2017 MATE International ROV Competition

Technical Report for *Panther Robotics* ROV

Pine Crest School

RANGER:
Panther Robotics

Pine Crest School Fort Lauderdale, Florida, USA

Danielle Bejar '18 ~CFO

Harrison Freedman '19 ~ CEO

Liza Goldstone '20 ~ Testing Operations

Kaitlyn Ockerman '18 ~ Fundraising, Marketing, and Media Outreach

Wyatt Ross '19 ~ Systems Engineering

Avyah Sharma '18 ~Research and Development

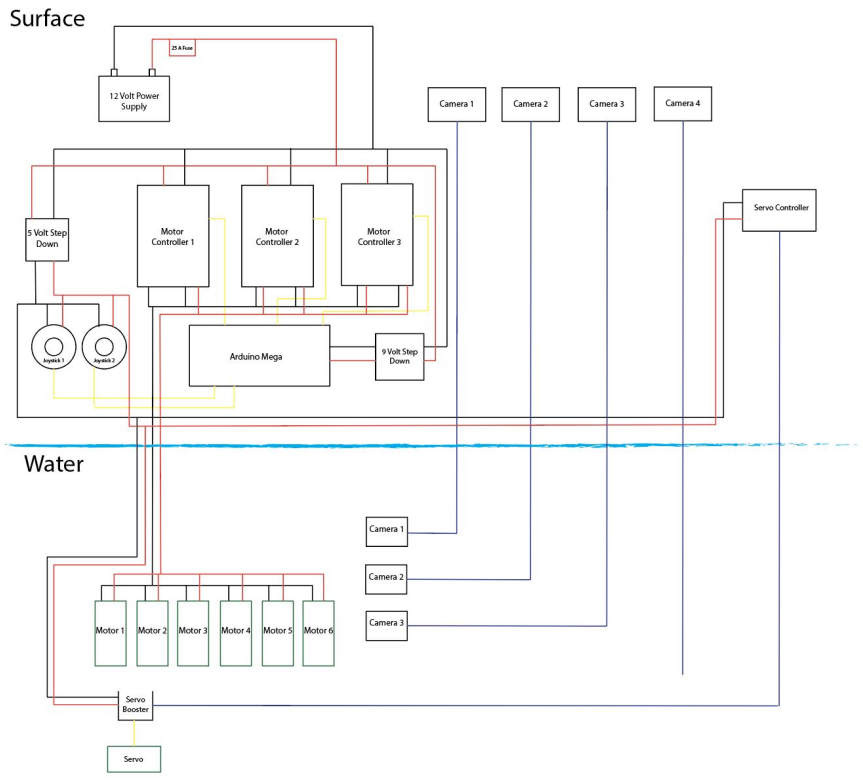
Simran Wadhwa '19 ~ Government and Regulatory Affairs

Table of Contents

1. Abstract

Participating in Mate ROV for the second time, Pine Crest Panther Robotics strives to produce an effective ROV through collaboration, determination, and innovation. Located at Pine Crest School in Fort Lauderdale, Florida, Panther Robotics is a co-ed company of seven members. Pine Crest Panther Robotics is a resourceful company specializing in finding versatile solutions to real-world marine technology problems such as exploring new opportunities for maintaining health and safety in future port cities. The daunting task of designing, prototyping, optimizing, building, and final testing began in January of 2017, giving us four months to complete our ROV and be ready for competition. Our company has designed the ROV with the intentions of 1) assisting with the installation of a Hyperloop system to expedite the delivery of goods and streamline commerce; 2) conducting maintenance on the port's water and light show to guarantee uninterrupted entertainment; 3) identifying and collecting samples of contaminated sediment then remediate the area to protect the health of people and the environment; and 4) identifying the contents of containers that fell off of a cargo ship into the harbor and map the accident site to ensure the safety of the port and its operations. During the construction of our ROV, our company used 3D printed materials and PVC pipes to make the ROV lightweight and cost-considerate. The control system uses the programming language C++ for the subsurface electronics and surface control panel.

