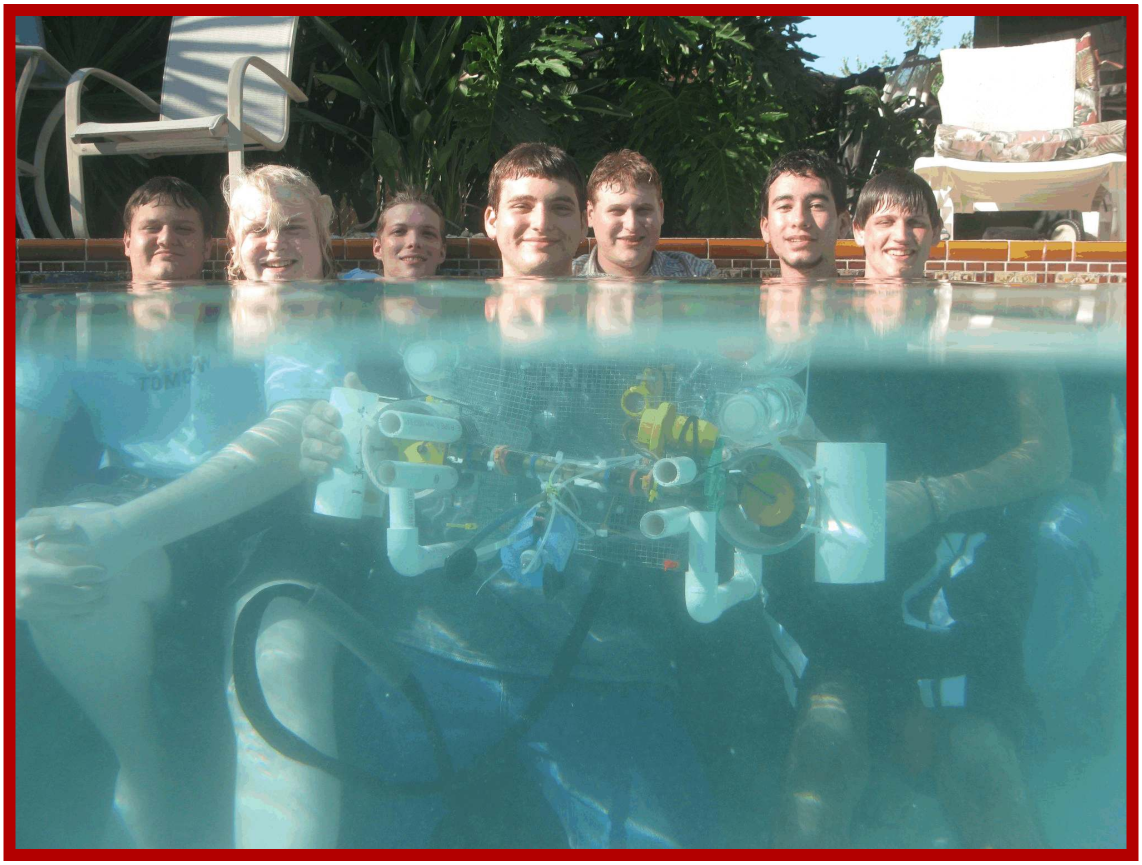
Technical Report

Ranger Class

Submitted by:

Aquatic Eagles

Edgewater High School
Orlando, FL



Caprimulgus

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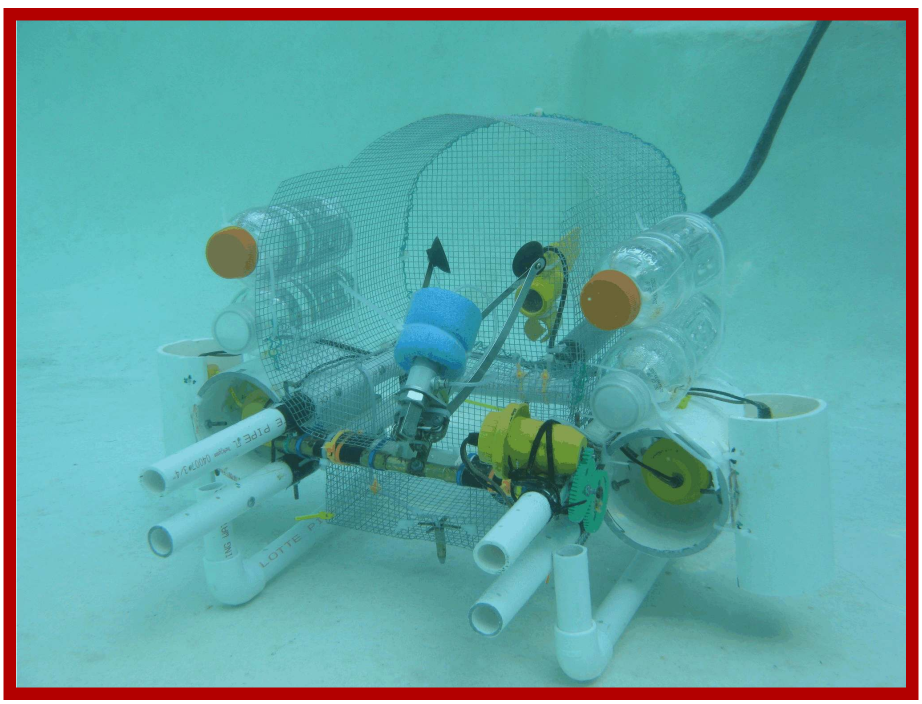
Abstract

The Aquatic Eagles' remotely operated vehicle (ROV), Caprimulgus, was designed to accomplish and exceed the 2008 MATE International ROV Competition mission requirements. The Aquatic Eagles took three factors into consideration: cost, reliability, and efficiency. The motto the Aquatic Eagles took to heart throughout this competition was "Keep it simple". This modicum was considered in all aspects of the design and construction processes.

Caprimulgus was designed not only to achieve the mission requirements, gathering living specimens, collecting geological samples, and taking thermal vent temperatures, but to accomplish them as quickly and efficiently as possible. From the start, we discussed which ROV designs would best fit each mission requirement, and decided to go with a "Garbage Truck" design for Caprimulgus. From the claw to the basket to the Gatorade bottles (for ballast), Caprimulgus was designed to be reliable, simple, and cost-efficient.

This report will outline both the development and creation of Caprimulgus and the growth of the Aquatic Eagles as individuals and as a team. The team has come far since the start of the project five months ago, working together to overcome both technical problems and interpersonal issues. This experience has helped us to gain both engineering experience and valuable lessons for the future.



