-in temperature sensors are implemented into the system. The company's Topside control panel has clear differentiation between the 120VAC and DC voltages via a server power bar, that is closed from the rest of the system. Mechanical hardware is also built to MATE safety standards, with all housings tested for 24 hours at a depth of 5 meters. Endcaps for the electronics housing use O-rings from the Parker O-ring Handbook in accordance with the industry standard sizes. IP-20 standards are used for all front and rear thruster guards, and sides of the ROV feature no sharp edges. The ROV housing also features tether strain relief via a blue robotics thimble. The pneumatic system is a simple hose attached to an open-bottom lift bag. Air blown through the hose goes under no pressure change and is designed according to FLUID-013, with a 10cm diameter hole at the end of the system. Featured below are checklists created by URI Hydrobotics to promote additional safety during ROV operation and construction procedures. Our construction safety checklist is from the OSHA workplace safety handbook.

CONSTRUCTION SAFETY CHECKLIST

- Under no circumstances should unapproved people be allowed to use the shop equipment.
  - Do not allow unauthorized persons to visit or loiter in the shop.
- Secure the shop when no one is present.
  - It goes without saying that you should *never* leave a machine in operation while it is unattended.
- Check emergency equipment such as first aid kits, emergency lighting, fire extinguishers and eye wash stations monthly.
- Periodically check all hand tools, portable power tools and larger shop equipment.
- Check area lighting, ventilation and fusible links on the self-closing covers.
- Good safety practices start with *good housekeeping*
  - Clean up spills immediately.
  - Keep walkways and stairs free of tripping hazards.
  - Store oily rags in a covered metal container and be sure to empty it every night.
  - Periodically remove excess cutting oils and filings from shop machinery.
  - Keep all tools in their place and inform mentor regarding tools that need repair.
- Never wear jewelry or loose clothing around rotating machinery.
  - Be cautious of any item that may become entangled, including long hair.
- Remember to follow all the proper steps when utilizing a lockout/tagout procedure.
  - Never cut corners because you think it's going to save time.

If you have any doubts or questions about the operation of a particular piece of shop machinery, never hesitate to ask your mentor.

OPERATIONAL SAFETY CHECKLIST

- Pre-Deployment Check
    - Clear all tripping hazards
    - PPE for all employees, safety glasses, slip resistant closed-toe shoes
    - Properly coiled and maintained tether
    - Inspect ROV System
        - Lubricated o-rings
        - Sealed electronics housing
        - Visually inspect cables for potential damage or loose connections
        - Ensure all thrusters have properly attached front and rear guards
        - Plug in tether to ROV subconn, anderson connecters, topside ethernet
            - <u>White line on in-line connector facing outboard</u>
        - Attach topside and ROV strain relief
- Power Up
    - Plugged in topside to 120V source
    - Deckhands clear away from ROV
    - ROV Pilot informs team of system power
    - Launch & Test cameras, thrusters, manipulation
        - Deckhands perform only visual inspection
- ROV Launch
    - When ready to deploy
        - ROV Pilot announces
        - Pilot clears hands from system
            - Verify with Deckhands
        - ROV Launch
            - Deckhands verify ROV is in water
                - Remove hands from system
                - Communicate to Pilot ROV is ready
- In-Water Ops
    - Tether Operator
        - No kinks or tripping hazards
    - Deckhands
        - Visual inspection for bubbles or other anomalies
- Surfacing and Deck Safety
    - Pilot announces surfacing
        - Hands off system at surface
        - Verify with Deckhands
    - Deckhands
        - 2 people lifting ROV from water
        - Visual inspection for damage and leaks
        - Deploy attachments with proper fasteners
            - Slow, steady movements even in a rush
- Power Off
    - Ensure ROV and Topside are turned off before tether disconnect

Build Process

After the initial design phase for the ROV, the company began the manufacturing phase to ensure that the robot would be in water as soon as possible. As soon as the structure was approved by the team and went through two rounds of design review, the company began to order off the main structure components, while the main panels were being machined by the company's sponsor RBA. Each member then began to prototype their respective projects for mission specific payload.

20-Hydro_04 before first in water test

Once the structural components arrived, the edges of each panel were filed to avoid leaving potentially sharp edges. A round file was used to reach each radius of the inner cuts, and larger files were used on the straight edges. After filing, each water jetted hole needed to be tapped according to its size. Each hole was individually hand-threaded to avoid cross-threading holes.

