LEE STINGRAYS

Lee County Public Schools

Jonesville, VA

2023 Ranger Division

2023 Team Members	Primary Roles
Wesley Honeycutt	Head of Mechanical, CAD Designer
Jacob Elkins	Head of Electrical, Programming, Pilot
Claira Cox	CEO, Mechanical Engineer, Head of Documentation
Atley McAlister	Programmer, Mechanical Engineer, Props Manager
Luke Young	Safety Officer, Electrical Engineer, Tether Manager

Team Mentors: Tonya Kennedy, Cindy Nickodam, Jerry Robinette

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ABSTRACT

The Lee Stingrays are a third year Ranger MATE team from Lee County, VA. Our company is composed of five members ranging from grades seven through ten. We represent two schools in our district: Pennington Middle and Lee High School. We believe that we have created an efficient and effective ROV for the clients who recently released a request for proposals to help sustain the ocean we need for the future we want. Together we built and designed an ROV equipped to tackle the real world problems of marine renewable energy, healing corals, preserving blue carbon, and monitoring ocean conditions.

The Stingrays have used the Triggerfish and Barracuda builds from the SeaMATE store for the past two years. This year, we have redesigned our ROV and control box to be more efficient and stable in the water. Our newly designed control box also allows us to troubleshoot our ROV system more effectively than our previous designs.

COMPANY OVERVIEW

The Lee Stingrays is a public school team. Members are from Pennington Middle School and Lee High School.

Mission: We are committed to designing and building ROVs that are equipped to tackle real world problems in our oceans and waterways and helping to maintain these systems.

PROJECT MANAGEMENT

Lee Stingray's organization is a small group of only five members. Because of this, all team members were involved in every aspect of the project, from the ROV build and design to prop building. Our team uses Google Classroom and Google Calendar to organize materials, meetings, and practices. We used Canva, Google Docs, and Google Slides to create our technical documents, SID, marketing display, and spec sheet. We used Google Keep to take notes at each practice. We used Google Sheets to organize and label our wiring for future reference.

TEAM ROLES			
Name	**Grade**	**Competition Years**	**Title**
Wesley Honeycutt	10	3	Head of Mechanical, CAD Designer
Jacob Elkins	9	3	Head of Electrical, Programming, Pilot
Claira Cox	9	3	CEO, Mechanical Engineer, Head of Documentation
Atley McAlister	8	1	Programmer, Mechanical Engineer, Props Manager
Luke Young	7	3	Safety Officer, Electrical Engineer, Programming, Tether Manager

Table 1. Team Roles and Members

Lee County Stingrays	Spinn Construction							
Project	2022		2023					
	Nov	Dec	Jan	Feb	March	April	May	June
Organizational Meeting								
Create Team Schedule								
Mission Review								
Design and Research								
Frame and Control Box								
Electrical, Waterproofing, Thruster Testing								
Programming								
Prop Build								
Cameras Installed								
Register for Regional Event								
Thruster Guards								
Manipulators								
Finalizing ROV								
First Trial in Pool with Props								
Technical Documentation								
Pilot Practice								
Prepare for World Championship								

Table 2. Projected Timeline for 2022-23 MATE Season

Solving Day-to-Day Operational Challenges

Last year's Stingray team had nine team members. This year, our numbers were cut nearly 50%, with only five team members. On top of this challenge, two of our members were splitting their time between other school activities. Another member had some health issues and missed several practices. Therefore, in some practices, we only had two members. This created some difficulty with staying on schedule. To help with this challenge, the team did have to meet several Saturdays, so all team members could be there. Because all team members did participate in the Blitz Build weekend in January, the majority of the build was completed. If we had not done this, more late nights and Saturdays would have been required to complete our ROV design and build.