Caprimulgus

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Design Rationale

A few decisions that were made before construction began should be noted here. The team decided that one size of machine screw and nut, #8-32, should be used for attaching all major components uniformly, making them smoothly interchangeable. Cost was another consideration, so we decided to use common materials wherever feasible. In addition, all major components would be compartmentalized and replaceable in under five minutes, and backups of each component would be brought along, in case damage was sustained. The team also agreed, even before designing specifics, that the ROV should be of minimal size, in order to be maneuverable in the limited area provided by the trench, and be durable enough to withstand significant abuse.

Tools:

Caprimulgus was designed initially to meet specific task requirements. The manipulation and payload systems were designed first, with all other systems subsequently designed around them. The overall design chosen was similar to that of a garbage collection truck, with a manipulator which can rotate back and drop samples into a basket. The basket would carry the samples to the surface. This would allow the ROV to obtain multiple samples at once, improving efficiency and reducing the need for repeated trips, which would be time-consuming and risky in an unstable mid-ocean ridge. The thermometer would be separate from this system.

The manipulator is comprised of a single rotating claw (Figure 1) that has a 230º tilt area, going from straight down to 50º back from vertical. The team decided that this large angle was necessary for reaching specimens in any situation and then placing the objects in the basket for transport. The claw is a Gopher Grabber®, chosen because it was the most reliable and replacable during testing. The aluminum shaft was cut down to 14cm and attached to a rectangular 1cm x 1/2cm brass bar extending 3cm past the cut, acting as a sturdy frame and attaching point for the axle. A 2.4cm pneumatic cylinder, operating on compressed air at 275,790 N/m^2, is attached to the underside of this bar, and extends outward to actuate the claw. The hollow brass axle connected to this "arm" is 1cm in diameter and connected at the far end to a gear, 5cm in diameter with 50 teeth. There is an intermediate gear of the same size connecting it to a smaller gear of only 10 teeth and a diameter of 1cm on a 1000 GPH Mayfair Marine bilge pump motor, attached on the top of the port side frame pieces. This gear ratio was chosen, given that the motor is designed for high speeds, to improve the torque of the arm. The aluminum shaft of the manipulator was

Figure 1: Rotating Manipulator System

also shortenedlater to 6cm, in order to bring the claw closer to the axle and subsequently decrease the necessary torque for lifting objects.

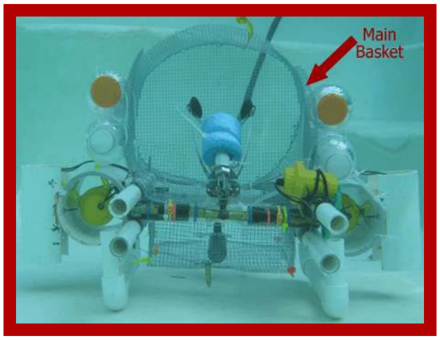


Figure 2: Main Basket

The payload system for carrying specimens and samples consists of two separate containers, one attached to the ROV and one independent. Originally, the main basket (Figure 2) was intended to be the only payload device. The material chosen was standard hardware cloth with 1/2cm squares because of its minimal weight and water resistance. It was made with a 16cm square base at the base level of the ROV with sides and back extending above the frame of the ROV to a cylinder reaching back past the rear of the vehicle, in order to hold the large crabs. After multiple trials, we decided that the basket would not reliably hold the crab specimens with extended legs, and that expanding the basket further would compromise the maneuverability and weight distribution of the ROV, so another payload basket (Figure 3) was designed. This basket, also formed from hardware cloth, is an 18cm tall cylinder, 33cm in diameter with an open top and closed bottom. A ring of insulation foam surrounds the top edge, both to counter the weight of the basket itself and to ensure that the basket would remain upright or right itself after tilting. A handle, made from a wire hanger covered in tape for visibility, forms an arch over the top of the basket and allows the ROV to grab the basket and transport it to and from the trench environment.

Figure 3: An Independent Basket for Transporting Crab Specimens

In order to accurately and quickly take a measurement of the water temperature flowing through the hydrothermal vent, the team found a thermal sensor with a high sample rate and precision, as well as a range capable of handling the temperatures that would be expected in the environment. The biggest issue was obtaining a thermometer that could be used underwater and meet all these requirements, as well as being able to send a reading up to the surface. The team finally found a refrigerator maintenance thermometer with a 3m cable and a waterproofed probe, which took a reading every second with a precision of one-tenth degree. We cut apart the cable, a standard four conductor flat jacket cable, and spliced in another 13m of similar cable. The display on the surface, operating off an individual 1.5V AA battery, sends a current down to a thermistor in the probe, reading the modified current on the surface. We chose this particular thermometer because it contained a potentiometer for calibration, since the extra 13m of wire changed the resistance. The thermometer probe was placed hanging down 3cm from the center of the bottom of the basket, in order to give the pilots maximum control of the positioning.

Frame:

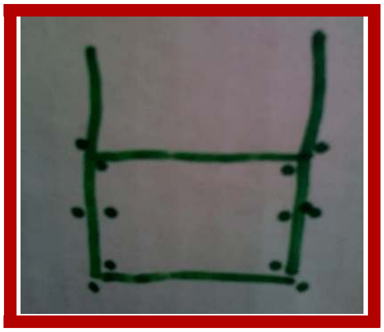


Figure 4: Frame Design, As Drawn On a Frozen Pizza Box

After we designed manipulator and payload systems, the frame was designed around them. The shape we decided upon was a box with forward extensions (Figure 4). The frame was made of PVC, because of its low cost and availability. It also has a relatively low weight and is easily cut and drilled without affecting stability. The frame is made of layered 1.8cm PVC stacked three high and jointed by long machine screws, and surrounds the base of the basket. Two bars extending forward on each side afford forward protection to the manipulator. The layering of PVC bars allowed attachment of all systems and components with ease. In addition, all components could be attached directly to the frame (Figure 5). This allowed a relatively small, centralized ROV with few extras hanging off to get caught on the environment. After the main components were attached, we found that both the bottom camera and the thermal probe extended past the lower bound of the frame. We decided, after seeing the VideoRay Scout® at regional competition, that a set of skids below the frame would be most beneficial in providing protection for the components. These two forward facing skids on the outside were made from the same 1.8cm PVC connected by 90° joints, rectangles with a height of 7.2cm and a length of 19cm.