21-First test fit of hull panels

22-Some light modifications to the frame

The design of the 2019 ROV allowed for a preliminary dry fit (As seen in the figure ##) so the lateral support beam measurements could be cross-referenced from the drawings and CAD files to the physical structure to account for loss of material during the water jetting of the panels.

After being correctly sized, a team member began to cut out the 1”x1” HDPE lateral supports. Measurements were made for each of the 3 lateral supports on the bandsaw following the correct safety protocols. Once the supports were cut, the holes for each support were drilled and tapped accordingly. While each support was being manufactured, the main frame was being brought together by other teammates using screwdrivers to prevent the threads from becoming damaged. Once the lateral support bars were made, each one was added to the frame. Each corner bracket was put into place underneath the mid panels and on the backside of the front lateral support bar to add additional stability. At this point, the final structure was ready to receive the electronics housing.

Critical Analysis

After the structure was put together the team had their respective mission specific prototypes ready to interact with the main frame. These were full-scale prototypes that had all the necessary articulation needed to test if the design was workable on the ROV after being tested off the ROV. After being verified that the design was workable (i.e. manipulator) or making the necessary tweaks needed for the design to work, the finalized product was manufactured. Each team member was responsible for a different design. A high-quality handmade product designed to interact with the ROV frame was finished, and the final iteration of the ROV platform was completed.

23-Second deployment of Hydro_04 during a local seaperch competition

Conclusion

Lessons Learned

Ellie Felderman

Sophomore Ocean Engineering Marine Biology

I learned far more about engineering in my first year with the Hydrobotics team than I did in my first year in engineering school. I gained a job, a summer fellowship, and a lifelong interest through my experiences with this team. Most days after classes ended, I would find myself in another learning space, working under the mentorship of the more senior members of the team. Their patience and understanding in guiding me through python for the first time, or showing me how to machine a part, is something that I will always appreciate and carry with me as I become more knowledgeable and begin to mentor new members myself. I value my experience with this team highly and know that I would leave here a very different engineer than I would without the company.

Jackson Sugar

2019 Graduate Ocean Engineering

This being my last year as an undergraduate, my transition to graduate mentor has been looming in the distance ever since I helped found Hydrobotics four years ago. The skills and experiences gained from my time competing have proven to be far more valuable than any lecture I attended in my undergraduate studies. I firmly believe any student participant in MATE is infinitely more prepared to excel in their post school endeavors. I can't truly assess my success alone. I want nothing more but to ensure this experience can be shared by many more students just like myself. Development of an inclusive, hands on and industry applicable team knowledge base is essential for the longevity of the Hydrobotics experience. I look forward to supporting the team from a new position. I am confident the next generation of team leaders will continue to provide the guidance and support necessary to carry this team for years to come. That'd be pretty rad.

Future Improvements

The Hydrobotics team has seen significant improvements in the four years the team has been active. Team members have gained experience in important skills such as soldering, PCB fabrication, software implementation, mechanical design and CAD modeling. The time that used to be taken up by the veterans of the team on basic skills required to build a robot is now directed toward passing on knowledge to new members. This allows for the team to start at a more experienced level every year.

Now that there is a more solid foundation of knowledge, some significant objectives of the team include making all parts of building the ROV more accessible to every member of the team. There is also a focus on good communication between the mechanical and electronics portions of the team, aiming to create a mechatronic approach and strengthen the skill set of every member of the team.

This year, the team made important steps towards achieving this goal. Lecture series created to make electronics less intimidating to inexperienced members will be improved upon, and clear and detailed documentation will allow for new members to get an overview of the work that has been done. This will allow for members to start at a more advanced point where they can contribute to the more challenging parts of the competition, rather than leaving the new members scrambling to catch up with veterans already comfortable with these skills.

As the team enters its fifth year, it has become clear for the senior members of the team that the experience and knowledge acquired in the last few years must be passed on to the rest of the team, which is why a focus on teaching all the basic skills will be a priority at the beginning of next year.

A focus on bringing in members that have business and leadership skills will be highly beneficial to the team, allowing for the captain to oversee communication between the subsections of the team. A task force in charge of funding and outreach can be dedicated to give these elements the time they require for success.