2. Systems Integration Diagram



3. Company Information

Danielle Bejar

Company Role: Chief Financial Officer

Poolside Role: Pilot

Danielle is in 11th grade at Pine Crest in Fort Lauderdale, Florida. This is her 2nd year competing in the MATE ROV Competition, and eventually she would like to be an ophthalmologist. She will graduate high school in 2018, hoping to attend college at Brown University.

Harrison Freedman

Company Role: Chief Executive Officer

Poolside Role: Will not be present

Harrison is in 10th grade at Pine Crest in Fort Lauderdale, Florida. This is his 2nd year competing in the MATE ROV Competition, and as an adult he would like to be an electrical or mechanical engineer.

Liza Goldstone

Company Role: Testing Operations

Poolside Role: Tether Manager

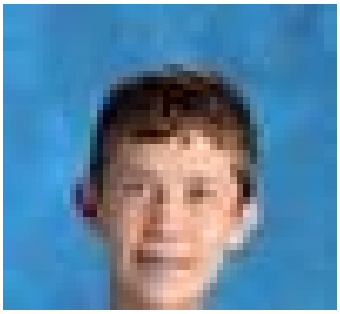
Attending Pine Crest School, Liza is currently a 9th grade student. As this is her first year participating in the MATE ROV Competition, Liza is very eager to learn new engineering skills while building new friendships with the team. In the future, Liza aims to pursue a career in environmental science.

Kaitlyn Ockerman

Company Role: Fundraising, Marketing, and Media Outreach

Poolside Role: Spirit Facilitator

Kaitlyn Ockerman, an 11th grader at Pine Crest School, is excited about participating in MATE ROV Competition. This is her first year participating in this competition; however, she has experience with FIRST robotics. After college, Kaitlyn would like to be involved in medical research.



Wyatt Ross

Company Role: Systems Engineering

Poolside Role: Copilot

Wyatt is in 10th grade at Pine Crest in Fort Lauderdale, Florida. This is his 2nd year participating in the MATE ROV Competition, and eventually he would like to be a software engineer.

Avyah Sharma

Company Role: Research and Development

Poolside Role: Overseeing Operation Officer

Avyah is in 11th grade at Pine Crest in Fort Lauderdale, Florida. This is his 2nd year competing in the MATE ROV Competition, and eventually he would like to be an entrepreneur or software engineer.

Simran Wadhwa

Company Role: Government and Regulatory Affairs

Poolside Role: Crane Manager

Simran is in 10th grade at Pine Crest School. This is her 2nd year competing in the MATE ROV Competition and she would eventually like to be a nuclear or aerospace engineer.

Brayan Delgado

Company Role: Mentor

Poolside Role: Mentor

Brayan is a 25 year old engineering teacher at Pine Crest School in Fort Lauderdale, Florida. He attended school at Florida Atlantic University where he obtained his degree in Computer Engineering. This is his 2nd year mentoring in the MATE ROV Competition, but it is his first time having his team compete.

Member	Desired Area of Study	Graduation Year
Danielle Bejar	Biology	2018
Harrison Freedman	Mechanical Engineering	2019
Liza Goldstone	Environmental Science	2020
Kaitlyn Ockerman	Chemistry	2018
Wyatt Ross	Computer Science	2019
Avyah Sharma	Computer Science and Economics	2018
Simran Wadhwa	Aeroscience Engineering	2019

Table 1: Each team member's desired future career paths and graduation dates.

4. Mission Theme

The mission theme this year is based off of the busy port of Long Beach, California. Long Beach is in need of a ROV to help with commerce, safety, entertainment, and health. A hyperloop system will streamline commerce. The ROV can help with the port's light show and can help clean any pollution in the water. With all of the commotion going on in the port, having a remote controlled ROV will allow for easier access of ways to help everything run smoothly within the port.

