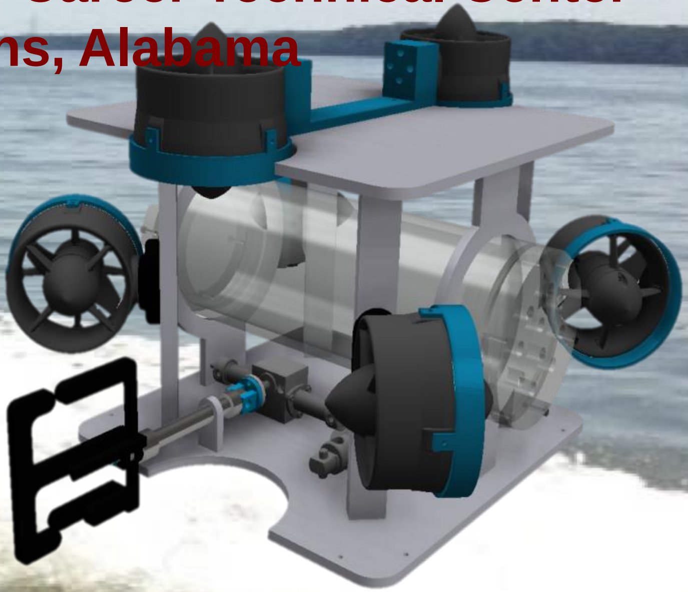
Lost Rockets

ROV

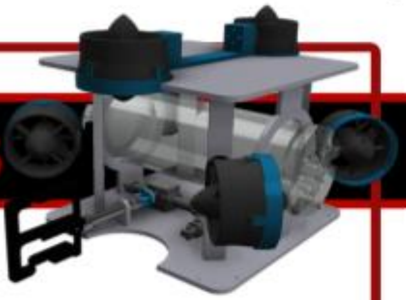
Limestone County Career Technical Center
Athens, Alabama



Coleman Cook: Chief Executive Officer

Kaitlyn Abernathy: Drafter/Technician
Blake Bennett: Chief Technology Officer
Jordan Kearns: Technician
Tristan Jay: Programmer/Technician
Mentor: Casey Wigginton
Mentor: Monica McConnell

Lance Perry: Technician
Rachel Long: Chief Mechanical Officer
Tyler Pressnell: Technician
David Sanchez: Technician
Lauren Simpson: Chief Presentation Officer
Mack Van Wagnen: Chief Operations Officer



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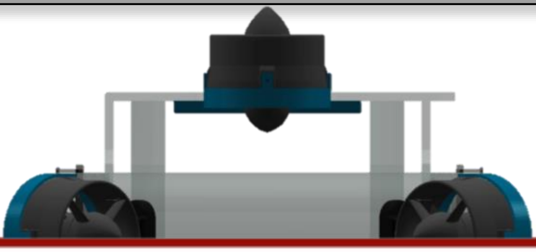
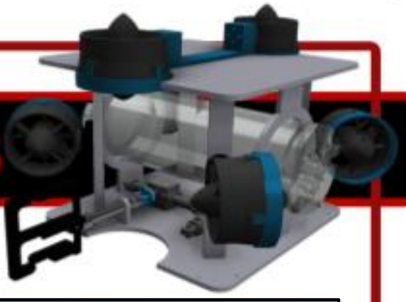




1.0 Abstract

As our first year as a MATE company, our mission goal as the Lost Rockets is to present an innovative, professional solution: A Remotely Operated Vehicle that can not only operate in outer space, but also operate under the stresses of working underwater.

Our solution to the presented mission is the Dirty Bubble, a Remotely Operated Vehicle designed, built, and tested for the purpose of manipulating objects within inner and outer space as well as taking sensor readings on other celestial bodies. Special features of the ROV include:

1. Cost-effective, efficient thrusters that provide movement along the XY and YZ planes of motion
2. Pneumatic pistons capable of trapping and manipulating bolts for use in most MATE mission tasks
3. Two wide range 120 degree cameras to provide a commanding view of the surroundings in an unknown environment
4. Blue Robotics pressure sensor capable of measuring pressures to 300 meters
5. Manipulator capable of retrieving multiple mission pieces at once, providing efficient collection and transport

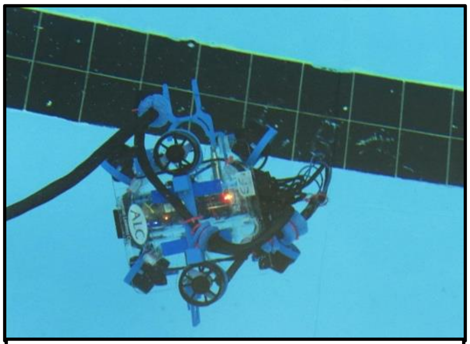


Figure 1: Robot at Regionals
-Casey Wigginton

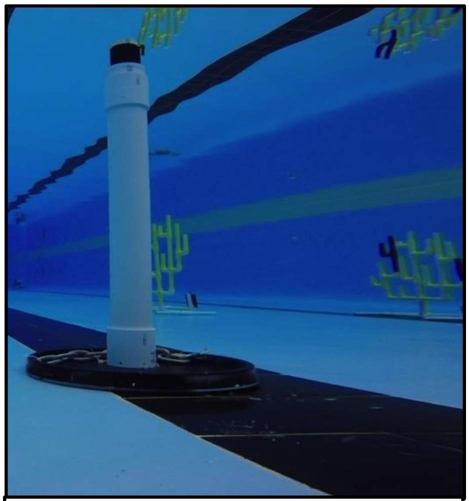


Figure 2: Robot GoPro
Footage

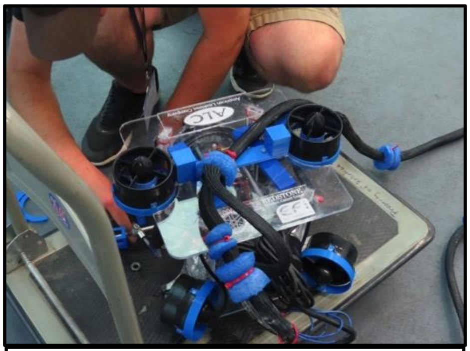
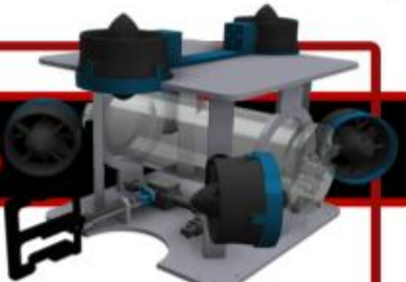


