2016 MATE International ROV

Panther Robotics

Pine Crest School Fort lauderdale, Florida

Harrison Freedman (CEO)

Wyatt Ross (VP)

Danielle Bejar (CCO)

Jacob Zipper (CBO)

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1. Abstract

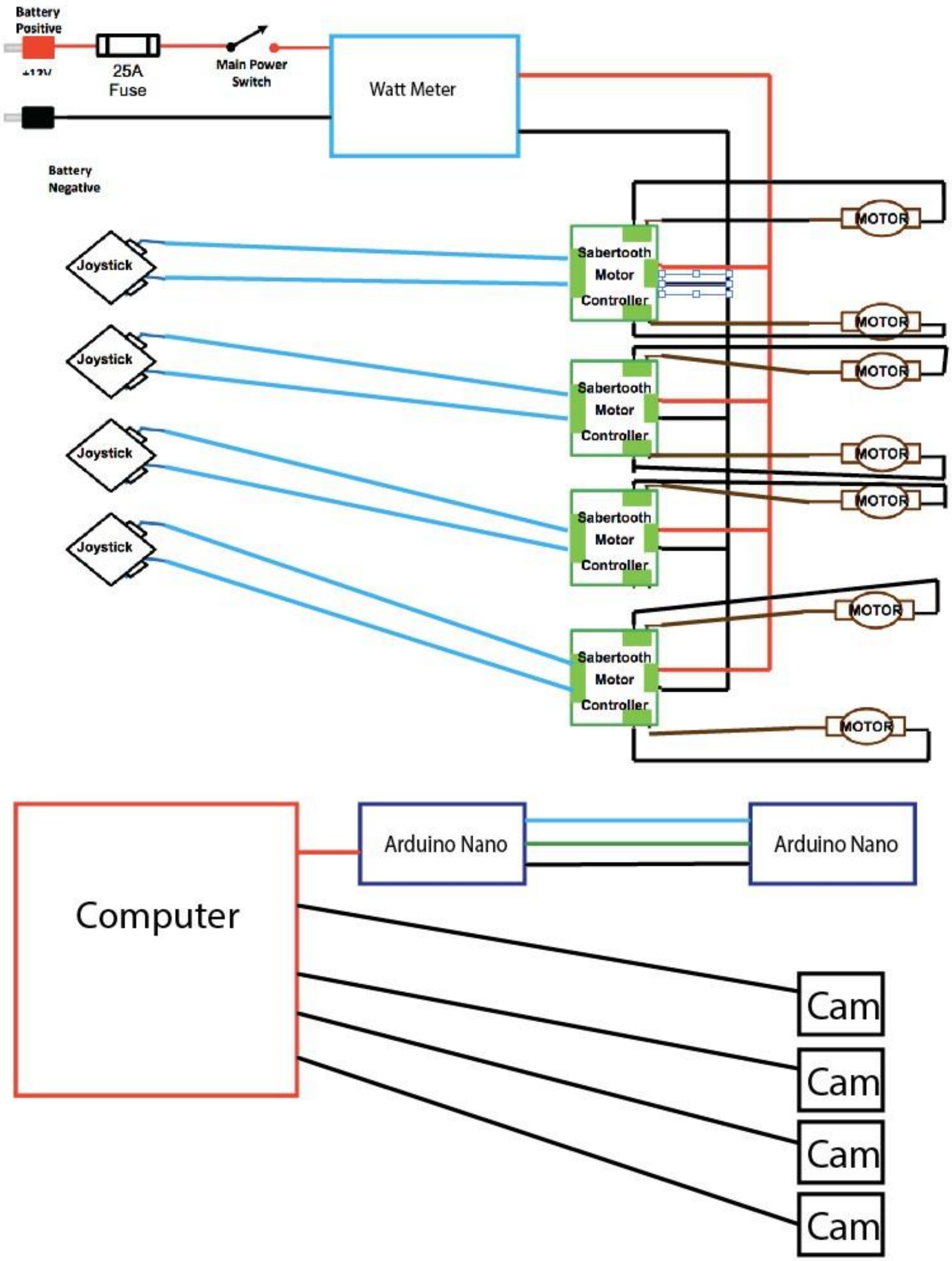
This is Panther Robotics first year of building a remotely operated vehicle and competing in the Mate ROV Challenge.