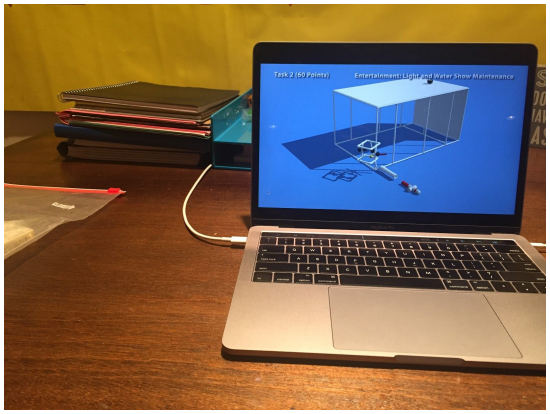


Figure 1: Team members watching the Fly Through video to go over mission tasks.

5. Safety

Safety is Panther Robotics' number one priority. We take every precaution necessary, especially because we work in an environment that includes electricity within proximity to water, sharp objects, and dangerous tools. We emphasize that our robot meets all of the required safety features including: no sharp edges, a 25amp fuse within 25 centimeters of the battery on the positive line, caution labels for moving parts, strain relief on the tether and all other cables, and thrusters that are both inboard and shrouded. On top of these strict requirements we added a few of our own, some include never modifying the robot while it is powered on or plugged in and never fixing any electronics poolside to prevent electric shocks.

During construction of the ROV, we followed a comprehensive safety protocol and Job Safety Analysis (JSA) which required proper Personal Protective Equipment (PPE). This includes the use of safety glasses, closed-toe shoes and gloves and masks (for potentially hazardous substances). The company complied with all Health, Safety and Environmental (HSE) standards in order to maintain a safe workplace.

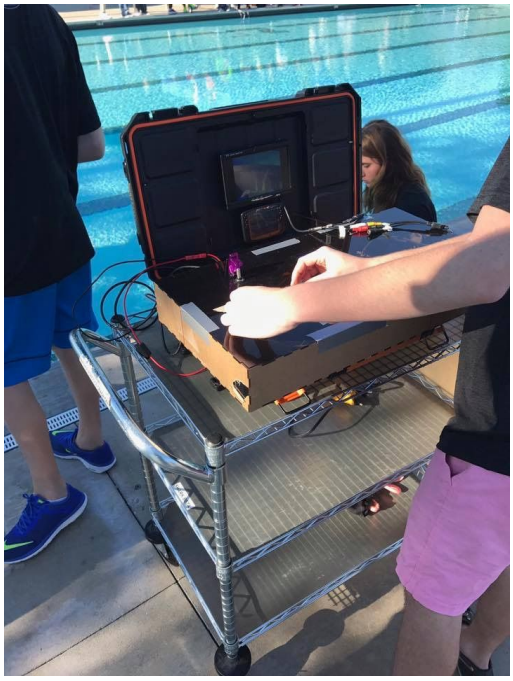


Figure 2: Team members run through safety precautions at Florida State Competition.

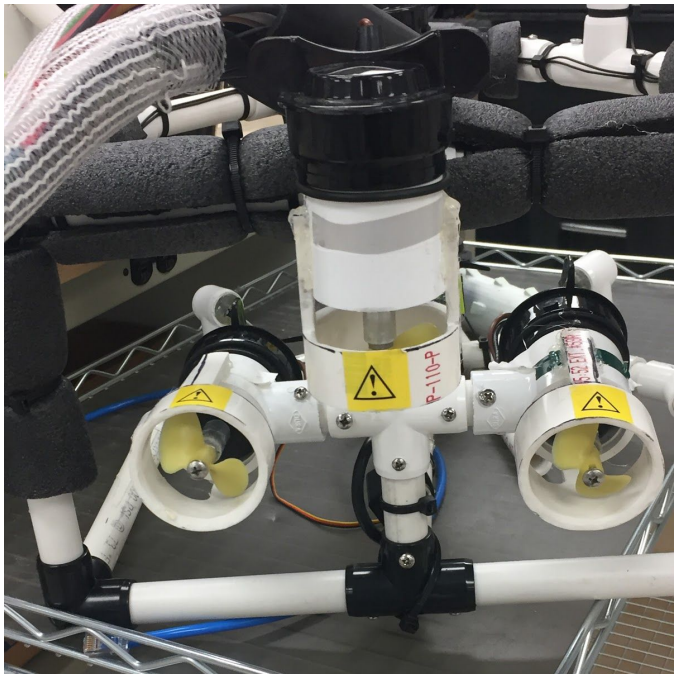


Figure 3: Our robot equipped with caution labels and motor shrouds.