Figure 3: Tyler With Robot
-Lauren Simpson



2.0 Company Information

Coleman Cook
Chief Executive Officer
Coleman is in 11th grade at Elkmont High School. He would like to be a biotechnologist.

Mack Van Wagnen
Company Role: Drafter/Technician/Pilot
Mack is in 12th grade at Clements High School. He would like to be a mechanical engineer.

Blake Bennett
Chief Technology Officer
Blake is in 12th grade at West Limestone High School. He would like to be a software engineer.

Rachel Long
Chief Production Officer
Rachel is in 12th grade at Ardmore High School. She would like to be a mechanical engineer.

Lauren Simpson
Chief Presentation Officer
Lauren is in 10th grade at Elkmont High School. She would like to work in personal relations.

Tyler Pressnell
Technician/Tether Manager
Tyler is in 11th Grade at Ardmore High School. He would like to be a mechanical engineer.

Lance Perry
Technician
Lance is in 12th grade at Ardmore High School. He would like to be a mechanical engineer.

*All head shot pictures credit to Casey Wigginton

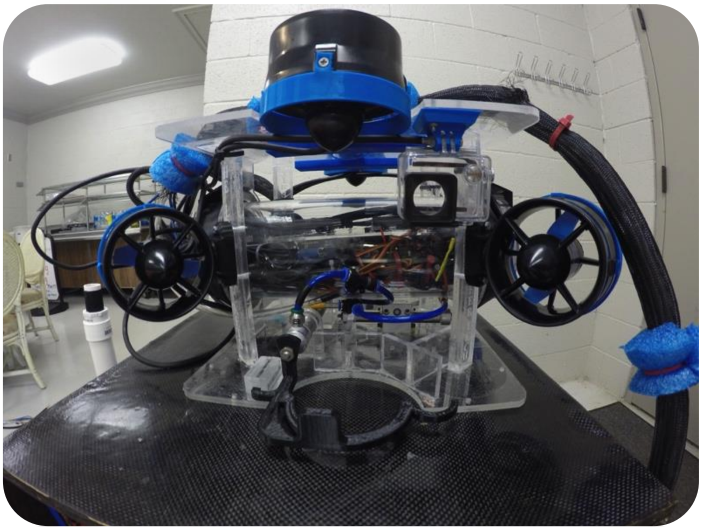
2.0 Company Information

David Sanchez
Presentation/Technician
David is in 11th grade at Tanner High School. He would like to be a software engineer.

Tristan Jay
Technician
Tristan is a student in Limestone County. He would like to be a computer programmer.

Kaitlyn Abernathy
Drafter/Technician
Kaitlyn is in 12th grade at West Limestone High School. She would like to be a mechanical engineer.

Jordan Kearns
Company Role: Technician
Jordan is in 12th grade at Ardmore High School. In the future, he would like to be a mechanical engineer.



ROV
-Mack Van Wagnen

*All head shot pictures credit to Casey Wigginton

3.0 Mission Theme

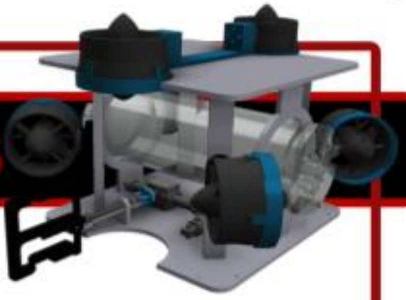
Remotely Operated Vehicles and their usage underwater have proven invaluable to researchers, constructors, and the like for their uses within areas as close as the Gulf of Mexico to as far as neighboring planets within our solar system. ROV's accomplish many tasks that man is incapable of accomplishing due to their ability to survive harsh environments such as underwater pressures and solar radiation. Additionally, ROV's can gather more precise information as well as determine possible crisis situations.

Within inner space, ROV's are of vital importance for the analysis of life under the ocean, as well as manipulation of objects deep within the ocean. Within the gulf, smaller ROV's are very commonly used by organizations such as the Dauphin Island Sea Laboratory to observe fish, coral, and other wildlife within the gulf to determine if a healthy ecosystem exists.
ROV's demonstrated another invaluable trait during the recent Gulf Coast oil spill, where a team of sixteen massive ROV's teamed together to seal off the leaking pipe during the oil spill, helping to prevent further catastrophe to the gulf. Without their presence, a much larger quantity of oil would have spread into the gulf, possibly costing the lives of thousands of animals living there.

Figure 4: ROV repairing a wellhead cap
-Associated Press

In outer space, ROV's are used in the same fundamental process of information collection, but with different instrumentation. The information that we know about Europa today is due solely to the work of ROV's in the form of satellites, such as the Hubble Space Telescope and several other flyby satellites, the most notable of which being the Galileo space probe. NASA's current "advanced research projects" are squid-shaped ROV's capable of using their tentacles to manipulate their environment and take sensor data underneath the surface of Europa.

The usage of ROV's within inner and outer space have without doubt expanded our horizons of knowledge from a watery moon that's farther from us than the sun, all the way to the ecosystems of a gulf bordering the United States of America.