Our first ROV had to complete many tasks because it was the first dual purpose ROV competition. The ROV is designed for use in the Gulf of Mexico for oil rigs and for use in a space mission to the moon of Europa. The daunting task of designing, prototyping, optimizing, building, and final testing began in January of 2016 this gave us 4 moths to finalize our ROV and be ready for competition. Since January our goal was to research as much as possible and use our previous machining knowledge to complete the tasks set by the MATE Center. Some of the unique things our ROV can do include:

- Having 5 axis of motion which is accomplished by using custom cost-effective and innovative thrusters with maximum power and thrust to size and weight ratio.
- A detachable 15.24 meter long braided tether that includes a power Cat6 ethernet, and a custom 12 stranded cable for data. This allows for maximum flexibility and protection from abrasion.
- And a maneuverable gripper that are able to pick up and manipulate all the items and complete the tasks for the 2016 MATE missions.

2. Systems Integration Diagrams

Surface | Under Water



3. Company Information

Harrison Freedman

Company role: Chief Executive Officer, pilot

Harrison is in 9th grade at Pine Crest in Fort Lauderdale, Florida. This is his 1st year competing in the MATE ROV Competition, and as an adult he would like to be an electrical or mechanical engineer.

Wyatt Ross

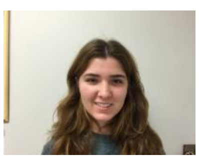
Company role: Chief Coding Officer, pilot

Wyatt is in 9th grade at Pine Crest in Fort Lauderdale, Florida. This is her 1st year participating in the MATE ROV Competition, and eventually he would like to be a software engineer.

Danielle Bejar

Company role: Chief CADing Officer, tether manager

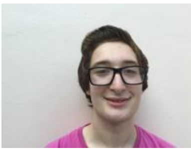
Danielle is in 10th grade at Pine Crest in Fort Lauderdale, Florida. This is her 1st year competing in the MATE ROV Competition, and eventually she would like to be an ophthalmologist. She will graduate high school in 2018, hoping to attend college at Brown University.



Jacob Zipper

Company role: Chief Business Officers

Jacob is in 11th grade at Pine Crest in Fort Lauderdale, Florida. This is his 1st year competing in the MATE ROV Competition, and eventually he would like to be either an entrepreneur or software engineer.



Brayan Delgado

Company role: Mentor

Brayan is a 25 year old engineering teacher at Pine Crest in Fort Lauderdale, Florida. He went to 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 1st time having his team compete.

4. Mission Theme

This year's missions theme is that NASA needs one ROV to accomplish multiple goals first it must travel to Europa under the ice and repair mission critical items and the second goal is that it must dive in the Gulf of Mexico seal an old oil well to transform into an artificial reef, collect oil samples, and photograph and compare the growth of coral.

These tasks are this year's theme because not only is it to reduce the cost of scientific research and action by having a multipurpose ROV but it also is teaching about preserving and saving the environment by researching the problem, solving it, then observing if the efforts were successful.

5. Safety

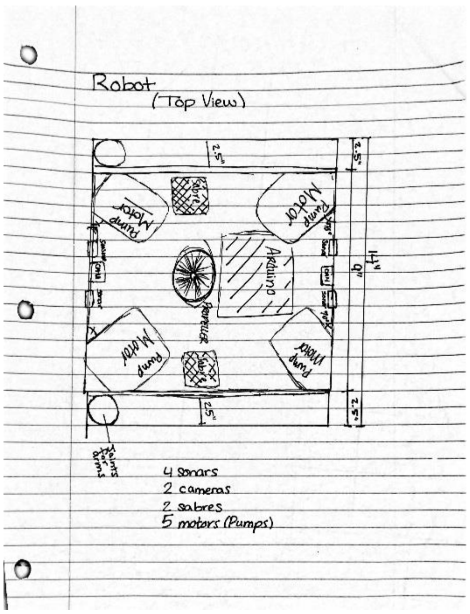
Safety is Panther Robotics number one priority second to none. We take every precaution necessary especially because we work in an environment which includes electricity within proximity to water, sharp objects, and dangerous tools. We meet all of the required safety features including: no sharp edges, a 25amp fuse within 25cm 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 workspace.