Figure 5: Constructed Frame with Attached Horizontal Thrusters

Cameras:

The team decided that two cameras gave the best perspective without compromising the maneuverability and buoyancy of the ROV. We also found that two cameras allowed us to get a good perspective and depth perception without encumbering the ROV. The necessity of this became apparent after our first plan, which involved a single camera mounted on the claw, didn't provide depth perception and considerably changed weight balance on the front. The second camera allows for more perspective, making maneuvering the trench easier. We started with FishTV® cameras, which had many issues including weight and picture contrast. The FishTV cameras were extremely heavy, almost 2kg, due to the lead casing around the

Figure 6: Bottom Camera Tilted Downward

cameras, which changed the weight of the ROV significantly. We switched to Atlantis brand AUC-60 cameras, which were lighter, at 114g, and had infrared illumination to improve contrast. These 0.8cm CCD cameras also sport a 70º horizontal viewing angle, affording a greater viewing area than the first cameras. We placed the first Atlantis camera (Figure 6) under the ROV at the rear between the skis, facing down, to give a view for collecting crab specimens and taking temperature readings. The second camera (Figure 7) was placed in the back of the cage for navigation. This camera was important, with a wide view from the rear, because it allowed the pilot an overview of the ROV to prevent tangles and also provided a horizontal forward view for navigation. This camera is also the main view of the manipulator when it is horizontal or angled upward.

Figure 7: Forward Facing Upper Camera

Propulsion:

After deciding on camera placement the group decided on propulsion systems. Horizontal and vertical motion, along with a 360° turning ability, were deemed essential for mobility. We achieved this by placing two horizontal thrusters and two vertical thrusters around the center basket. The centralizing of the motors around the payload basket gives more control to the horizontal thrusters and makes lift easier for the vertical thrusters (Figure 8). The two forward facing horizontal thrusters provide for all forward and backward movement, as well as turning. The two vertical motors on the outside provide for ascent and descent. The thrusters are Mayfair marine bilge pumps that can pump 1000 gallons per hour. These were the highest powered waterproof motors in the region for a reasonable price. The pump casing had to be cut to turn the bilge pumps into pure motors (Figure 9). We used brass propeller shaft adapters from Octura models to adjust the motors for use with our

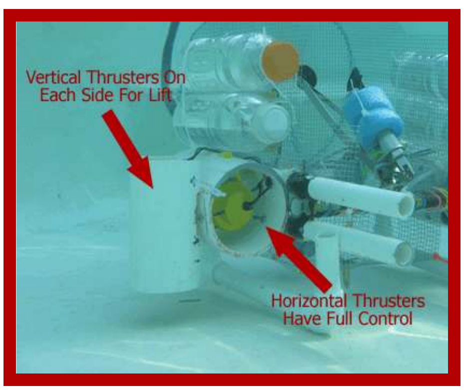


Figure 8: Motor Placement

Figure 9: Development of a Thruster from a Bilge Pump

propellers, converting a 4mm rounded shaft to 3/16" empirical threaded. The propellers are 62mm two blade plastic boat propellers from Octura Models. The propellers have a pitch of 8.676cm. At full power, one thruster pulls 5.1 Amps at 12 Volts in the water, and a simple pull test rated the force produced at 9 Newtons. Each thruster, for safety purposes, was encased in a large PVC tube, horizontal thrusters in 10.2cm PVC and vertical thrusters in 7.6cm PVC.

Buoyancy:

Initially, buoyancy was achieved through a consistently changing system of distributed pool foam, which was added or removed with changes to the ROV. After the final forms of other systems were completed, a more precise buoyancy system was deemed necessary. The ROV was weighed submerged on a standard balance and registered 1950g. In order to get neutral buoyancy, the weight of water displaced would need to be equal to the weight of the ROV, and the water's density is assumed to be approximately 1.0kg/L, the buoyant objects would have to displace almost 2.0L of water. The team agreed on using four Gatorade bottles (Figure 10), each of 591mL. The bottles were chosen due to their availability and reliability during testing. Water could be readily added to the bottles in small amounts to balance the buoyancy precisely, especially when changing between testing areas of different densities. We decided to locate the main buoyant force of the bottles centrally, since all the main components were also centralized. Two bottles were stacked on top of each other on each side of the cage, providing a more stable buoyancy system so that the ROV stays level.

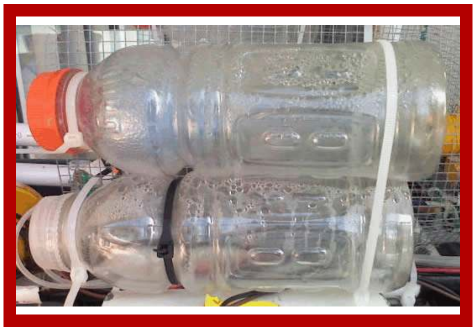


Figure 10: Buoyancy System of Stacked Gatorade Bottles

Tether:

We approached tether construction in a way that the team had previously used and believed would still work efficiently. After placing the cameras, motors, and pneumatics in their proper locations, we bundled their cables together and threaded them into a "snakeskin", which is nylon mesh that can expand and be used to protect and contain the cables from the ROV to the command center. For each of the five motors, we used 18-gauge two conductor insulated copper wire to connect each motor to the command center. These wires were chosen because their resistance is only 1/100th of an Ohm for every 15m of length. We decided to use two lines ¼in plastic tubing for claw pneumatics because the tubing works well at the relatively low 275,900N/m^2 (40 psi) without losing pressure. We chose phone cord for the thermometer because of its durability and compatibility with the input and display portions of the thermometer. One of the Atlantis brand cameras came with 38m steel mesh cable, while the other camera came with 20m steel mesh cable, which we left as is to prevent any complications with the cameras. At the control end of the tether, all cords were given plugs, so that the tether could be removed from the control system for transportation purposes. The twelve standard conductors, ten for motors and two for the thermometer, were put in one RadioShack twelve-pin power plug, and the pneumatic tubing and camera cables were left with the original plugs. The team also decided that it would be beneficial to make the tether neutrally buoyant, so we placed 15cm lengths of round, 1 cm thick insulation foam every 1.5m along the tether. The insulation foam positions were adjusted slightly by hand, making the tether close to neutrally buoyant.

Controls:

The team decided to stick with a realtively simple control system comprised of switches for each component. One cross-wired double-pole-double-throw (DPDT) center-off momentary switch controls each motor (see Appendix A), allowing the power to be reversed so that each thruster can go forward and backward and the claw can rotate either direction. When both horizontal switches are flipped up or down, the ROV moves forward or backward, respectively, and the switches can be flipped opposite each other to turn. A similar set controls the vertical thrusters. The two horizontal thruster switches are in series with a 5 Ohm, 50 Watt potentiometer, and the vertical thrusters have another. These potentiometers allow the thrusters to operate at full speed when finding the mission area and the task objects, then turn down and become more controllable when on approach, especially when inserting the thermal probe into the small vent. The motor controlling manipulator rotation uses a momentary rocker switch on a separate accessory box (see Appendix B), so that rotation can be controlled by another operator. The manipulator itself is also controlled by a separate controller, a manual pneumatic switch, so that the manipulator operator can work standing with one control in each hand. The two sets of cameras and monitors, each set drawing 2-3 Amps at 12 Volts, are powered by the system, as well. Each camera system has a built-in 3 Amp fuse, in addition to a 3Amp fuse for each in our electrical system. The entire system has an inline 25 Amp blade fuse, as per MATE requirements, and an on-off switch that can be slapped off in case of emergency.