4.0 Design Rationale

4.1 General Overview

This year's robot mission was uniquely demanding in the need for a design that was small and light, along with the capability of accomplishing mission tasks. This resulted in a small robot that was not only light, but agile. The designed ROV is capable of not only moving swiftly, but also moving with several degrees of motion.

The tools that the robot used also needed to be small, light, and multipurpose, in order to cut down on unnecessary weight contribution to the maximum load capacity. Software barriers were introduced to avoid tripping our 25 amp breaker as per regulation with MATE, lowering current to our thrusters to avoid overuse.

Figure 5: ROV on carry crate
-Mack Van Wagnen

4.2 Frame

The robot frame is constructed out of laser-cut ¼ and ½ inch acrylic plate, which was assembled with acrylic glue. Our frame was constructed out of acrylic due to its ready availability and its sturdy resistance to pressure and temperature underwater. The acrylic is also transparent, giving the cameras a larger field of view through the frame.

Since the acrylic was capable of being glued together and laser cut, the frame was designed to surround our electronics housing and provide mounting point for our thrusters. The acrylic was then cut out and glued together, providing a sturdy, reliable frame.

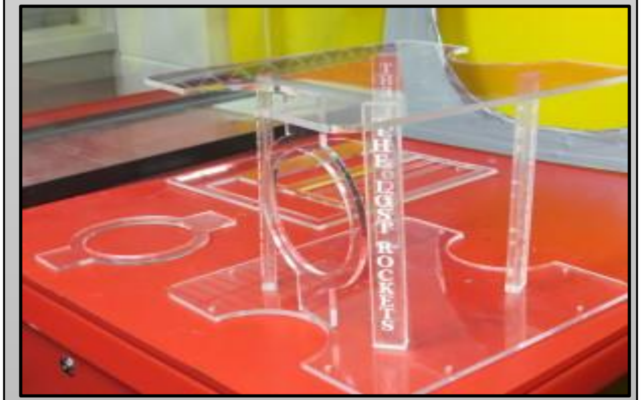
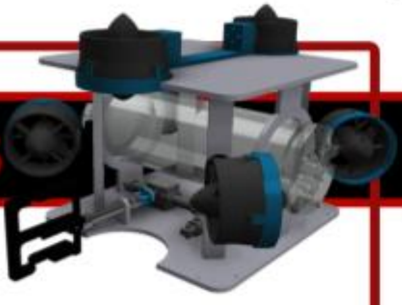


Figure 6: Frame Pieces Before acrylic bonding
–Mack Van Wagnen

Before creating the frame, the entire robot was designed using Autodesk Inventor to accommodate for all aspects of the robot, confirming locations of electronics and manipulators to avoid possible conflicts of pieces of the ROV. To mount our T-100 thrusters onto our ROV, Motor mounts were 3D Printed, utilizing the CAD model provided by Blue Robotics. The bracket was altered and then 3D printed by keeping the screw holes, but moving the mounting holes to allow them to mount onto the drive frame.



4.0 Design Rationale

4.3 Thrusters

T-100 Blue Robotics thrusters were used on the ROV, due to their power-to-thrust efficiency and overall cost-effectiveness. Blue Robotics thrusters also came with their own ESC Speed Controllers, which provide precise control and speed regulation in software. Blue Robotics also provides amperage diagrams for their thrusters, which enable regulation of motor power to avoid blowing our 30 Amp circuit breaker.

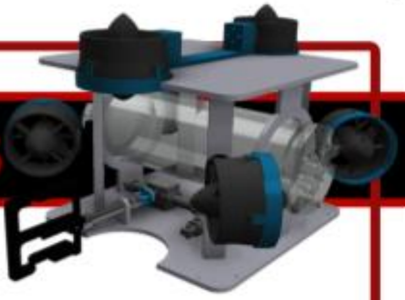
The T-100 thrusters are placed on the robot frame. Four of them were placed at 45 degree angles centered at the corners of the robot on the XY plane to allow omni-directional movement on the XY plane of the robot in the water. Two other thrusters were mounted to the top plate of the frame, to allow for XZ plane movement with the robot. Three of the T-100 Motors had their impellors taken out and replaced, to create an equal force of thrust throughout the robot.

Figure 7: Side View of ROV
-Mack Van Wagnen

To determine which thruster to use, (eventually selecting the T-100), a trade study was conducted of thrusters we could use on the robot. The T-100 received the highest score.

Figure 8: Cad Model of T-100
-Coleman Cook

Figure 9: T-100 thruster on ROV
-Mack Van Wagnen



4.0 Design Rationale

4.4 Electronics Housing

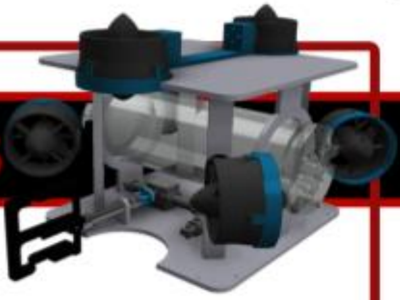
The robot utilizes a 4" (10.16 cm) Diameter by 11.75" (29.8 cm) acrylic tube sold by Blue Robotics with o-rings, flanges, end caps, and cable penetrators for a secure, watertight seal of the electronics. The housing is held in place by two acrylic pieces that simultaneously encircle the housing and provide structure between the top and bottom plates of the frame. The housing also has a 3D printed spacer on each side to secure it to the frame.

Figure 10: Empty Electronics Housing -Lauren Simpson

Within the frame is a 3D printed mount for the ROV's electronics, designed to utilize the maximum amount of space for the electronics and cut down on spare space within the housing. The mount is also attached to the housing cap, allowing easy removal.