Panther Robotics Safety Checklist:

- ❏ Everyone is wearing closed toe shoes and safety glasses
- ❏ There is a 25 amp fuse
- ❏ We have a Ground Fault Circuit Interrupter (GFCI)
- ❏ The tether strain relief is in place
- ❏ Control boxes are plugged in correctly
- ❏ The two anderson plugs for power are plugged in properly [red (+), black (-)]
- ❏ All the switches are powered off
- ❏ The tether / control case is clamped to the table
- ❏ The tether is plugged into the control box

6. Design Rationale

We have placed to motors on the sides, which fold out, two motors in the back, and motors mounted on the top bar of the ROV, oriented facing down. The motors on the side help the robot move forward and backwards, they fold out to give them a better moment for turning, as they are the only active turning motors. Out top motors are set up so that they are for power and the top propellers move the robot up and down. Each of the propellers is able to fire individually in order to control the pitch of the ROV. In addition, we made use of a

large number of custom designed 3D printed pieces because they are cheaper and they weigh less.
As is visible from Figure 1, the Panther Robotics sketched a basis for the ROV on whiteboards so that they could come up with their design plan.

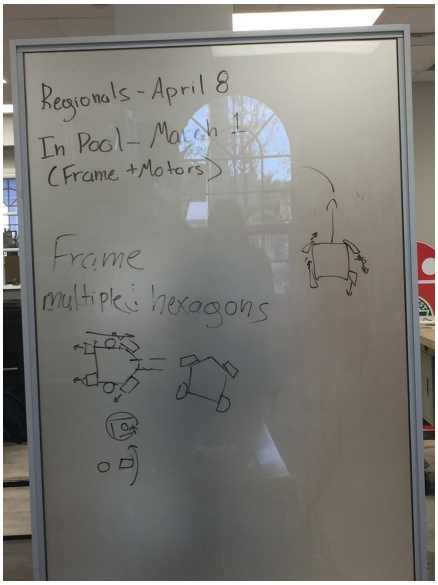


Figure 4: Discussing deadlines and frame shape

6.1 Frame and Flotation

Panther Robotics has designed our frame to fit within a 48 centimeter diameter sphere. By doing so, we are ensuring receipt of the highest amount of point bonus for size. In addition, with a weight of 23.5 Kg, we will receive more points toward our score. Furthermore, in order to maintain approximate neutral buoyancy, the Panther Robotics ROV is equipped with pool noodle around the pipes to add flotation. The pool noodles surround the top layer of the ROV as well as the two sides that are on the rear of the ROV.

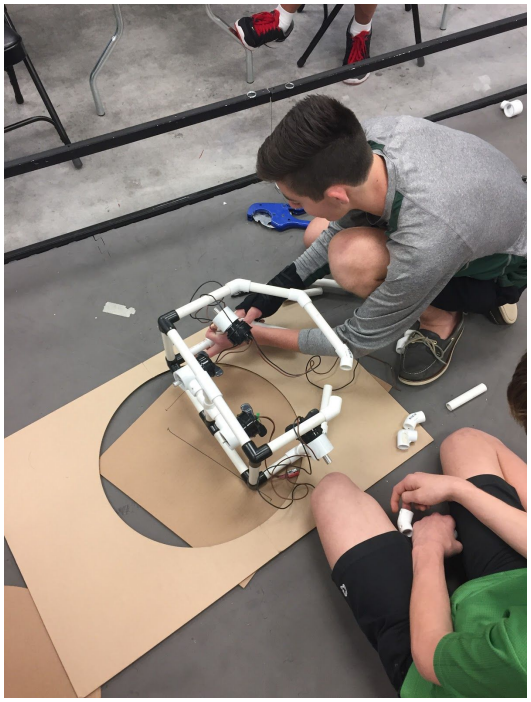


Figure 5: Building the frame (keeping in mind the size bonuses)

Figure 6: Preparing the ROV to be weighed

6.2. Waterproof Electronics Canister

The only electronic component on the ROV is a cat6 receiver servo controller. It is encased in polyester resin; this resin block is then placed a laser cut box which is mounted in the ROV. Through past projects, we have come to recognize the importance of waterproofing thoroughly to avoid complications during competitions.