Are we wearing closed toe shoes and safety glasses?
Is there a 25 amp fuse?
Is there (do we have) a Ground Fault Circuit Interrupter (GFCI)?
Is the airlock system on the ROV? Is the port closed? Has the ROV been airlock tested?
Is the tether strain relief in place?
Are the two control boxes plugged in correctly (check labels)?
Are the two anderson plugs for power plugged in properly (red is + and black is -)
Are all the switches in the off position? (Main power)?
Is the tether/control case clamped to the table?
Is the tether plugged into the control box?

6. Design Rationale

There were many special considerations that went into the designing of a professional ROV capable of operating in multiple extreme environments. There were many physical limitations to account for. These include a small form factor and light weight to be able to travel to space. The team also had many personal goals to accomplish. One of these was to build custom waterproof container to increase size efficiency and decrease drag. Another was to have as much underwater movement and freedom as possible on the ROV.



A sketch drawn by Harrison and Wyatt depicting the original design.

6.1 Frame and Flotation

The frame of the ROV is made from laser-cut and CNC Starboard (a marine-grade version of high density polyethylene, or HDPE). Among its beneficial properties are its durability, its dimensional stability (it will retain its physical characteristics underwater), and its low density characteristic that allows it to float. The frame was designed to have useful features including a quick snap together construction with PVC, skids to protect the bottom, and cable control.

The frame was first designed in Solidworks to ensure a fast PVC snap fit construction so the pieces fit together perfectly in a rigid streamed structure. Only eight screws were needed to hold the PVC in place for its assembly, which both minimizes its weight and is anything goes wrong can easily be dismantled and inspected.

In order to ensure neutral flotation we calculated the weight of the ROV and positioned low density foam around the edges and extra foam in the front to compensate the distance our arm extends.

6.2 Waterproof Electronics Canister (WEC)

The WEC is designed to safely and neatly contain the onboard electronics. This is why we decided to manufacture a custom box to hold our electronics. and water sensitive equipment.

There are two openings in the box an entrance which is on the top and an exit which is on the front. These holes not only send and receive cables but they also serve as strain relief on the tether along with the motors and sensitive equipment. This is executed by drilling an extremely precise hole, filling the tiny gaps with epoxy, then coating it with marine grade sealant to ensure a fully watertight and flexible seal.

6.3 Thrusters

The basis of each thruster is a 12 volt bilge pump brushed motor. These motors were chosen for their high power energy ratio and their cost- effectiveness compared to similarly preforming brushless motors. In order to comply with safety regulations we 3d printed a motor holder and shroud in combination to reduce the height of our robot, protect the prop, and increase motor efficiency. The thruster assembly is mounted to the frame with snap tight PVC parts. There are six thrusters total; four for horizontal and two for vertical motion. The horizontal thrusters are positions to about 45 degrees to allow the optimal amount of forward-backward motion.

6.4 Control System and Tether

The control system we utilized included an analog output from 4 joysticks at the surface which is powered by an Arduino nano which is plugged into the computer. The 8 joystick data wires are run all the way down underwater to to the 4 sabertooth motor controllers which power the motors..

In order to read our pressure and temperature sensor we have an Arduino nano at the surface and another Arduino nano underwater which are communicating over RS232 in order to ensure clean data transmission.

The tether we use has 12 strands of copper wire that allow us to send all of our data transmission through one solid cable. We are utilizing 8 of the wires in the tether for the joysticks, then we are only using 3 more cables for the RS232 communication, RX, TX, and common ground. Also in out there we have two 14 gauge stranded wires that allow us to power all of our electronics underwater with one power and ground. Finally we run a single Cat 6 ethernet cable to send all of the video transmission over one cable. This super thin, flexible and braided design helps greatly with maneuverability and control.