Figure 11: Electronics -Lauren Simpson

As an added safety feature, the electronics housing contains a cable penetrator vent plug, which allows for a vacuum pump to be plugged into the electronics housing. The vacuum plug creates a vacuum seal within the electronics housing, testing for leaks and ensuring that the electronics housing is watertight.



4.0 Design Rationale

4.5 Control System

The robot is controlled by a SunFounder Mega 2560, a microcontroller, which was chosen for its computing power and cost efficiency. The microcontroller computes data for our robot sensors, sends out signals for motor controller commands, and relays data to and from the driver station via an Ethernet to USB tether to a driving laptop running an interface to the Mega. The Mega is programmed in C, using the Arduino IDE, along with an interfaced processing program, also programmed in C.

Figure 12: Pneumatic Control System
-Mack Van Wagnen

4.6 Mission-Specific Equipment

For manipulation of the game objects, the ROV is equipped with a total of three pneumatic actuators with 3D-printed manipulators at the end of each actuator. The front manipulator is designed with a dual hook system, to hook CubeSats, bolts, and coral samples with ease. The second actuator is a rotary pneumato-turn piston, designed to rotate bolts that have been picked up at 180 degree angles, allowing for sideways application of bolts and easier access to object manipulation. The end hooks of the first manipulator are easily detachable for transport, to accommodate for a smaller size parameter.

The rear manipulator is composed of a single pneumatic piston with a circular hook design, specifically modelled and printed to latch onto oil wellhead caps and flanges. A second hook, branching off of the first, allows for latching onto the water vent, to allow for stable readings of temperature. The rear manipulator end hook is also detachable for transport, and contains a guide within the robot frame, to prevent manipulator rotation.

4.0 Design Rationale

4.6 Tether

The robot tether is composed of a 15 Meter bundle carrying two positive and two ground wires, four pneumatic lines, and an Ethernet cable signal wire to relay signals to the central controller. The tether is wrapped in wire loom to keep the tether bundled and flexible. Due to the exit hole of our electronics housing (the cylinder opens to the right), the tether was wrapped around the side of the ROV, to the back, to keep the ROV from drifting right from the force of the tether.

4.7 Sensors

The ROV contains three sensors: two 120-degree FOV USB cameras, and a Blue Robotics barometer/temperature sensor. The cameras are connected via a USB hub within the electronics housing leading up the controlling laptop, allowing switching between front and rear cameras. This enables the front and back of the ROV to be used for different purposes, while the omni-directional drive system treats any ROV side equally in thrust.

The Blue Robotics barometer/temperature sensor is used to test pressure and depth underwater and can detect correct temperature to the range of .2 degrees Celsius, providing accurate readings for water temperature. This sensor was selected among others due to it dual ability, easy interface with the SunFounder Mega, and its accuracy in underwater readings.