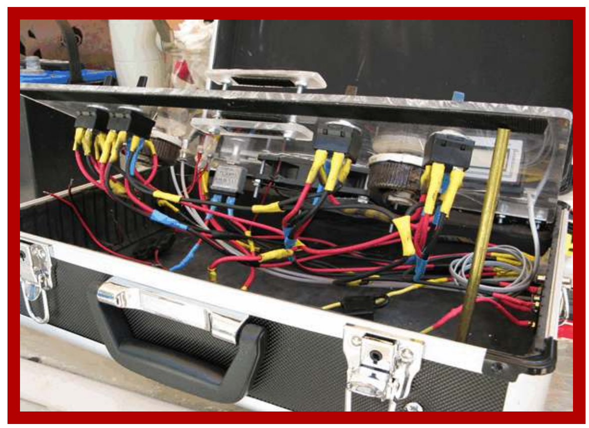


Figure 11: Underside of the Control Panel

Challenges

One of the most substantial challenges facing the Aquatic Eagles was communication. In any group there is likely to be disagreement, and we had to prepare ourselves to cope with it. We resolved to calmly and logically present our opinions and to openly listen to the ideas of others. On occasions when the team could not come to an immediate conclusion, we would use testing to decide. Each idea would be built and tested and the most reliable system would be adapted to the ROV. This allowed us to make an even better ROV, without alienating any team members.

Another challenge that we came across was organization, deciding when and where to meet. We had trouble with this because not every member could meet at the same time, so we had to work around their schedules. Because of this, not every team member was aware of changes to the ROV. To fix our problems we decided to create a set schedule and worked around the days that not all members could meet. We arranged for meetings three times weekly, along with arranged transportation and food preparation. This way, every team member could know meeting times in advance and schedule around them.

One of our technical problems was finding components for the ROV, specifically a thermometer. Since the team did not want to purchase an expensive high end thermocouple, and we did not think that waterproofing our own would be reliable, we had to find an inexpensive waterproofed thermometer. We searched a number of boating supply and pool stores, talking to managers and suppliers for possibilities. We solved the problem by looking to local pet stores. In one, we found an aquarium thermometer that fit most of our needs, which we were able to wire into our tether. Later, we found a waterproofed thermistor for a low cost at a refrigeration supply store, which the team decided was best for our goals.

Troubleshooting Techniques

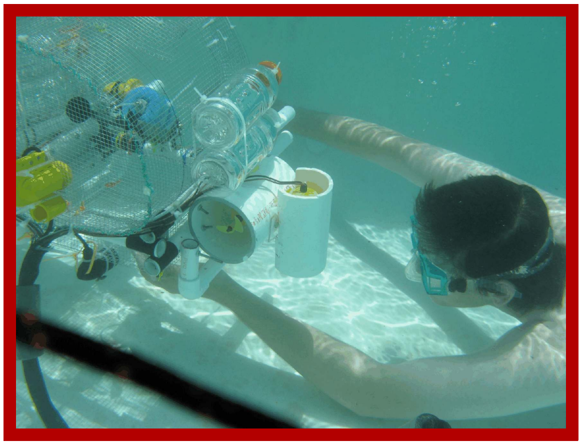


Figure 12: Team Member Works to Repair Thermometer

Throughout the construction of Caprimulgus many systems have been built, tested, improved, or scrapped to benefit the overall performance of the ROV. The primary method for figuring which systems worked best for our goals was troubleshooting. Some of the systems worked the first time they were tested, such as how the claw was able to open wide enough to pinch both rocks and crabs. Other systems weren't as straight forward. If a particular system or part was not working properly, or didn't work at all, we simply examined the part, made an educated guess as to what the problem could be, and tried to fix the 'error' that we had found. On rare occasions there would be more than one problem with one part. If this was the case, the same process was used and often resulted in much frustration, but eventually the problem would be solved.

Some problems were easy to figure out, but the solutions for these problems commonly came from several redesigns. One such example of a drastic redesign was the basket for the rocks and the crabs. The rocks would always go into the basket smoothly, without any complications whatsoever. The crabs, on the other hand, could be troublesome. Most of the attempts at gathering crabs ended up with a crab tangled in the claw, lying on top of it when it rotated back, or getting stuck in the wire mesh that the basket is made of. To solve this problem several systems were produced and altered, then were tested against each other in order to discover which was the most effective solution. One of the tested options was to put little curves of wire mesh positioned at the entrance of the basket on the ROV. This solution only stopped the crab from being pulled out of the basket, but didn’t solve the problem of crabs getting stuck on the claw. The best of all the tested solutions, a basket separate from the main body of the robot which is carried to the mission area to put crabs in and brought back up after all tasks have been completed, persevered because it didn’t get crabs stuck on its frame and saved time. Overall we put an emphasis on caution and the fact that most of our ideas didn’t work the first time.

For the competition itself, we have prepared for many kinds of emergencies. If there is any sort of problem or glitch we will: examine the area of interest, make a decision as to what went wrong and fix it by trying different things until it starts working again. In the event that a tool or system doesn’t work, replacement parts will be on hand for every aspect of the ROV, making last minute modifications and repairs simple and efficient.

Lessons Learned / Skills Gained:

The MATE competition has been more than building a ROV and making it move, although that was a lot of work. It is a learning experience, one in which everyone grew and gained new and interesting skills, which helped the ROV and the team to become more than they could have been beforehand.

One of the most important parts of the building process is communication. We all had to learn how to present our ideas and opinions logically. We put these skills into effect when trying to perform the tasks. We learned to talk between members of the team calmly and coolly, which in turn allowed us to perform the tasks in a much shorter time than previously possible. We branched out and communicated to many nearby companies, which allowed for the entire team to learn how to make corporate contacts and present our project and our team in a professional manner.

Figure 13: Team Members Learn to Work Together

Concept mapping is a very important part of building something, because without it you have no ideas upon which to build. We originally brain stormed for days on end. But when we tried to put those storms into effect we learned that storms tend to dry up. So we gathered more storms, and formed new ideas. We then implemented these new ideas and used them to build Caprimulgus. Through this, we learned how to properly map out our ideas in ways which were understandable by others.

By far the most important lesson was safety. At the start of our build, team members were always getting little nicks and scrapes, but as time and wounds progressed we thought that safety should become more of a priority. So we made sure that any dangerous tools were kept in safe locations when not in use, and that all those who used tools knew how to properly use them. When any injury would happen, and they did, we would make sure that an emergency medical kit was within a few steps of the work area. Never was a cut without a band-aid for more than thirty seconds.