ROV DESIGN RATIONALE

Frame and Structure

For the 2022 regional competition, the Lee Stingrays used a trapezoid design and the frame was built out of PVC pipe. Four PVC caps were used for buoyancy. This design worked well and the ROV was maneuverable in the water. The team had used the Triggerfish and Barracuda kits from the SeaMATE store and decided this year, they would go in a different direction. The team reached out to Ned Vorhees, one of the mentors of the World Champion SEAL team from North Carolina. Due to the fact that the SEAL team would no longer be competing, Ned was offering his expertise to teams in rural areas who did not have access to mentors and individuals with electronic/engineering backgrounds. After speaking several times with Ned, a weekend was chosen and our team headed to Greensboro, NC for a blitz building weekend.

Figure 1: Our team with Ned

The team brainstormed several ideas for the size of the frame of the ROV. It was decided that the frame would be 28 cm x 28 cm x 23 cm. We wanted to keep the frame small in order to maximize points for size. For the top and bottom flat pieces on our chassis we used .65 cm HDPE (high density polyethylene) plastic sheets. For the four posts on the corners of the chassis we used 1.9 cm PVC lumber trim boards. As our new frame began to come together, the team decided to name the ROV Spinn, after Ned's dog that was very entertaining throughout our stay.

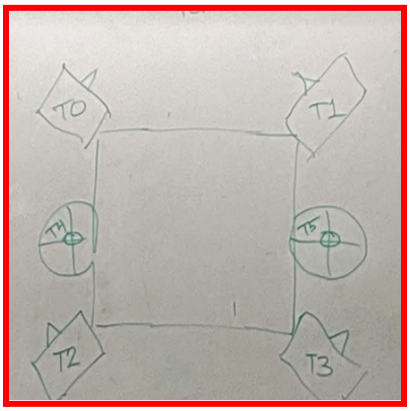


Figure 2: Rough Draft of Chassis (left)

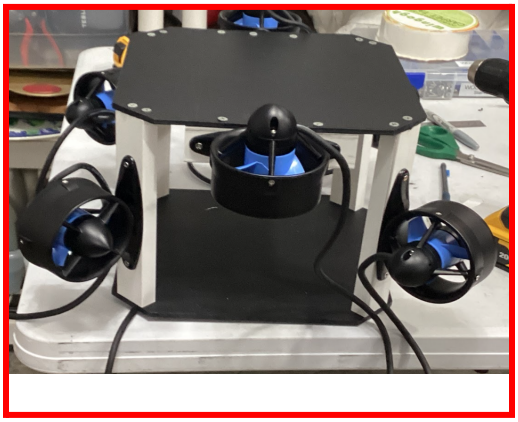
Figure 3: Spinn Chassis (right)

Propulsion/Thrusters

Lee Stingrays are using six Blue Robotics T200 Thrusters for propulsion. Because the majority of the challenges are at the bottom of the pool, our thrusters needed to be at the top of the chassis so they weren't in the way. We decided to place thrusters on each corner for best efficiency and to maximize horizontal velocity.

Two thrusters were placed on top of the chassis for vertical velocity. Vertical thrusters were placed with the front of the motor facing up in order to maximize power going up. This is the first year we are using the T200 thrusters. We subscribed to Blue Robotics Youtube channel and watched several videos to learn more about the T200[1]. The first time we tested them in the water, we could feel the difference of the movement in this ROV compared to our last two ROVs in which we used the 12 volt thrusters from the SeaMATE store. The ROV maneuvered faster and more precisely.

Figure 4: Placement of T200 Thrusters



Buoyancy

For buoyancy, Spinn is equipped with polystyrene high density foam. Team members placed the foam in several locations to determine which locations would be the best. It was decided that floatation was best secured at the top of the ROV. The weight of the gripper and gear box placed at the bottom of the ROV, along with the floatation at the top, provided neutral buoyancy for the ROV. Buoyancy was also added to the tether by placing pieces of pool noodles around the tether about every 10 feet and secured with zip ties.