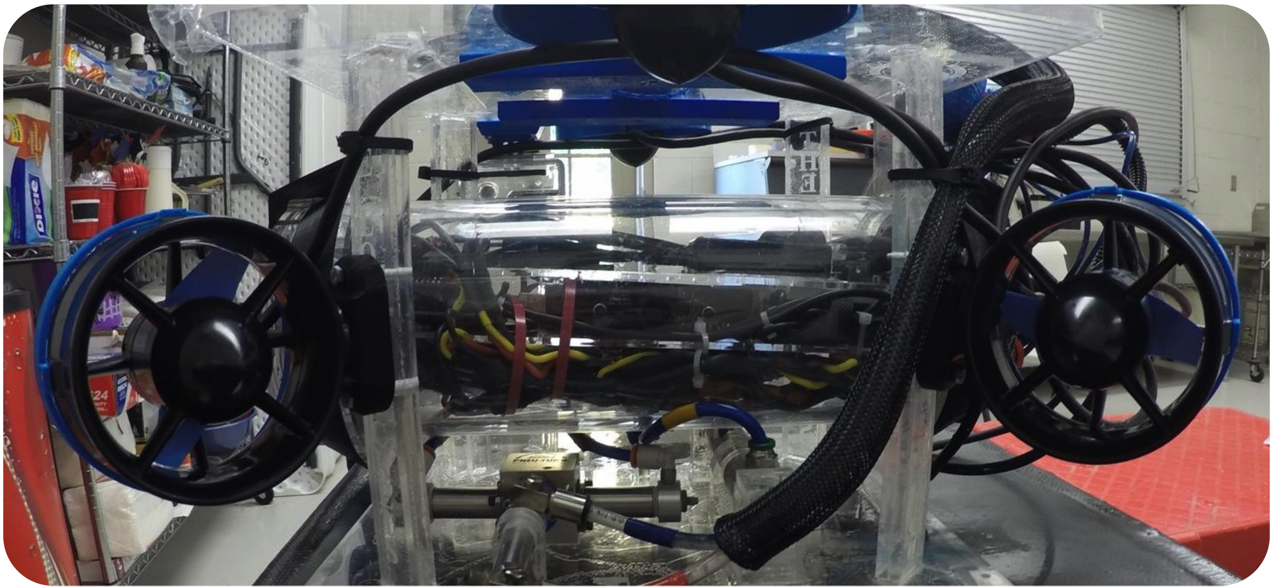
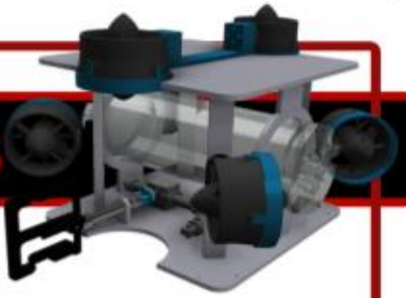
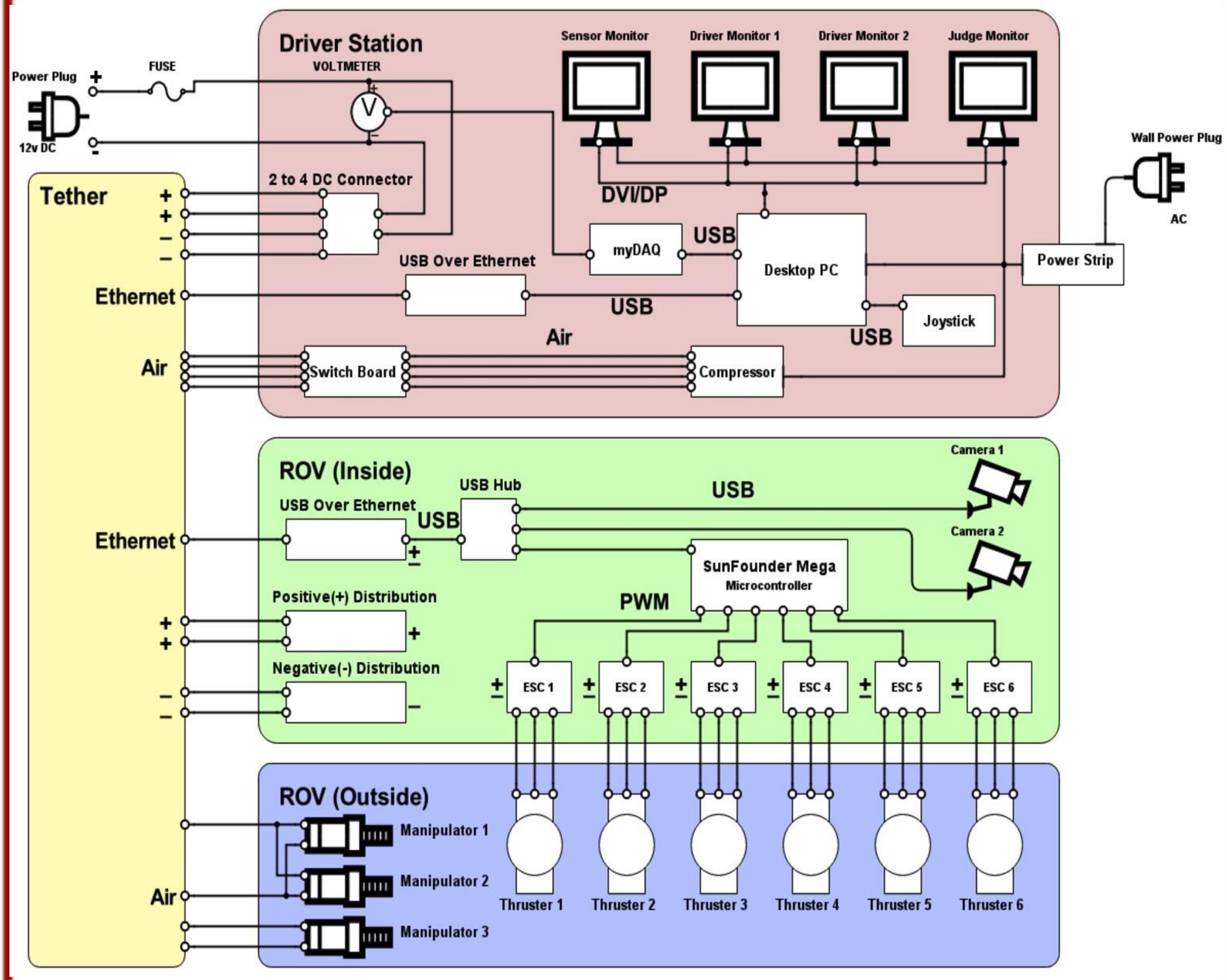
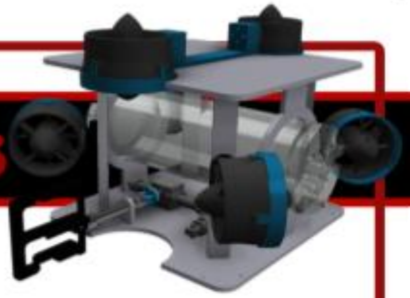