Discussion of Future Improvements:

Looking back on the long road to the competition, one of the most obvious problems that the team had was time. Time turned out to be one of our greatest enemies. In the future, we plan to be far more organized and start meeting sooner in the year. Extra time will allow us to further improve next year's ROV, and increased practice will make us even more prepared for competition. We also hope to start fundraising sooner in the year to make sure we have the funds ready to construct the ROV and its associated costs.

Figure 14: Team members race against the clock making repairs before regional competition.

Another great problem the team had to overcome was acquiring funds. After our first attempts at the ROV and the many changes made over time, the team realized that our personal funds would not stretch far enough to cover the costs, and that money is difficult to come by. In the future we, plan to create an organized efficient way to share information about our ROV, by creating a website. This will help us to spread the word and more easily ask for sponsorship. We will also communicate earlier with possible sponsors, to secure funding beforehand.

Although the ROV moved sufficiently to complete all tasks, we are always seeking to improve its speed and power. Greater motor force will allow us to more quickly reach the mission area and accomplish the tasks. In the future, we will try to find more powerful motors, by searching stores outside our local range. We also hope to test a more varying group of propellers, including beryllium propellers and three bladed racing boat propellers. By testing a wider range of propellers, we can try to improve power without buying expensive motors.

Another possible improvement comes about when studying the frame. The team immediately decided to use PVC, and to stay with the original frame design. Even though this worked, and other systems were tested and changed, it might be possible that another design for the frame would work better. In the future, we would like to test different materials for the frame, including aluminum, which could make our ROV stronger. In addition, we wish to test different frame shapes before moving on to other systems. While our frame was durable and worked reliably with other systems, another shape may be even better.

ROV Tiburon at Juan de Fuca Ridge

Figure 15: ROV Tiburon (Courtesy of MBARI)

The Remotely Operated Vehicle (ROV) Tiburon, was designed and built by the Monterey Bay Aquarium Research Institute (MBARI) for deep sea scientific research to go beyond the limitations of today's standard ROVs. Since its creation the Tiburon has recorded over 400 dives which resulted in the creation of an unique exhibit at Monterey Bay Aquarium, systematic studies of several deep sea mid-ocean ridges including Hawaii, the Gulf of California, and the Juan de Fuca Ridge, several studies of deep sea ecosystems, the discovery of several new types of fish, and many other important deep sea discoveries.

Tiburon set a new dive record of 4000 meters, which made the study of deep sea environments like black smokers easier and allowed for more detailed analyses of previously unexplored, uncharted, and unreachable areas a realistic proposal. This allows for a better study of the deep sea ecosystems and the life forms that live in them. This exploration allowed Tiburon to discover new species of fish like Tiburonia granrojo, a new type of deep sea jellyfish, and several new species of deep sea squid. Tiburon also aided in a better understanding of Earth's crust and plate movement, as well as extended studies of key locations in the Atlantic.

Figure 16: Tiburon's Manipulator Collecting a Specimen (Courtesy of MBARI)

One of the Tiburon's original successes was its first expedition to the Juan de Fuca Ridge in 2000. The first expedition team consisted of several experts and interns from colleges around the United States. It was MBARI's first expedition to the Juan de Fuca Ridge and collected 137 geological samples as well as over 700 biological samples, using innovative tools like a drillsled for taking vertical rock core samples, magnetometer instruments, and wax cores for basalt glass sampling. This study led to the discovery of many previously unknown life forms, such as a new species of tubeworms. The trip was a success, bringing back many new images of black smoker vents and the ecosystems formed around them.

The Tiburon's original successes led to its continued use. Tiburon's last success was a deep sea dive to the Juan de Fuca Ridge to sample Carbon Dioxide (CO_2) levels in black smokers. These samples are leading to a better understanding of the black smoker environment and how the organisms that live in this environment survive. Tiburon dove to a depth of over

1000 meters and, as it had before and will again, collected new information about CO_2 using sensors designed specially to detect the concentration of the gas dissolved in the water around it.

These studies and discoveries have led to a greater understanding of life without 'conventional' means in black smoker environments. These environments are extremely hostile to life, with pressures exceeding 34,473,786 N/m^2, many toxic elements, and absolutely no light. Some organisms, such as sulfur-oxidizing microbes, have adapted to survive in these deep sea environments by creating renewable energy without light. Their adaptations, once understood, have many real life applications in fields like space travel, in which the ability to produce renewable energy from common chemicals will be of assistance, and human survival in hostile environments.

Figure 17: Black Smokers (Courtesy of University of Bremen)

The real-life applications of Tiburon mirror the simulated situations that our competition ROV, Caprimulgus, has to overcome. Tiburon's success brought deep sea research to a new level, just as the MATE ROV competition has raised ROV awareness to a new level. These ROVs are siblings of the sea, Tiburon and Caprimulgus. Tiburon opened the door to deep sea exploration, and we the Aquatic Eagles walked through it. Tiburon was the first unmanned vehicle to travel 4,000 meters into the sea, and it allowed for the further exploration into the field of deep sea research.

Works Cited:

- "20 Years - Designing and Building Remotely Operated Vehicle Tiburon." MBARI (Monterey Bay Aquarium Research Institute). 30 May 2008. MBARI (Monterey Bay Aquarium Research Institute). 31 May 2008 <http://www.mbari.org/twenty/Tiburon.htm>.

- MBARI Homepage. Digital image. [Picture of MBARI's ROV Tiburon Using a Drillsled to Collect Tubeworm Samples]. MBARI (Monterey Bay Aquarium Research Institute). 31 May 2008 <http://www.mbari.org/news/news_releases/2000/aug02_stakes.html>.

- "MTS Remotely Operated Vehicle ROV Committee." Marine Technology Society. 31 May 2008 <http://www.rov.org/pressreleases/jan_2005.cfm#Jan19.>.

- "Ridges 2005 Expedition." MBARI (Monterey Bay Aquarium Research Institute). 29 Aug. 2007. MBARI (Monterey Bay Aquarium Research Institute). 31 May 2008 <http://www.mbari.org/expeditions/ridges2005/august_29.htm>.

- Petrology of the Oceanic Crust. Digital image. [Image of Black Smokers]. Geosciences Department, University of Bremen. 31 May 2008 <www.geo.uni-bremen.de/Ozeankruste/main_e.htm>.

Fundraising / Community Outreach

One of the team's earliest lessons about engineering was that funding is often difficult to come by. The team was able to build the ROV for Florida Regional Competition out of the pockets of certain team members with summer jobs, but quickly realized that competing in the international competition would require numerous improvements as well as a number of costs not associated with building. Between housing and airfare for team members, team shirts for engineering presentations, and shipping the ROV to and from San Diego, the costs incurred would be far more than the construction phase of the ROV, so the team had to find considerably greater funds. The team did receive sponsorship from VideoRay, LLC as well as a number of small businesses and family friends, but we knew that it would be necessary to raise more funds to cover all costs.