[1] https://www.youtube.com/watch?v=Q2pl3XF_XU4

Control Box

Lee Stingray's control box is completely new this year. An Apache weatherproof protective case was used to enclose the electrical system. A sheet of Lexan polycarbonate was used to protect the system by cutting it and placing it on top and inside the case. Plywood was placed flat on the bottom of the case. Another piece of plywood was used to hold all the circuitry. This enables the team to be able to remove the board from the box to work on wiring. Notches were also cut into the case for easy removal of the circuit board. Our ROV, Spinn, is controlled with one wireless PS2 controller.

Electric System

This year we used an Arduino Mega to run the Python program to control our ROV. The Arduino is controlling the thrusters by regulating the values to change the thruster speed when necessary. We also incorporated a wet box to organize the motor/tether wires. This was a new concept for our team. It did help make the wiring look neater and gave our ROV a more professional look.

Tether

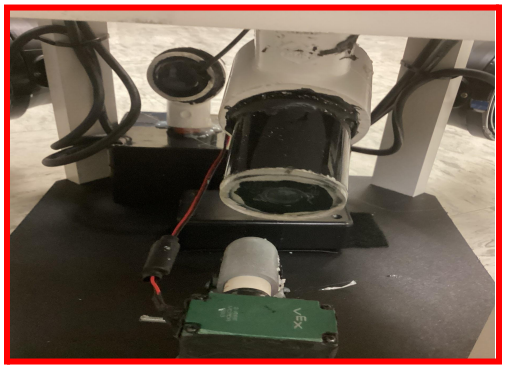
We used 22 AWG cable for our tether. We have a 2 wire tether. Also included in the tether is the wiring for our two cameras, our six thrusters, and our Vex motor. The tether is bundled and covered with Alex Tech split sleeving for protection.

Cameras

Visual imaging systems are used to provide the ROV pilot with a perception of the operating environment. We are using two cameras. Both cameras are being re-used and were taken off of last year’s ROV, Trygonus. One will be positioned near the top, front, center of Spinn. This camera is the main forward-facing camera and is for control of the vehicle. It will also give our pilot a better view of objects below and of the Vex claw in order to manipulate items to complete the

necessary tasks of the challenges. The second camera is located on the back, center of Spinn. The back camera will give the pilot a better view of what is around the ROV since most of the view of the main front camera is blocked by the claw. The cameras we are using are part of the Barracuda Video System Kit we purchased from the SeaMATE store. They are small and lightweight and work perfectly with our ROV design. We also purchased the camera waterproofing kit from the SeaMATE store to waterproof our cameras. The cameras are connected to two external monitors that are mounted in the control box. The cameras are held in place by using the pvc motor mounts that were included in the camera kit.

Figures 5 & 6: Back (left) and Front (right) Cameras



Manipulators

Our primary manipulator is a lift-assist device that will be used to help maneuver objects on and around the ocean floor. Our team is using a Vex Claw as a manipulation tool. We are using a 2-wire Motor 393 with our claw. The claw is attached to the bottom of our ROV with pvc pipe extensions. It is controlled with a switch that has been added to the control box.

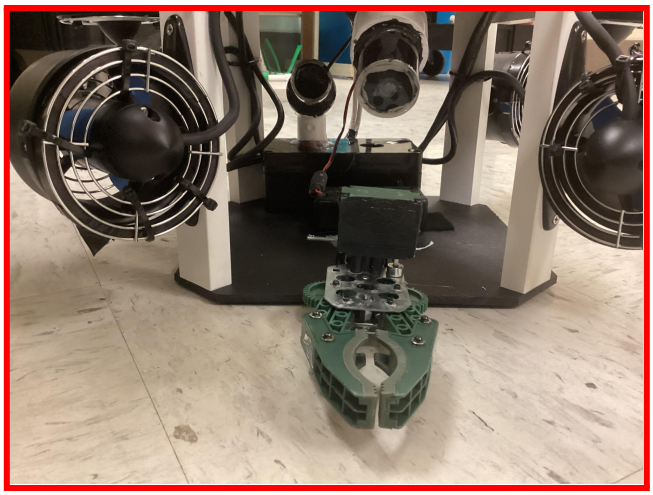


Figure 7: Vex Claw

CAD

Our team used a file from Thingiverse[2] to 3D print the back of the T200 thrusters. Which are secured on the motors using zip ties.