Figure 13: Front View of Electronics
-Mack Van Wagnen

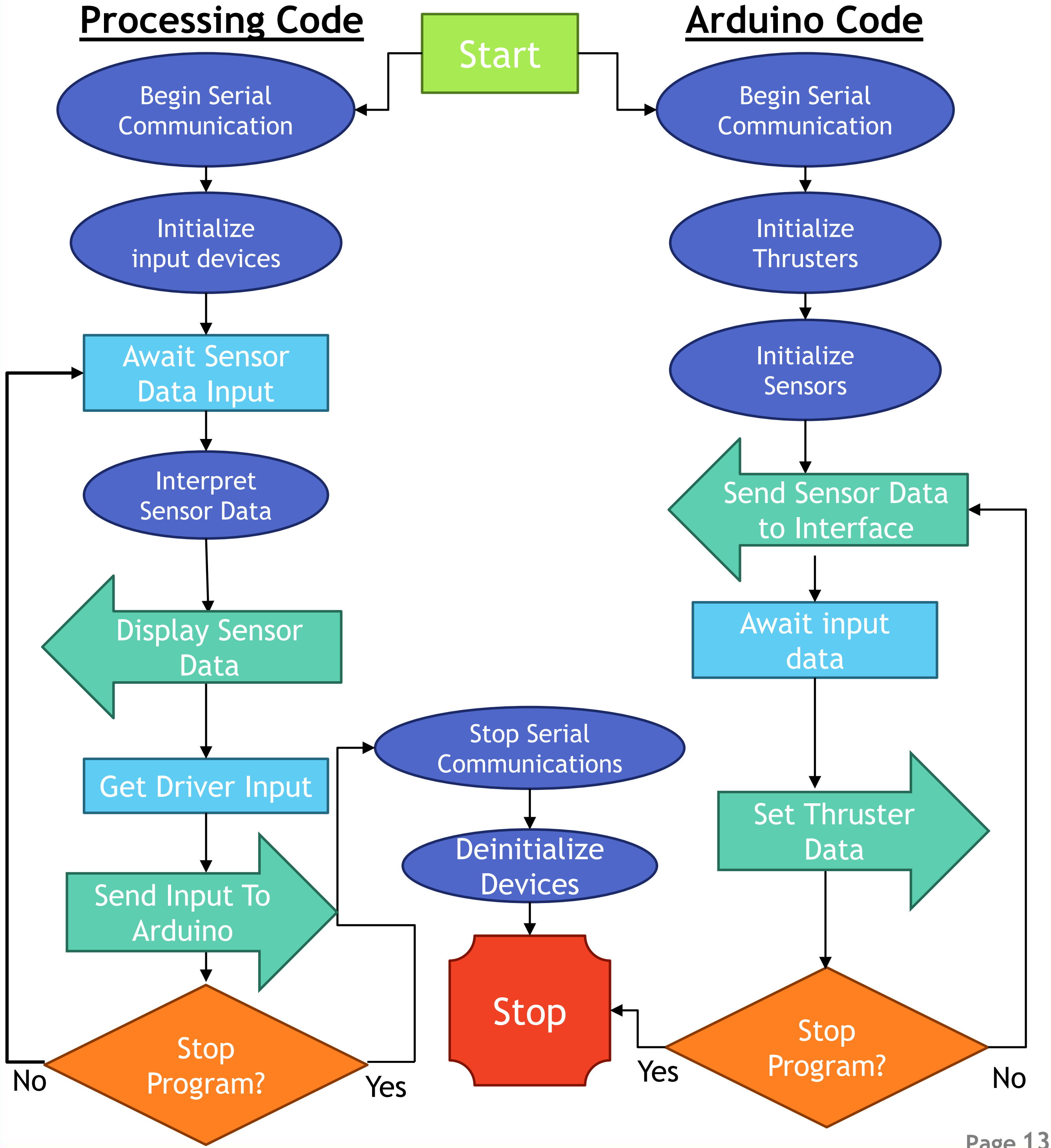


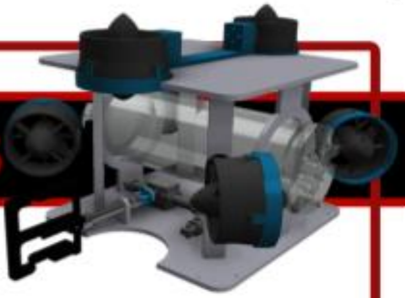
5.0 System Interconnection Diagram





6.0 Software Flowchart





7.0 Safety

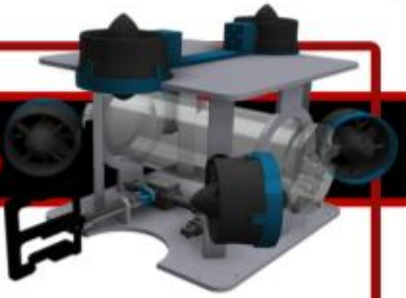
Safety is undoubtedly the most important part of the construction of the ROV, due to not only the presence of multiple moving parts, but the possibility of electrocution due to the nature of electronics and the shorting of circuits. Due to this, the robot consists of many safety features shown by filleted edges, motor shrouds on the thrusters, and a sealed electronics housing that was tested for leaks using the cable penetrator vent plug. before being put in the water. Also, working with acrylic comes with its own set of risk due to the gases produced when cutting or gluing acrylic. Special care in the form of surgical masks and rubber gloves were taken to avoid health hazards.

Figure 14: Mack Using Laser
-Lauren Simpson

Along with the robot, team members followed specific safety regulations involving:

- ✓ Wearing Person Protection Equipment at all times when working on the robot.
- ✓ Removal of hats and pinning up of long hair within the work space.
- ✓ Wearing of appropriate safety equipment (Masks, gloves) when soldering or gluing specific materials.
- ✓ Observance of regulations in use of the 3D printer and Laser Cutter.