6.3. Thrusters

Our thrusters are SPX 500 gph bilge pump motors. The propellers came from the Triggerfish ROV Kit. In order to comply with MATE Safety Regulations, we designed our own shrouds to cover the motor's propeller. In addition, the shrouds assist in maximizing the efficiency of the motors in the water. With six motors total, four are utilized for horizontal movement while the other two control vertical movement.

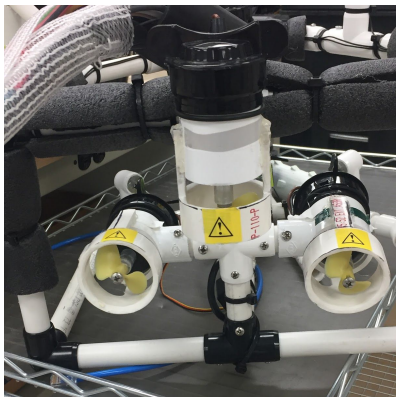


Figure 7: Our back three thrusters allow for both horizontal and vertical movement.

6.4. Control System and Tether

The control system is a custom acrylic laser cut box that includes 2 Joysticks and 2 potentiometers that controls our servo. The control box also holds our Arduino Mega and 3 motor controllers which power our motors underwater. These Motor controllers also include lights so we can test the system without the ROV plugged in. Along the side of the box there is a set of anderson's to allow the ROV to be detached easily for transport. Our control box also holds a larger monitor to view the cameras underwater. Our tether is made of a custom set of silicon coated 16 gauge wire to power the motors and the servos an ethernet cable to control the servos, and thin cables to power the cameras. The surface end of the tether is also crimped with anderson connectors so that we can easily plug it into the control box.

Figure 8: After the regional competition, we recognized the importance of having a very organized control box, so we redid it to live up to Panther Robotics standards!

6.5. Mission Specific Tooling

Claw: Using SolidWorks, our team researched and designed a claw that would maximize efficiency in tasks under the water. With custom edges, this claw grabs elements more consistently and quickly than previous prototypes. The claw is built out of 3D printed resources, 6 screws, and a waterproofed 180 servo.

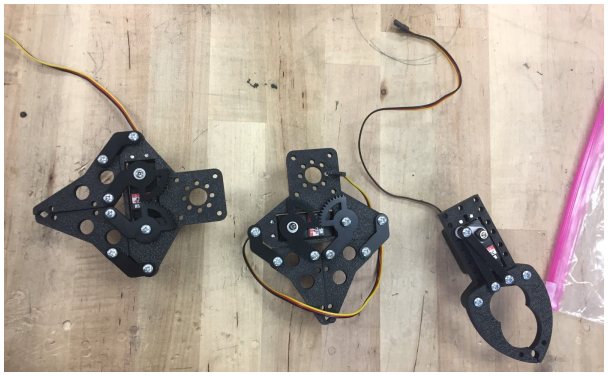


Figure 9: We tried many claws to find the one that was the most efficient.

7. Troubleshooting

Motor polarity: When testing our ROV on May 26, we discovered that our motor polarities were reversed. When discovering the source of the problem, we came to the conclusion that it must be a software issue or the mirror controllers. We identified this problem by taking the ROV out of the water and testing each motor individually. By testing the motors we found that the polarities had been reversed and were moving in the opposite direction. Our solution to this problem was to rewire the connectors. This way, the polarities could return to their normal state, instead of rewriting code.