6.5 Mission Specific Tooling

Manipulator: Our manipulator is used in the task of lifting the power connector, opening the door to the power connector, retrieving oil samples, and securing the well flange and cap. Our arm utilizes a simple extruded aluminum piece for easy disassembly and reassembly, and a motor that powers a simple gripper.

Temperature: We had to attach a temperature sensor to the end of the manipulator arm so we would be able to position the sensor inside a 1/2 inch venting fluid opening.

Depth Sensor: we had to attach a sonar and pressure sensor to accurately read the depth of the ROV. This is because for the mission we needed to read the depth of the ice and the water.

7. Troubleshooting

One distinctive instance of troubleshooting was during our very first design of the ROV when we were trying to epoxy PVC pipes to indents manufactured into the starboard. We quickly discovered this led to very unstable and periodically broken attachments. in order to solve this problem our first attempt was to to just add more epoxy because we figured more glue equals more hold, we were wrong. Our second and final solution was to glue a flush end cap on the end of the PVC pipe then drill a screw through the starboard and into the PVC ending to hold it securely.

In order to test to be sure each system would hopefully work flawlessly on the first try we would rapidly prototype everything in cardboard first to be sure it would work on the first time. Another more unusual form of troubleshooting was just piloting our ROV in the water. This is because as we drove the ROV more and more in the water we were able to discover minuscule handling problems that would have not been discovered other than by driving.

8. Teamwork and Organization

As there is only one builder, one coder, one CADer, and one business person on our team teamwork and organization was crucial. Organization is one of the biggest factors to the success of our team because even though we are well rounded and are able to do each others jobs it is crucial that we all stick to our strict schedule so that as a team we do not fall behind schedule. Teamwork is also a very important because it is very easy for ego to get in the way of the design process so we all have to be sure to keep our ego in check and clearly think out everybody's ideas and not let ego get in the way of the better design.

9. Project Management

As this was our first year competing in the MATE ROV competition we were forced to build the entire robot frame from scratch. Having this forced upon us helped greatly with the design process because we needed to research how to design an ROV frame. In order to accomplish this steep task is an extremely short time frame of only four months we had to utilize all of our previous knowledge from competing in FTC and tinkering in the lab, and implement it into this competition.

In order to achieve all of the complex goals we set in such a short amount of time we had to keep to a very strict schedule balancing our copious amounts of schoolwork, sports, and this competition.

10. Challenges

10.1 Technical Challenge

One challenge we faced in this competition was overcoming how to waterproof our circuits while still making them accessible. In order to overcome this we used a custom sized box that is filled with wax for insulation. in order to be able to remove the electronics with ease we wrapped them in plastic so that they would not come into contact with the wax.

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 for some slacking 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

11.1 Technical Lesson

When the competition started for our team we instantly faced daunting challenges in using tour equipment. One major tool we were unsure how to operate was our CNC machine. In order to learn this useful skill our mentor taught us all of necessary safety precautions and taught us how to CAD up our design and export it to the machine. This allowed us to fabricate our frame extremely precisely with little to no error.

11.2 Interpersonal Lesson

One very important lesson all of us learned is that everybody works at their own pace and even though we follow a strict timeline we cannot jump on each others backs to get things done as this delays the process. This is an invaluable lesson for the future because now that we have all learned this we understand how to work in groups much better and manage other peoples work without making it your own.

12. Future Improvements

As this was our first year competing we had lots to learn, now we can use our knowledge from building the ROV from this year and improve our designs greatly. Some things we would like to improve upon include a more streamlined hydrodynamic frame, faster and less amp draw motors such as brushless motors, more cameras are always useful to view what we are approaching underwater, a variable buoyancy system using compressed air, and an acrylic electronics housing to be placed underwater.

13. Company Reflections

This competing season we faced many daunting task some include having to learn to code in different variations, learning design limitations and why things will not work, and learning not to forfeit when it gets tough. When we initially designed our robot with pen and paper during class we had not taken into account all of the things we had to learn in order to execute our design nor did we look into real world limitations which were clearly looked over. For future years we are going to try to make our initial designs more realistic to allow the prototype build process go smoother.