Figure 15: Pnuematic Controls with pressure regulators
-Mack Van Wagnen

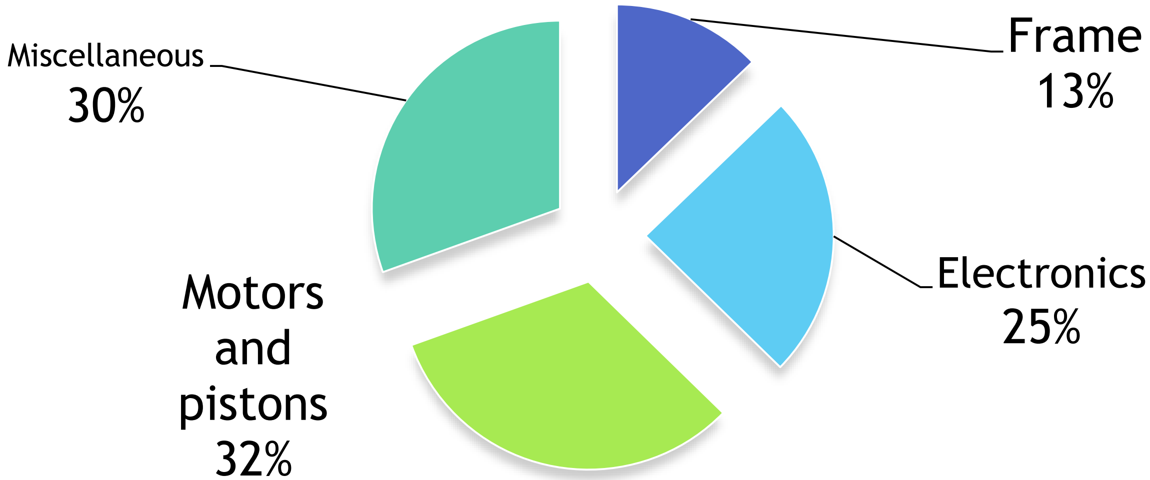


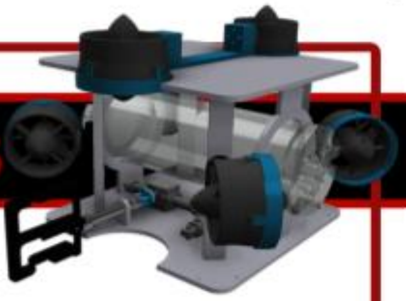
8.0 Budget

As our first year, it was quite a tall order to organize enough funds to build a product and attend an underwater robotics regional, along with an international competition. Upon the formation of the company, all members gathered research using other MATE teams’ budget spreadsheets to estimate how much money to allot for our ROV. After careful research, the company agreed on $2,250 for our ROV budget, which we matched almost exactly in execution.

For the costing of the trip, the company ran received quotes of various travel types agreed on a total cost of about $12,300 for travel, food, and lodging at the international competition.

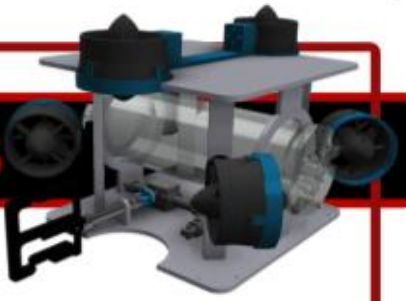
ROV Cost Analysis





8.0 Budget

	Item	Quantity	Total Cost
Frame	Cast Acrylic Tube-11.75, 298mm(2"Series)	1	$54
	O-Ring Flange	2	$58
	Clear Acrylic End Cap	1	$16
	End Cap with Holes	1	$20
	Enclosure Vent and Plug	1	$8
	UV Resistant Epoxy Resin	1	$4
	Cast Acrylic Sheet 8 Pack	1	$44.3
	Presa Premium Paint Brushes	2	$19.98
	O-Ring Pick	1	$4
	Loctite Marine Epoxy	3	$18
	Spare O-Ring Set	3	$9
	Vacuum Plug	1	$8
	Cable Penetrator Blank(No Hole)	20	$60
	O-Ring Set for Cable Penetrators	10	$20
	Total		$343.28
Motors and Manipulators	T100 Thruster With Basic ESC	4	$864.00
	Bimbo Pnuematic Piston	2	Donated
	Bimbo Rotational Pneumatic Piston	1	Donated
	Total		$864.00
Electronics	OffBrand Arduino Mega	2	$35.98
	PnumaticPlus Air Pressure Regulator	1	$24.99
	Ingersoll Rand Line Filter	1	$18.47
	Jump-N-Carry 12 volt jump starter	1	$128.45
	ABN Brake Bleeder and Vacume Pump Kit	1	$25.99
	WEme USB Extender to RJ45 Over cat 5 to 100 meter	1	$46.99
	EBOUE 6-Port USB Hub 2.0 Powered	1	$13.99
	Basic 30A ESC	6	$150.00
	25 Amp fuses, 25 pack	1	$4.99
	25 Amp Circuit Breaker	1	$40.47
	Female Panel Mount Waterproof Connectors	2	$23.56
	12 Volt Signal Lamp Bulbs	1	$4.84
	12V to 5V Module	1	$9.13
	100ft of Braided Sleeving	1	$20.85
	12 Gauge Stranded Wire	1	$44.77



8.0 Budget

Electronics Continued

Powerwerx Panel Mount Digital Red Volt Meter	1	$19.99
Powerwerx Panel Mount Red Switch	1	$9.99
Powerwerx PanelPole	1	$18.99
CigBuddy	1	$14.99
Total		$657.43

Miscellaneous

Velcro	1	$9.00
3M Spray Adhesive	1	$8.44
Shipping	1	$40.00
Shipping	1	$59.00
Total		$116.44

Fundraising

Campaign	Input cost	Total Raised
Go Fund Me	$24.6	$5220
Game Night	0	$125
Total		$5345

Complete Overview

Area		Cost
Frame		($343.28)
Electronics		($657.43)
Motors and pistons		($864.00)
Travel *Estimate (Future)		($2,500.00)
Miscellaneous		($116.44)
Fundraising		$5,345.00
		$863.85

9.0 Lessons Learned and Future Improvements

9.1 Mechanical Lessons

In the completion of the company project, the company found many challenges; some were foreseen, and some that were never anticipated. These challenges were frustrating at some points, but proved to be very effective learning indicators for future projects and troubleshooting.

A problem encountered early on in construction was the measure twice, cut once philosophy that was drilled, or rather, laser cut into the company members' heads after the first several acrylic pieces of the robot frame were measured incorrectly, resulting in an off-center frame, teaching the company of the value of exacting measurements. Lessons were also learned concerning the usage of heat near acrylic frame work, resulted in the base plate cracking and being sawed off for a replacement.

The most educational of the mechanical aspects on the ROV were undoubtedly the thrusters. The thruster mounts for the corners of the ROV frame took approximately 7-9 iterations to get right, and were eventually scrapped altogether, since the mounting of thrusters low on the frame created a massive upward angle of drive. The company's knowledge of the thrusters themselves were put to the test when one of the top thruster's motor shaft snapped, which resulted in a dead motor, which had to be disassembled and replaced.

Figure 16: Mack Holding Design 1
-Lauren Simpson

Figure 17: Broken Thruster
-Casey Wigginton

9.0 Lessons Learned and Future Improvements

9.2 Electrical/Programmatic Lessons

Once the ROV was built, wiring and programming taught the company of the ability to troubleshoot immediate problems and overcome software obstacles, many of which were presented in the project.