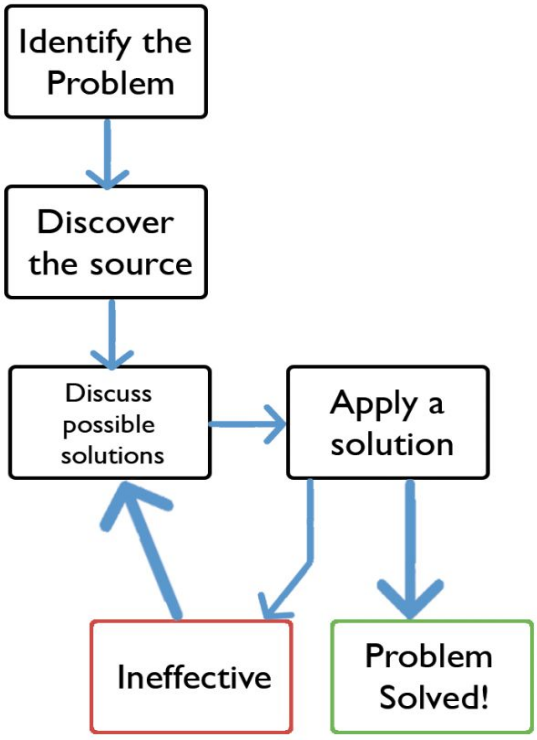


Figure 10: When we encounter problems, our team is sure to utilize these problem solving strategies.

8. Teamwork and Organization

Our company always strives to work together and promote collaboration. As individuals, we all have our own assigned titles; however, our teamwork stretches beyond those titles. All team members work on the robot and help each team member with his or her assigned tasks. Panther Robotics is organized in a structure similar to that of a business. We have a CEO, CFO, Government and Regulatory Affairs Head, Research and Development Head, Systems Engineering Head, and Business Head. But, each team member is not limited to the tasks responsible of their title. In order to communicate with one another and extract ideas, Panther Robotics uses GroupMe to chat with all team members. Here, team members write down important information regarding the progress of the robot and the tasks that need to be completed each week.

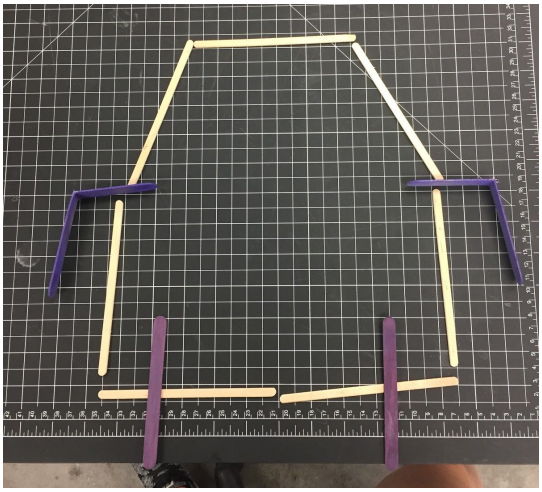


Figure 11: A model made of our initial plans for the ROV using popsicle sticks. The tan ones are PVC pipe and the purple represent the motors.

Figure 12: Our team has lead to new friendships being created!

9. Project Management

Beginning in January, our company has worked together under a project management system aimed to increase efficiency and communication. At the beginning of the season, the team developed tentative deadlines or checkpoints. Over the course of the season, these were altered to fit our schedules and become more specific. Prior to physically constructing the ROV, we had planning deadlines to establish research and

development goals. In order to maintain team cohesion, we communicated via email and GroupMe to see what tasks had to be completed.

10. Challenges

10.1 Technical Challenge

One of the challenges we had when building and designing our robot is that we did not take into account the wires, so when actually building the robot, we had to deconstruct and reconstruct it a few times in order to accommodate for the wires.

Another problem we encountered is that, when testing the robot, we did not double check that all of the cameras were waterproofed, so we had two cameras malfunction during the testing. We had to replace these cameras because they were no longer suitable for the production of the robot.