Build vs Buy, New vs Used

As a third year team that had used the SeaMATE store Triggerfish and Barracuda kits for the past two competitions, we decided to build our ROV from the ground up this year. We felt by building we would be able to specialize areas that had failed us in the past. However, there were a few components from our past ROVs we decided we could reuse.

We built our dry box this year with ESC (motor controllers), a 12 to 9 V converter, and an Arduino Mega rather than using the circuit boards in the SeaMate builds. In the past we had issues with soldering, fuses blowing, camera connections, etc. Our new build allows us to troubleshoot much easier because we feel it makes it easier for us to make changes because we can plug/unplug wires rather than checking all the soldering connections on the circuit boards.

[2] https://www.thingiverse.com/thing:4581933

We were able to reuse the Vex claw from our previous ROV. We successfully removed and rewired it to Spinn and it functions perfectly in the water. We were also able to reuse both cameras and monitors from our previous ROV.

Due to the fact that we had so many issues with controllers that we built out of joysticks and potentiometers, we chose to buy a wireless PS2 controller. Using the joysticks as controllers in the past was very unreliable. We were constantly resoldering wires that continuously broke.

Testing/Troubleshooting

Our school system purchased our team an Intex pool that is 3 m X 76 cm. While this is large enough for us to test waterproofing and some of the tasks for the competition, it is not large enough to set up all the tasks similar to how they are placed in the pool at competition. We do not have access to a larger or deeper pool. During our build weekend in North Carolina, we used a 90 gallon trash can filled with water to test our thrusters and buoyancy. We thought this was a neat little trick that Ned was willing to share with us.

Figure 8: ROV Thruster Test

We have been able to test our ROV several times in our pool at this point, including at the Appalachian Highland Super Regional Competition. This is the first

year we have had everything completed and had more pool time to practice tasks. In the past, we had no pool time and were not able to practice.

Now that we have qualified for the World Championship in Longmont, CO we will have time to practice tasks in a full size pool. Our local pools are opening on May 27th and have agreed to give us access before and after the pool opens for the next three weeks. We have never had the opportunity to do this before and we are excited about this opportunity.

Figure 9: Controller/Manipulator Test

Figure 10: Additional Pool Testing

SYSTEM INTEGRATION DIAGRAMS (SID)