One of the most valuable lessons learned throughout the entire project was the importance of waterproofing. The usage of the vent plug on our ROV to pressure-test for leaks proved to be a life-saver for the company, as leaks were caught before the ROV was put into the water on several occasions.

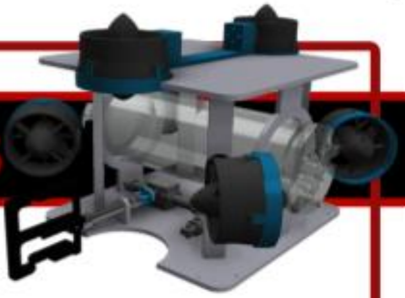
A programmatic challenge that threated to disable ROV function was the incompatibility of the first planned software language that was used on the ROV: LabVIEW. A few days before the company's first competition, the ROV code failed, forcing the company to switch languages to Arduino and get the robot operational with two days remaining.

9.3 Non-Technical Challenges

Throughout the project completion, the company has not only picked up technical skills concerning engineering, but skills concerning peer cooperation and teamwork. By working together, the company was capable of finishing work many times faster than a single individual working. This was exemplified in the final days before the company's first product demonstration. Through delegation, Blake would monitor while David would analyze coral samples, while Mack would pilot and Coleman would oversee team productivity, creating a productive and efficient work environment.

Figure 18: Blake Bennett programming in LabVIEW -Lauren Simpson

Figure 19: Mack Van Wagnen, Blake Bennett, and Rachel Long getting the ROV inspected- Casey Wigginton



10.0 Reflection

Looking back upon the tasks that have been accomplished within our current project, we have noticed that implementation of simple, yet effective strategies had the tendency to work far more effectively than a complicated solution, with many possible tendencies to waver in results. This was exemplified by our usage of the drive frame. The frame is very simple in general design, but allowed for a lot of customization, leaving a very effective result.

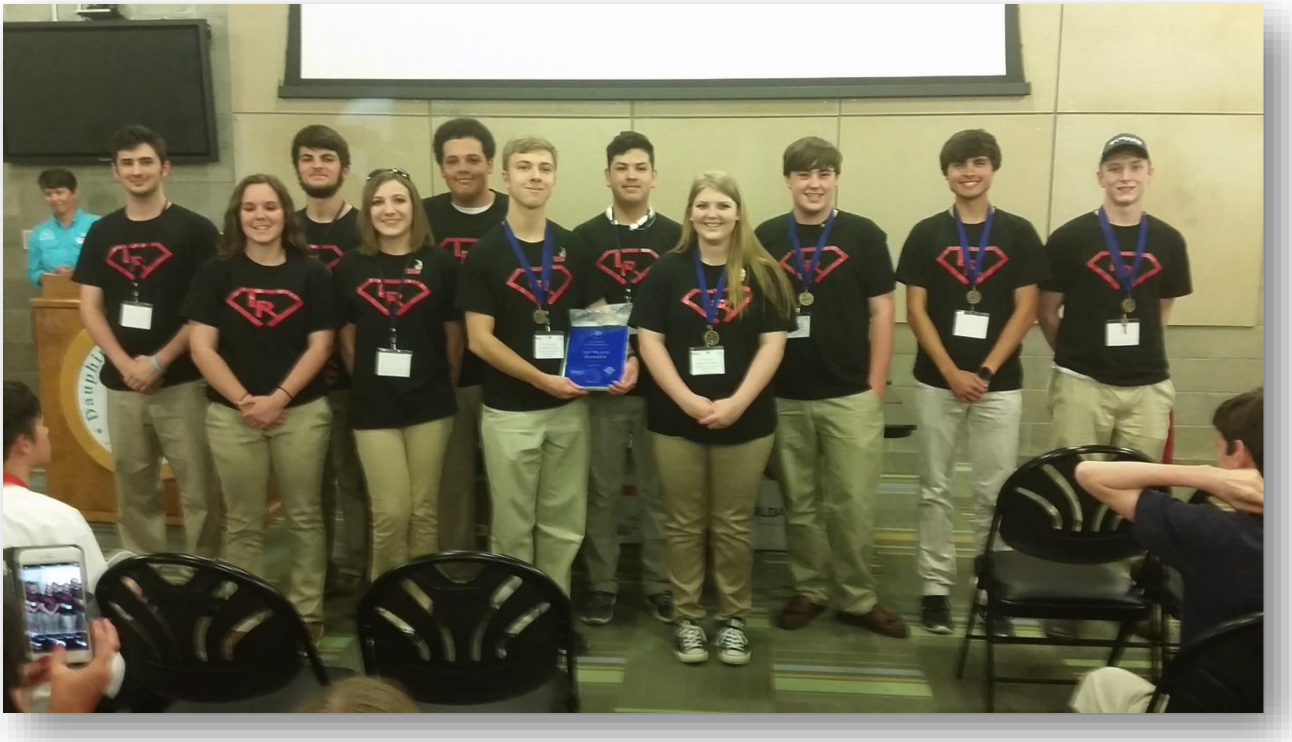
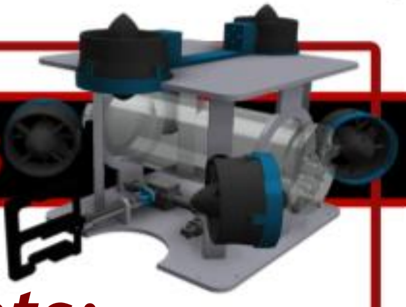


Figure 20: Lost Rockets at Regional Awards Ceremony
-Casey Wigginton



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And a special thanks to our mentors:
Casey Wigginton and Monica McConnel

12.0 References

Figure 4

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