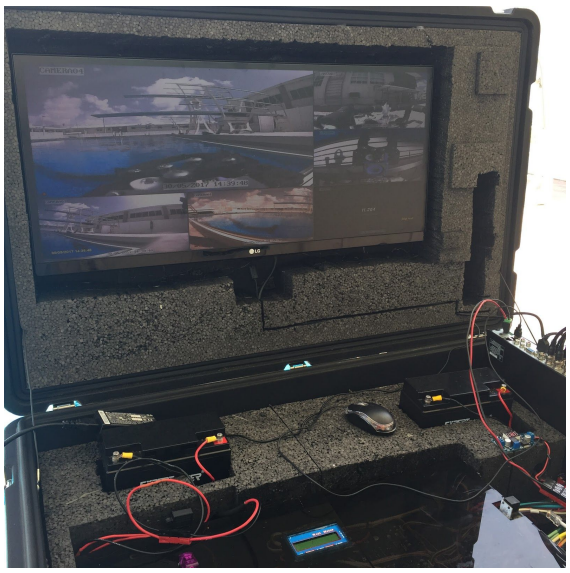


Figure 13: Our new monitors that allow us to have all vision under water.

10.2 Non-Technical Challenge

A large challenge that we faced as a team was staying concentrated. As there are so few of us on the team it was crucial that we all stayed on task and completed what we needed to in a timely fashion. Often this did not happen because we were all very easily distracted with other projects and ideas. In order to compensate for this we added many hours to our days to allow room for slacking to be built into the schedule. This also allowed us to further innovate on our robot because when we finished our tasks we would normally have extra time to work on another task or come up with new and better ideas.

11. Lessons Learned

Liza ~ “As this was my first year participating in MATE, I entered the season with minimal knowledge about the building aspects of an ROV. Now, as we continue in the season, I feel more confident with not only building and design but also coding and business.”

Kaitlyn ~ “From my experiences in MATE Robotics, I was able to explore my interest in business by contributing to thoughtful business documents.”

Avyah ~ “Teamwork is everything.”

Harrison ~ “The aspects of this year’s tasks have challenged us to think outside of the box.”

12. Future Improvements

In the future, our company aims to maintain constant communication to stay in connection with one another. Also, we have decided that we will use a large wall calendar in our work space so we can easily identify approaching deadlines. Looking at the Ranger Class Manual frequently is additionally extremely important. Likewise, we aim to complete our ROV enough in advance to have ample practice time in the water. We have had a very productive season this year and are looking forward to next year’s challenge to continue our progress.

Figure 14: Late night practice to prepare for the Florida regional competition!

13. Budget

Our second year as a MATE ROV team, Pine Crest School has given us a generous budget of $800; however, we plan on spending under $600. Pine Crest garners its money from Zimmerman Advertising, and they fund all Pine Crest Robotics and Innovation Programs. Panther Robotics also received sponsorship from Pallas Management. As shown below, our robot cost approximately $584.32, which was $215.68 below our $800 budget and $15.68 under our projected cost of the robot.

14. Project Costing

When designing our ROV, we planned on spending at a minimum 25% lower than our given budget. We wanted our ROV to be costly effective as well in order for mass production. The cheaper materials we could find that would serve the same function, we used because we wanted the cost to mass produce our ROV to be very low so that there would be a larger margin of profits.

Picture	Name	Store SKU / Website	Amount	Cost per item	Total Cost
	1-½ in. PVC DWV Hub x SJ Trap Adapter	189855	4	$1.42	5.68
	O-rings for 1-½ in diameter	678185	1 package but a lot of them	$9.98	$9.98
	Dipable plaxidip	250084	1	$6.98	$6.98
	Bilge Pump Motors	Amazon	8	$17.56	$140.56

	Props	SeaMate	4	$24	$96
	Camera	Amazon	4	$21.99	$87.96
	Camera 2	Amazon	1	$6.99	$6.99
	USB Cable	Amazon	2	$19.99	$39.98
	RJ45 Connector	Amazon	6	$4.99	$29.94
	Controller	Amazon	2	$21.99	$43.98
	Surge Protector	Amazon	1	$9.04	$9.04

	USB to Serial	Amazon	1	$6.99	$6.99
	Motor Controller	RobotShop	4	$23.99	$95.96
	Pool Noodle	DollarMart	2	$1.00	$2.00
					Final Total: $584.32

In addition to the cost of materials, each team member is responsible for paying a $650 fee that includes travel costs and the hotel bill. Each team member is also responsible for their meal plan during the trip. Pine Crest School, however, covers the cost of registration fees as well as the shipping and handling of the ROV.