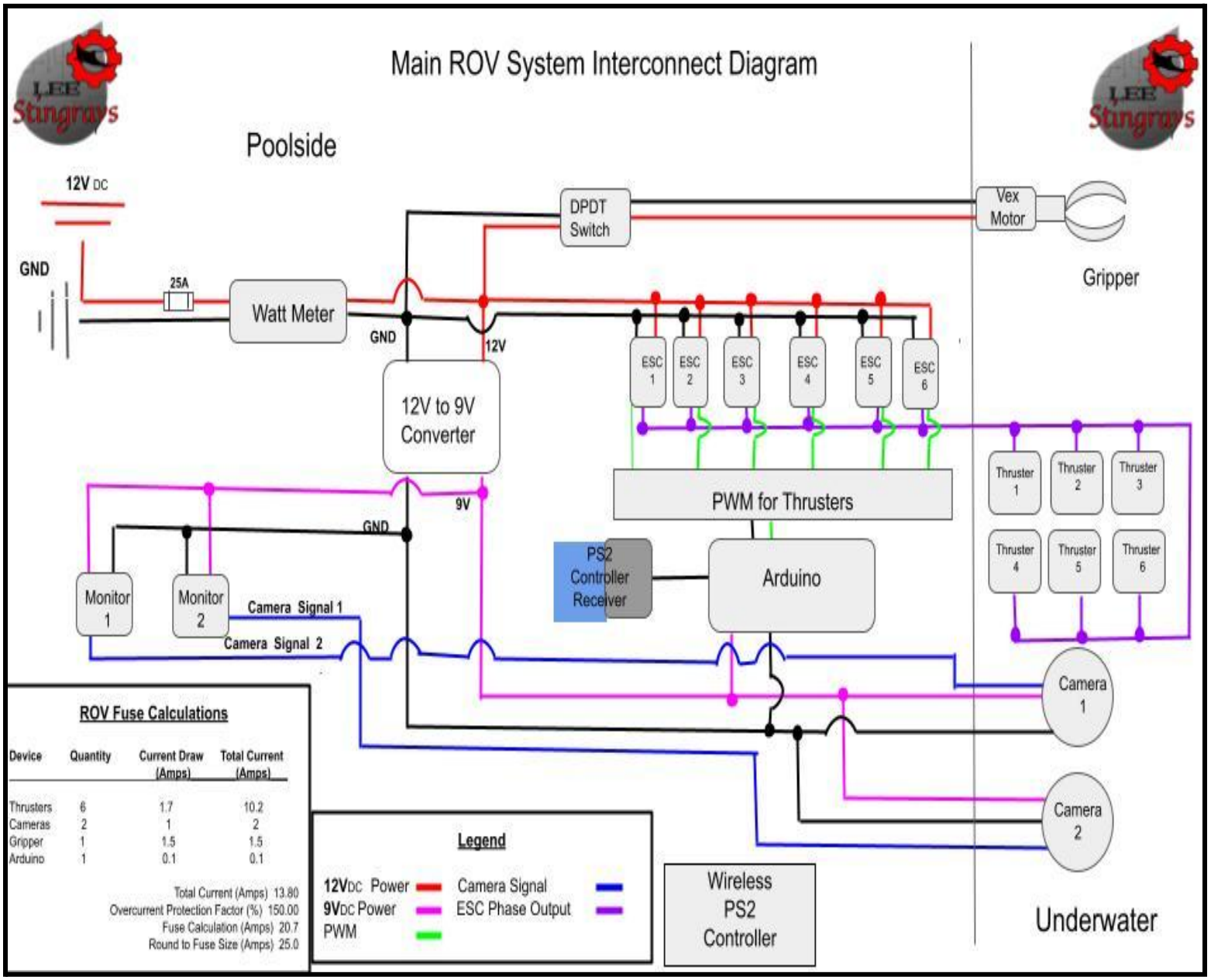


Figure 11: Main SID

SAFETY

Safety was a high priority while constructing our ROV. Safety rules and checklists were part of our team's Code of Conduct which had to be signed by each member. First-aid kits were always in the room and available if needed. At the beginning of the season we discussed the proper safety procedures when building our ROV. We also viewed videos showing the proper way to use the various tools needed to construct our ROV and our props. We made sure our ROV had no sharp edges so there would be no damage to an individual or the pool during competition.

Figures 12 & 13:
Front/Back Shrouds

Safety Features

- Shrouded thrusters
- Single main power switch that controls all the power to the ROV.

Pre-Run Safety Checklist

- All ROV components are secure.
- No sharp edges on ROV
- No wires exposed.
- Surrounding environment is safe.
- All members follow proper safety procedures.
- One adult is always present at any testing.

Product Demonstration Safety Checklist

- Power connection is secure and away from water.
- No horseplay during demonstration/team members focused.
- Control box placed carefully and secure on the table and away from water.
- GFCI (Ground Fault Circuit Interrupter) used for additional safety near water.

Post-Run Safety Checklist

- Make sure all equipment is safely loaded back on the cart.
- Check ROV for any missing pieces that may have fallen in the pool so divers can be notified.
- Team members thank judges before exiting the product demonstration area.

ROV Construction Safety Checklist

- Closed-toe shoes worn at all times.
- Safety glasses worn when operating power tools or soldering.
- Long hair is tied back.
- No loose clothing.
- Assist team mates with any safety concerns.
- Proper behavior (no horseplaying).
- At least one adult supervising.