14. Budget

As this was our teams first year ever building a robot for a MATE competition our school allowed us a strict $1000 budget to work with. On this budget we had to build a robot from scratch because we had no frame from a previous year that we could reuse and construct the mission for practice. As seen in our project costing section we ended up under budget by around $107. This will be extremely helpful in improving our robot for our future completions.

15. Project Costing

Part	Amount Spent UDS
Video Capture X4	$80
Waterproof Cable Glands X1	$4.84
Waterproof Box X1	$10
2 Function Joystick X4	$60
Transceiver Breakout - MAX3232 X2	$12
Assorted terminal crimp connections X1	$17.42
Assorted Heat Shrink Tubing X1	$8.95
8 way terminal block X1	$12.98
100 foot 14 gauge wire (Red and Black)	$38
waterproof camera X4	$48
Makeblock robotic gripper X1	$29.55
Sabertooth motor controller X4	$240
Waterproof temperature sensor X1	$10

Part	Amount Spent UDS
Pressure sensor breakout X1	$60
Toilet Wax X8	$12
100 foot 12 conductor 24 gauge wire X1	$100
Johnson 500 GPH bilge pump X6	$108
Digital Watt Meter X1	$13
Waterproof fuse holder X1	$6
Anderson Powerpole connectors X1	$21.95
Total Spent	$892.69

At this point in time we have not purchased plane tickets to Houston, Texas nor reserved hotel rooms near the space center but we expect that it will cost around $2500.

*All purchases were in Imperial units

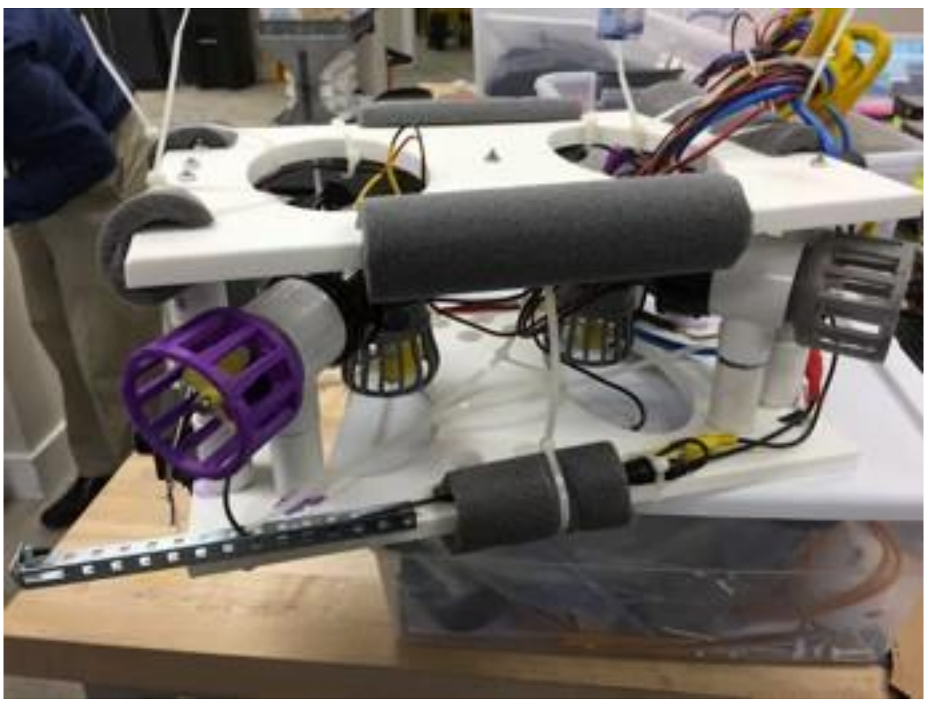


Figure 1: Completed ROV ready for competition

16. References

- Mr. Delgado, our mentor, provided helpful information and critiqued our design to make our structure better.
- Arduino.cc provides resources for practicing code
- Solidworks.com provides tutorials

17. Acknowledgements

- Zimmerman Advertising – We thank Zimmerman Advertising for continuous support funding our school's innovation program and donating to our company.
- 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.
- Matt Trask – We thank Matt Trask for being another amazing mentor who helped with many of the technical issues we faced and giving us his real world business experience.
- 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.