15. Publicity

Panther Robotics has taken it upon themselves to spread awareness about their company through the networking of social media in the fields of Twitter and Instagram. @PCmateROV is the screenname for the Panther Robotics social media outlets and is important to their publicity. On these social media accounts, Panther Robotics keeps updated information regarding their company and significant achievements made by their team members.

In addition, Panther Robotics has worked with Pine Crest School to expand their range of communication. The Pine Crest mate team has been featured on the Pine Crest web page as well as social media outlets and the school newsletter.

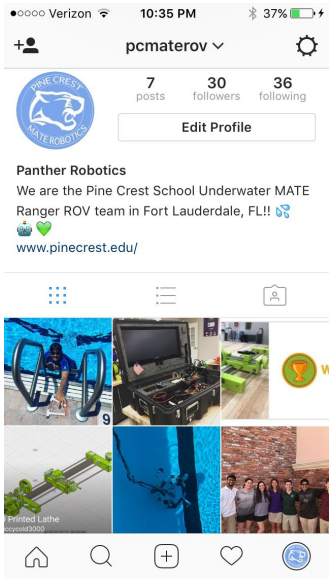


Figure 15: PCMateROV Instagram account in action!

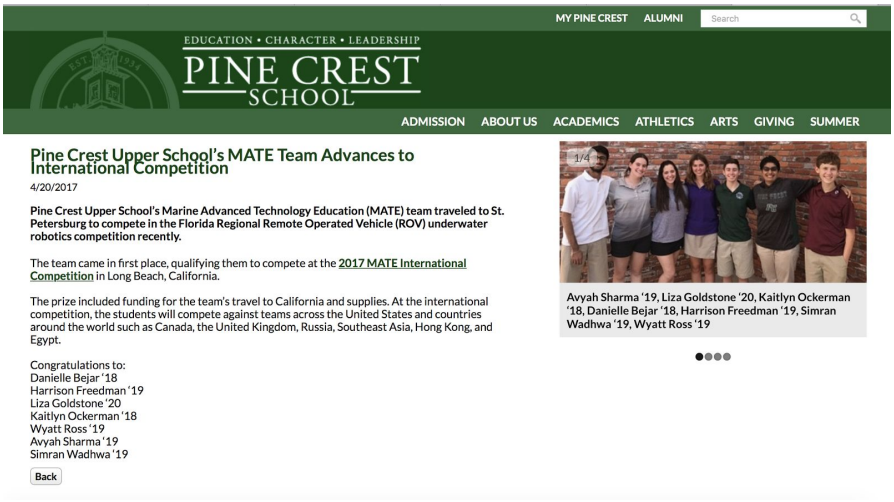


Figure 16: Our mention on the Pine Crest School website.

16. References

Our references include:

- Our mentor Brayan Delgado who helped provide helpful information as well as critiqued our overall design to make our structure better.
- Arduino.cc which provides resources for practicing how to code
- Solidworks.com provides tutorials for CAD software

17. Acknowledgements

- Zimmerman Advertising – We thank Zimmerman Advertising for continuous support funding our school's innovation program and donating to our company.
- Pallas Management - We thank Pallas Management for their generous donations to our teams.
- SolidWorks – We thank SolidWorks for providing us free access to their fantastic unparalleled software for 3D modeling.
- Brayan Delgado – We thank Brayan Delgado for being a fantastic mentor to the members of our company and guiding us through the whole process of building our company and being our coach.
- MATE – We thank MATE for allowing us the experience to compete in a competition that challenges our minds and allows us to better our skills as engineers and members of a company.