Tether Handling Protocol

We ensured that the tether is properly attached to the ROV and the control box with adequate strain relief on both sides. While on the poolside, we handle the tether safely to avoid tripping hazards by keeping the tether contained and off to the side. After we get the robot out of the water, we use a cable clamp to hold the tether together. The clamp enables us to hang the tether neatly on the cart.

EVALUATION

Lessons Learned/Learning Opportunities

We feel our team learns more about robotics, electronics, coding, using power tools, waterproofing motors and cameras, etc. each year. This will be our third year of competition and we are much more confident in our skills, but we know we still have much to learn. Last year, we stated in our technical documents that we hoped to learn more about Arduinos next competition year and possibly

build our ROV out of material other than PVC pipe. We were able to achieve both of those goals this year. We incorporated an Arduino into our control box and learned how to code it with Ned's help and by watching tutorials on Paul McWhorter's YouTube channel[3]. We also built our ROV out of HDPE (high density polyethylene) plastic sheets and PVC lumber trim boards. We are slowly advancing our skills and knowledge.

Team Building Skills

Learning to work together as a team was difficult at first. We came from two different schools and from a wide range of grade levels. We had to learn to communicate with each other, most importantly listen to everyone's ideas. After endless hours spent together, we have learned how to work well together, even if we don't always agree. We have learned how to brainstorm ideas together and troubleshoot problems. We have also learned how to resolve conflicts in ways that were beneficial to our team and that would help us reach our goals for the competition year.

We will now be spending the next month together preparing for the World Championships and traveling to Colorado. We will definitely have our team building skills fine tuned by the end of June!

Figure 14: ROV Team Build Photo

[3] https://www.youtube.com/@paulmcwhorter

ACCOUNTING

Budget

ROV BUDGET - Lee Stingrays 2023				
Income				
Source				**Amount**
VDOE Grant				$5000.00
PhARMA Grant				$2500.00
Donations				$1275.00
Expenses				
Category	**Type**	**Description**	**Projected Cost**	**Budgeted Value**
Prop Supplies	Purchased	Prop Build	$300	$300.00
Specialty Tools	Purchased	Titanium Drill Bits, Dremel, Sander	$150	$150.00
Tether	Purchased	Tether, Sheath, Strain Relief, Waterproofing, etc.	$300	$400.00
Control Box	Purchased	Arduino, Wiring, Connectors, Waterproofing, Epoxy, etc.	$500	$500.00
ROV Thrusters and Electronics	Purchased	Thrusters, Speed Controller, Bracket, ESCs, Waterproofing, etc.	$2000	$2000.00
Team Shirts	Purchased	Team Shirts	$160	$160.00
Registration	Purchased	Regional Competition	$250	$250.00
Travel/Food	Purchased	NC Build, Regional Competition/Meals	$3000	$3000.00
Misc	Purchased	Misc. Expenses	$500	$500.00

ROV BUDGET - Lee Stingrays 2023				
Income				
Source				**Amount**
VDOE Grant				$5000.00
PhARMA Grant				$2500.00
ROV Cameras/Monitors/Water proofing Kits	Reused	Video System Kits/Waterproofing Kits/SeaMATE Store	$260	-
Grippers/Servos	Reused	Vex Claws/Motors	$125	-
Prop Supplies	Reused	PVC Pipe and Fittings	$100	-
ROV Frame	Donated	HDPE, PVC Lumber Trim Board	$100	-
		Total Projected Income Available		$8775.00
		Total Projected Expenses		$7260.00
		Total Projected Expenses minus Reused		$6675.00
		Total Fundraising Needed		$0.00

Table 3. Budget for 2023 season ROV build.