One of the team's fundraising projects was a booth at a local Farmers' Market in Maitland, FL. We arranged with the City Events Coordinator to have a spot where we could set up our ROV and present to visitors about the MATE/MTS International ROV Competition, as well as our ROV and the mid-ocean ridges that we are studying. The team spent six hours at the market, presenting information and asking for donations to help with our shipping costs. While the team raised $215 in donations through the course of the day, including some from other vendors at the market, this was not the greatest gain for us. Team members used this opportunity to practice presenting and answering questions about our ROV, and had the chance to educate many people about ROV's and mid-ocean ridges. Many passersby were quite interested in what we were doing, some even stating that they wished to learn more about the ROV Competition. In addition, some visitors were engineers and researchers, including the leader of a local engineering society. These proved to be impressive contacts, who were able to help the team not only in future fundraising, but freely shared knowledge and skills with team members, which aided us in further improving our ROV and our presentation ability.

Figure 18: Team Members at the Maitland, FL Farmers' Market

The team also reached out to local news networks, hoping to improve awareness in the community and exposure of the team and the MATE competition. We received a response from Central Florida News 13, and they came and filmed a short news spot of the ROV and the team. This piece was then broadcast on the evening news and thousands saw it. The team soon received numerous messages from locals who wanted to give aid, and many close friends commented on how "they saw the robot guys on TV". This in the end allowed for the team to receive both financial and informational resources which would otherwise have been untapped.

Figure 19: A Middle School Science Class Watches the ROV Perform Tasks in an Inflatable Pool

Another of the team's projects, aimed more toward community outreach, was a series of presentations at local middle schools. The team decided that these presentations would, in the spirit of the MATE competition, interest future engineers in the underwater fields, in addition to helping the team practice. These visits allowed team members to practice publicly giving a timed presentation, as well as educate students in regard to remotely operated vehicles and mid-ocean ridges. The team set up an inflatable pool with all of the trench apparel, and gave a fifteen minute presentation to each science class period, followed by questions and a time for students to try to complete the tasks with our ROV. Many of these students were excited by the chance to pilot an "underwater robot", and one teacher commented later to our instructor that she saw students who had never been interested in engineering now considering the high school engineering magnet. The team enjoyed the opportunity to speak to young minds about engineering career fields, and to field questions of all types, many of which led to further insight and improvements to our ROV. The students piloting the ROV provided an added bonus, helping the team to discover flaws in the ROV and parts that wore down. Through this, we were able to greatly augment the durability of Caprimulgus.

Figure 20: Students Practice Piloting the ROV and Learn the Difficulty of Navigating with Only Cameras

Personal / Professional Reflections

Eddie Crouse - I learned this year that everyone has something to bring to the table and that working with groups isn't always a bad experience. Previous experience had taught me to avoid group projects due to undependable partners who shirked duties and left them for me to deal with, but this experience has been a learning experience that I have gleaned a great deal from. Overall this project has given a new understanding and tolerance for group projects, hands-on experience I would otherwise not have, and a reliable group of friends.

Seth Baklor - I think the most beneficial part of competing has been the hands-on application of ideas previously considered purely conceptual to me. While I learned how to create an electrical system in school, I learned much more here by putting one together.

Jeff Gambrell - I have learned that over 100 zip ties and 100 solders, 4 Gatorade bottles, PVC pipes of all sizes and miscellaneous parts of trash collecting utensils can be brought together to make a fully functional robot. It is truly amazing how all these different parts can come together. This has taught me to always keep an open mind while accomplishing what needs to be done.

James Douberley - One of the unexpected things I learned is that working with a team, even of very smart people, is not always easy. In the process of building the ROV, I mastered a number of new skills and found that writing a technical report is a real challenge, even when I understood all the components.

Walker Talton - This has been an eye opening experience, as far as what skills are really useful in engineering. I have learned that control system layout is just as important as anything else, so that the ROV is easier to use. I also learned that engineering takes skills like patience and calmness, when trying to fix difficult parts, just as much as electrical and mechanical skills .

Josh Katz - I've learned that everyone has to look out for the team. When one person drops the ball, everyone has to be able to pick it up for them. Though this experience has been tough, I wouldn't trade it for anything else. I now have invaluable knowledge in engineering, team building, and Mid-Ocean ridge anatomy.

Chris Burgos - I have learned a lot throughout this year with my team. I have learned all our limits and strengths. I have come to learn how to work as a team to complete a stressful and time taking job. I have learned new ways of creating solutions to a problem and how to formulate ideas as a team. This experience this year has truly been amazing and I have grown with my team to be a better person as a whole.

Budget/Expense Sheet

		Period	
School Name:	Edgewater High School	From:	1/14/2008
Instructor/Sponsor:	Mary Douberley	To:	5/28/2008