Karla Haiat
2020 Team Captain

Accounting

Budget

Utilizing donations and contributions to the company, URI Hydrobotics was able to purchase several new materials necessary for development of this year's ROV. Some parts from previous years were re-used, including much of the topside. Most mechanical and electrical components were purchased and developed from scratch. Continuing with this year's theme of education, several Raspberry Pi's and fitting components were purchased using a portion of the budget. The company's pursuit of sponsors this year left approximately $1100 in remaining funds that can be put towards next year's ROV.

School name:		**University of Rhode Island**			**Reporting period From: 09/01/2018 To: 05/23/2019**
Sponsorship Income				**Materials Donation**	**Money Donation**
URI Departments of Engineering					$2,500
IGUS				Tether Materials	$0
Raytheon					$2,500
Electric Boat					$500
Hydroid					$500
URI Undergraduate Research Institute					$1,400
Solidworks				20 Licenses Premuim Solidworks	$0
Rocky Brooks Associates				Custom HDPE Panels	$0
Hydro Group				Sub-Sea Connectors	$1,000
Navatek					$1,000
				TOTAL	**$9,400**
EXPENSES					
Category	**Budget**	**Type**	**Expense**	**Description**	**Cost**
Mechanical Production	$2,100				
Frame support		Purchased	Production materials	Support beams, ballast, brackets	$183.38
Thrusters		Purchased	Production materials	Blue Robotics T100 & T200 thrusters	$289
Cannon Catcher		Purchased	Production materials	Tivar arms, thumb screws, shaft collars	$20.38
Manipulator		Purchased	Production materials	UHMW sheeting, worm gear set, mounting clamp	$255.53
Electronics Bottle		Purchased	Production materials	Acryclic cylinder & enclosure, dome, endcap	$278.88
Props		Purchased	Production materials	EXPLORER class prop manufacturing	$139.03
Sensors		Purchased	Production materials	Temperature, pH, pressure, sonar	$517.90
Cameras & Lights		Purchased	Production materials	Omni Vision 13.2 MP cameras, LEDs	$151.12
Motors		Purchased	Production materials	12V DC 200RPM gear motor	$140.97
Metal Detector		Purchased	Production materials	Ferrite ceramic magnets	$5.99
				TOTAL	$1,982.18
Electrical Production	$2,000				
Development		Purchased	Software	Nano Pi M4, 128GB uSD card	$171.74
Power Supply		Purchased	Software	Parts necessary for voltage conversion	$443.39
HAT		Purchased	Software	ATMEGA2560, headers, mosfet	$135.73

Resin Splicing Kit		Purchased	Software development	82-F1 3M Scotchcast	$700
Monitors		Purchased	Software development	HP 24 inch FHD IPS monitor	$219.98
Keyboard & Mouse		Purchased	Software development	Logitech K120 keyboard & mouse	$28.80
Computer Components		Purchased	Software development	16GB RAM, 500GB SSD, HDMI cable	$303.93
				TOTAL	$2,003.57
Topside	$870.13				
Intel NUC Kit		Purchased	ROV operation	Intel NUC 8 Performance-G kit NUC8i7HVK	$870.13
Pelican Case		Re-used	ROV operation	Pelican Air 1605 case with foam	-
Monitor		Re-used	ROV operation	25" LG UltraWide IPS Monitor	-
Keyboard & Mouse		Re-used	ROV operation	Logitech K120 keyboard & mouse	-
Xbox Controller		Re-used	ROV operation	Xbox wireless controller	-
				TOTAL	$870.13
Education	$1,150				
Raspberry Pi 3 B+		Purchased	Education	Element14 Raspberry Pi 3 B+ Motherboard	$275.10
Electrical components		Purchased	Education	Power supplies, breadboards, Pi accessories	$865.10
				TOTAL	$1,140.20
Operations & Travel	$2,300				
Lodging			Team operations		$1,700
Travel			Team operations		$300
MATE Entry Fee			Competition		$300
				TOTAL	$2,300
				Total income	$9,400
				Total expenses	$8,296.08
				Remaining Funds	$1,103.92

References

MATE 2019 Competition Manual

- **Used as source for mission spec**

OSHA Workplace Safety Checklist

- **Used for Hydrobotics Construction Checklist**

ROS.org

- **Used to learn about ROS software**

Parker O-Ring Handbook

- **Industry Standard O-Ring sizes**