Project Cost - Lee Stingrays ROV Build 2023 October 2022 - May 2023						
Income						
Source						Amount
Grants and Donations						$8775.00
Expenses						
Date	**Type**	**Category**	**Expense**	**Description**	**Amount**	**Running Balance**
Oct- 22	Purchased	Electronics	Thrusters and Electronics	7 Blue Robotics T200 Thrusters, Speed Controller,	$1650.10	$1650.10

				Bracket, ESCs, Waterproofing, etc.		
Oct-22	Purchased	Electronics	Control Box	Arduino, Wiring, Connectors, Waterproofing, Epoxy, etc.	$345.38	$1995.48
Oct-22	Purchased	Hardware	ROV	Tether, Sheath, Strain Relief, Waterproofing, etc.	$300.00	$2295.48
Oct-22	Reused	Electronics	Video Components	Video System Kits/Waterproofing Kits	-	$2295.48
Oct-22	Reused	Hardware	Grippers /Servos	Vex Claws/Motors	-	$2295.48
Oct-22	Reused	Hardware	Prop Build	PVC Pipe and Fittings	-	$2295.48
Oct-22	Donated	Hardware	ROV	HDPE, PVC Lumber Trim Board	-	$2295.48
Jan-23	Purchased	Hardware	Tooling	Titanium Drill Bits, Dremel, Sander	$99.95	$2395.43
Feb-23	Purchased	Hardware	Prop Build	Plastic Frogs, Lures, LEDs, Photoresitors, PVC Pipe and Fittings, etc.	$250.56	$2645.99
March-23	Purchased	Registration	Registration	MATE Regional Competition	$250.00	$2895.99
April-23	Purchased	Team Shirts	Team Shirts	MATE Regional Competition	$175.00	$3070.99
Jan 23-May-23	Purchased	Food/Travel	Food/Travel	Competition Year	$2850.00	$5920.99
				Total Funds Raised		**$8775.00**
				Total Spent		**$5920.99**
				Balance		**$2854.01**

Table 4. Project Cost Accounting Expenditures for the 2023 ROV Build

ACKNOWLEDGMENTS AND SPONSORS

Lee Stingrays would like to thank the following businesses and individuals for their help during this competition season:

- STREAMWORKS and the interns for always being there to answer questions and support us from the beginning.
- Bryan Bales, LCCTC, for helping us with our 3D printing and Beth Shell, LCCTC, for helping us learn how to use the Glowforge machine.
- Mark Long, Principal of LCCTC for supporting this initiative from day one!
- Greg Rasnic, LCCTC, Carpentry teacher, for the use of his saws and expertise.
- Ned, Maureen, and Spinn Voorhees for hosting our team during our weekend blitz build.
- MATE Program and Staff, Competition Judges, and Volunteers
- Tonya Kennedy, Cindy Nickodam, and Jerry Robinette (our mentors) for learning with us, feeding us, and always being there for the team.
- Dr. Steve Wright for his support and feedback that helps our team improve each year. Thank you for all your volunteer work and dedication to STEM.
- Pennington Pharmacy for their $25 donation.
- Jonesville Drug for their $200 donation.
- Builders Hardware, LLC for their $100 donation.
- Moving Forward Physical Therapy, Inc. for their $200 donation.
- Farmers & Miners Bank for their $200 donation.
- Lee Bank & Trust for their $200 donation.
- Lee Family Dental for their $250 donation.
- Scott's Well Service, Inc. for their $100 donation.
- PhARMA for being chosen as the $2500 grant recipient.

REFERENCES

1. “Blue Robotics Product Overview T200 Thruster” Retrieved January 2023 from URL https://www.youtube.com/watch?v=Q2pI3XF_XU4
2. “T200 Blue Robotics Motor Guards” Retrieved April 2023 from URL https://www.thingiverse.com/thing:4581933
3. “Hand Tool Safety” Retrieved February 2023 from URL https://www.youtube.com/watch?v=oIyoldUnV0k
4. “Arduino Tutorials” Retrieved January - April 2023 from URL https://www.youtube.com/@paulmcwhorter