Funds

Date	Type	Description	Notes	Amount	Balance
1/14/2008	Deposit	Beginning Balance	Early Donations from Team Members and Families	$850.00	$850.00
1/16/2008	Expense	1.8cm PVC Pipe	Plastic Pipe for Frame	-$11.90	$838.10
1/16/2008	Expense	Square Brackets	Right Angle Brackets for Keeping Frame Straight	-$1.50	$836.60
1/16/2008	Expense	Machine Screws and Nuts	One Size Screws for the Whole ROV	-$2.69	$833.91
2/12/2008	Expense	1000 GPH Bilge Pumps	Bilge Pumps for Thruster and Manipulator Motors	-$98.86	$735.05
2/13/2008	Expense	Plastic Propellers	65mm Plastic Propellers from Octura Models	-$5.40	$729.65
2/21/2008	Expense	Shaft Adapters	Brass Propeller Shaft Adapter from Octura Models	-$38.50	$691.15
2/22/2008	Expense	Chicken Wire	Wire Mesh for Baskets	-$15.97	$675.18
2/22/2008	Expense	Gopher Grabber	Claw for Manipulator System	-$9.99	$665.19
2/22/2008	Expense	Pneumatic Cylinder	Cylinder To Actuate Manipulator	-$32.75	$632.44
2/24/2008	Expense	Gears	Various Sized Gears for Manipulator Rotation	-$10.00	$622.44
2/24/2008	Expense	Nylon Tape	Tape for Attaching Systems	-$2.09	$620.35
2/25/2008	Expense	X-10 Cameras	Self-Waterproofed Cameras	-$205.00	$415.35
2/28/2008	Expense	Pool Noodles	Pool Flotation for Early Buoyancy	-$3.00	$412.35
3/11/2008	Expense	75m Wire	75m of 18Awg 2-Conductor Wire for Motor Controls	-$120.00	$292.35
3/11/2008	Expense	Lead Case	Original Control Box Case	-$7.00	$285.35
3/11/2008	Expense	Momentary Switches	DPDT Momentary Switches for Motor Control	-$7.50	$277.85
3/11/2008	Expense	Potentiometers	5Ohm Potentiometers for Controlling Motor Power	-$14.50	$263.35
3/11/2008	Expense	Zip Ties	Zip Ties for Use In Construction	-$20.00	$243.35
3/12/2008	Expense	Gorilla Glue	Glue for Use in Solidifying Attachments	-$7.99	$235.36
3/12/2008	Expense	Plexiglas Plate	Plate for Control Board and Attaching Motors	-$6.50	$228.86
4/8/2008	Expense	FishTV Cameras	Commercial Cameras for Early Use	-$199.98	$28.88
4/9/2008	Expense	Thermometers	Aquarium Thermometer for Thermal Reading	-$18.00	$10.88
04/14/08	Deposit	Donation	Account Starting Donation by Seth Baklor	$200.00	$210.88
04/16/08	Deposit	Donation	Donation from Crockett Challenge Award	$200.00	$410.88
04/16/08	Deposit	Donation	Sponsorship from Maritime Reporter Magazine	$250.00	$660.88
04/25/08	Deposit	Donation	Sponsorship from Armando Fuentes, M.D.	$500.00	$1,160.88
04/24/08	Expense	Chemistry Thermometers	Another Type of Thermal Probe Tested	-$46.91	$1,113.97
04/25/08	Expense	Backup Pneumatic Cylinder	Replacement Cylinder in Case of Emergency	-$36.21	$1,077.76
04/28/08	Expense	Swimming Pool	Inflatable Pool for Presentations	-$53.49	$1,024.27
04/28/08	Expense	Backup Grabbers	Replacement Grabbers in Case of Emergency	-$21.38	$1,002.89
04/28/08	Expense	Misc. Hardware	Extra Nuts and Bolts	-$12.27	$990.62
04/28/08	Expense	Misc. Hardware	More Small Pieces for Various Purposes	-$6.30	$984.32
04/28/08	Expense	Backup Propellers	Replacement Propellers in Case of Emergency	-$2.66	$981.66
04/30/08	Expense	Wire and Snakeskin	Extended Wire for Tether and Snakeskin Cover	-$60.39	$921.27
05/01/08	Expense	Camera	Atlantis Cameras for Improved Vision	-$139.09	$782.18
05/06/08	Deposit	Donations	Needles Case Management Software and Sandy Baklor	$2,000.00	$2,782.18
05/06/08	Expense	Thermos	Final Refrigeration Maintainance Thermometers	-$65.37	$2,716.81
05/07/08	Expense	Back-Up Camera	Replacement Camera and Accessories for Emergency	-$106.99	$2,609.82
05/07/08	Expense	Thermo Accessories	Extra Phone Wire and Connectors for Thermometer	-$15.92	$2,593.90
05/09/08	Expense	Polo Shirts	Professional Shirts for Presentations	-$343.90	$2,250.00
05/12/08	Expense	Back-Up Adapters	Numerous Replacement Shaft Adapter for Emergency	-$64.40	$2,185.60
05/12/08	Expense	Pool Noodles	Newer Pool Noodles, Never Used	-$12.76	$2,172.84
05/14/08	Expense	Back-Up Motors	Replacement Motors for Emergency	-$74.53	$2,098.31
05/16/08	Expense	Home Depot	PVC for Skids and Parts for Mission Props	-$98.00	$2,000.31
05/20/08	Expense	Shirts	Team Shirts for Wear During Competition	-$416.78	$1,583.53
05/20/08	Expense	Housing Payment	Check for Housing of Team Members at UCSD	-$1,285.00	$298.53
05/21/08	Expense	Canvas Cloth	Cloth for Control Center Tent	-$27.69	$270.84
05/21/08	Expense	Scuba Tank Refill	Visual Inspection and Refill of Scuba Tank	-$19.17	$251.67
05/22/08	Expense	Banana Plugs	Extra Banana Plugs for Control System Emergency	-$8.46	$243.21
05/27/08	Deposit	Donation	Proceeds from Maitland Farmers' Market	$215.00	$458.21
05/27/08	Deposit	Donation	Donation from Friends of Seth's Parents	$50.00	$508.21
05/27/08	Expense	New Trex Gears	New Gears for Improving Claw Rotation	-$34.04	$474.17
05/27/08	Expense	Polypro Rope	Polyproplyene Rope For Tether	-$23.66	$450.51
05/01/08	Deposit	Donation	Donation from Idea Club of Orlando	$210.00	$660.51
05/28/08	Deposit	Donation	Graduation Donation from Robin Angel	$500.00	$1,160.51

Final Balance Before Shipping and Competition:	**$1,160.51**

Sponsors and Supporters

VideoRay LLC

Armando Fuentes, M.D. Maternal Fetal Center

Needles Case Management Software

Sandy Baklor

The Idea Club of Orlando

Crockett Challenge Award

Edgewater High School

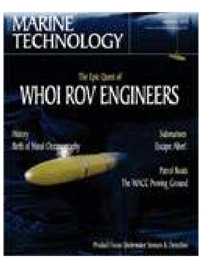
Marine Technology Reporter Magazine

Special Thanks To:

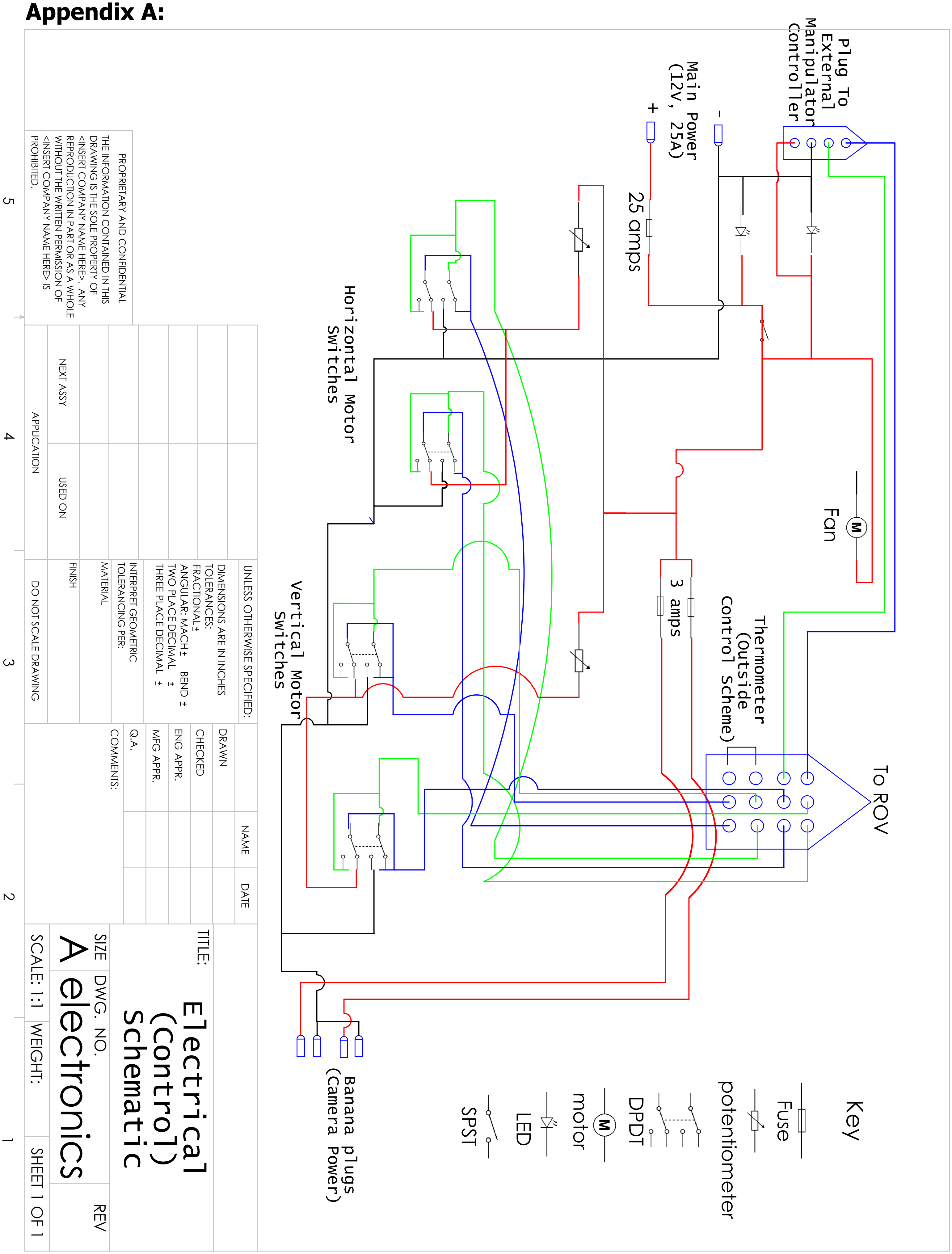
MATE Center for providing us with the opportunity, support to participate in the competition, and funding for travel expenses.

Joe and Beth Wise for mentoring us, sharing their time, their home and pool, and their support.

All of our parents, grandparents, friends and families for providing support, funds and food.



Appendix A: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Main Power (12V, 25A)
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To ROV
Banana plugs (Camera Power)
Key
Fuse
potentiometer
DPDT
motor
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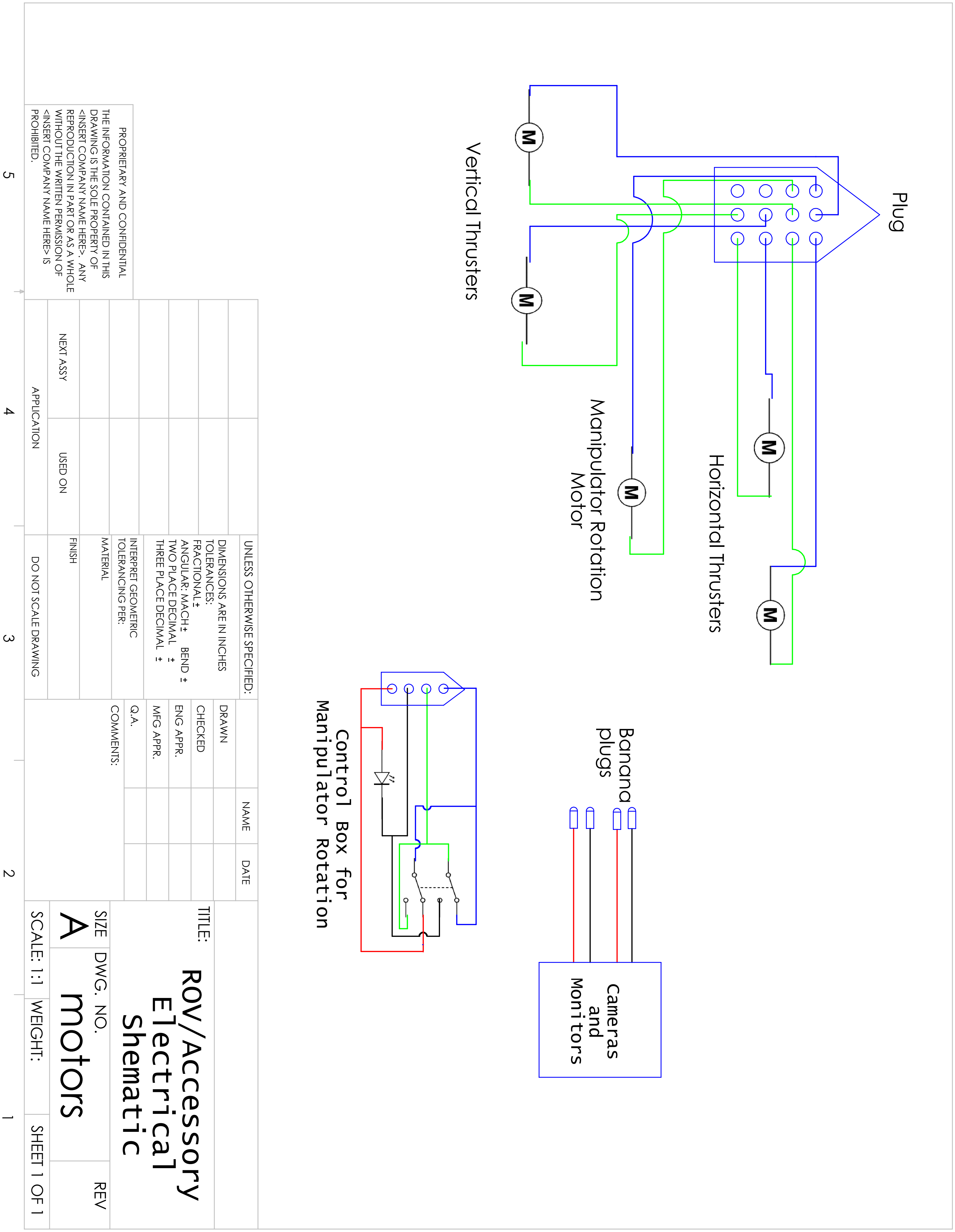
Appendix B:



Plug
Vertical Thrusters
Horizontal Thrusters
Manipulator Rotation Motor
M
Banana plugs
Cameras and Monitors
Control Box for Manipulator Rotation
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