TECHNICAL DOCUMENTATION

Team Members: Riley DeLoach and Cody Adams – Co-CEOs, Hayden Rimscha – Engineering Supervisor
Seth Monk and Noah Handley – Electronics and Wiring, Grady Jackson – Safety Supervisor
James McCord – Engineering, Marketing: Grace Jarrett, Jacob McCord, Kaitlin Cornelius, and Jackson Roberts, Mentors: Mr. Walter Handley and Mr. Billy DeLoach

URSA APEX ROBOTICS/COTTONWOOD HIGH SCHOOL, Cottonwood, Alabama

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Figure 1: Team Photo, Top Row: Mr. Handley, Hayden Rimscha, Cody Adams, Grace Jarrett, and Kaitlin Cornelius

Middle Row: Seth Monk and James McCord

*Bottom Row: Noah Handley and Grady Jackson **Not Pictured: Riley DeLoach, Jackson Roberts, and Jacob McCord*

Teamwork and Project Management

The company met on Tuesdays, Thursdays, Saturdays, and occasional Sundays while working around school and parents' schedules. Some weeks, we met nearly all week. We normally met at 5:30 to 7:30 sometimes later if needed. On Saturdays, and some Sundays we would meet all day. We planned ahead in order to make sure it was possible to meet on certain days.

First, we started by reading the manual and brainstorming possible designs in order to complete the tasks at hand. Soon enough, we began developing prototypes and testing the possible designs on obstacles we built. We divided into several groups of 2 or 3 which helped us accomplish more in less time. Dividing into groups helped us stay on task. One group developed a frame design while another group worked on the claw/hook design, another group built all the obstacles, and the last group worked on wiring.

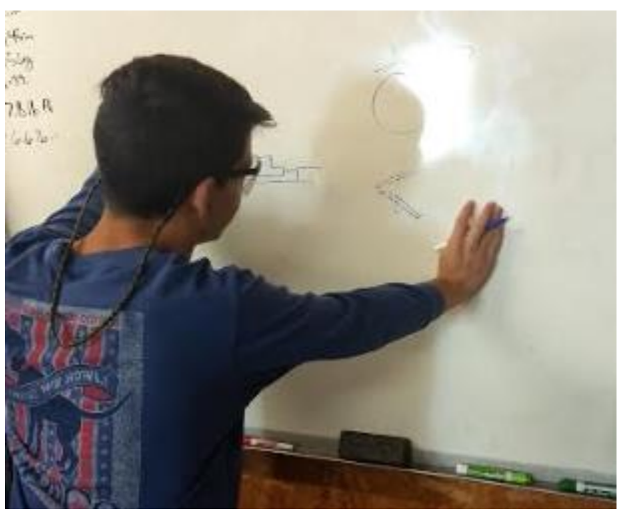

Figure 2: Riley brainstorming ideas

Design Rational

During our first meeting, we met to discuss the tasks we were presented with. We did a brief overview of the tasks to gain an understanding of what we needed to complete. After getting a general idea of the problems facing us, we went into more detail in the tasks. While diving deeper into the tasks, we started brainstorming possible solutions. We knew that we wanted a device that could accomplish multiple assignments, so we used this as a basis for our designs. Ideas were designed to be well rounded. We group brainstormed as a team and drew up ideas on a large whiteboard. Members would contribute and build off of each other's designs. When ideas were thrown up, we talked through them and the actuality of them.

There was a large amount of designs we brainstormed, but to decide which ones we would make prototypes of, we made a pros and cons list of each design. The main points of the list were: materials constructed of, ease of construction, and efficiency. A few of the designs were selected for prototyping and we started developing them in further detail.

To complete tasks such as replacing filters, removing tires, and retrieving cannons, we had multiple solutions. A fish hook, a three-prong claw, and a servo powered claw. The fish hook would be constructed of polypropylene plastic, and bolted to the ROV frame. The hook would have a barb or lip close to the tip of the hook, keeping objects from sliding off. The pilot would still be able to remove the object, but it would not fall off unless desired to be removed. This device worked well and had the potential to complete most of the tasks. The three prong claw would have one barb on the top, and two on the bottom. The two on the bottom would scoop up items, and the third would keep them in place. This would be made from aluminum rods. This device was not able to secure the items well, and was ultimately scrapped due to the ability of it to hold objects. The third device, the servo powered claw, used one claw on the bottom and two on the top. This sort of resembled a crab claw. It would be made from polypropylene plastic and powered by a servo. The top two claws would clamp down on the object that is grabbed, and hold on until the pilot releases the object. This worked well in theory, but the servo was not strong enough to clamp down on the object and keep it held. The fish hook was our clear choice for the design.

The ROV also needed to collect small pebbles and dispense them under the dam. We also had to safely relocate trout fry without gripping down on them. We wanted to make one design that could complete both of these assignments. We developed two designs, a 4” PVC pipe that held the desired objects. The objects would be held by a plastic door that would slide out when moved by a servo. The other design was a bucket or box made from plastic, that would dump the objects out by a latched door on the back. The PVC design was easier to construct then the bucket or box design, since the container portion of the device would not have to be built. The box design’s latch would also have to be reset after releasing, whereas the PVC design would not. The PVC pipe was our decided solution.

The ROV was also required to measure a large quantity of items. The ROV has to scan a dam for cracks and measure the largest crack. It is also required to measure the three different diameters of a cannon, along with the length. To measure the crack, we produced three different ideas. Our first idea was to use a ruler to measure the crack and to guesstimate when the crack was at an angle. To add onto this idea, we considered adding a servo to rotate the ruler, but the ruler would still not be able to rotate far enough. Another idea was to use two lasers with known distances between and extrapolate the length of the crack. This could also be used for measuring the cannon, but was quickly shut down when we talked about the specifics and the complications of using lasers. Our final idea was to cut a clear plastic circle with a diameter the same as the longest possible length of the crack. The circle would then have smaller circles drawn inside of it with specific diameters. This would allow the crack to measure at any angle and any length. This was the design we chose.

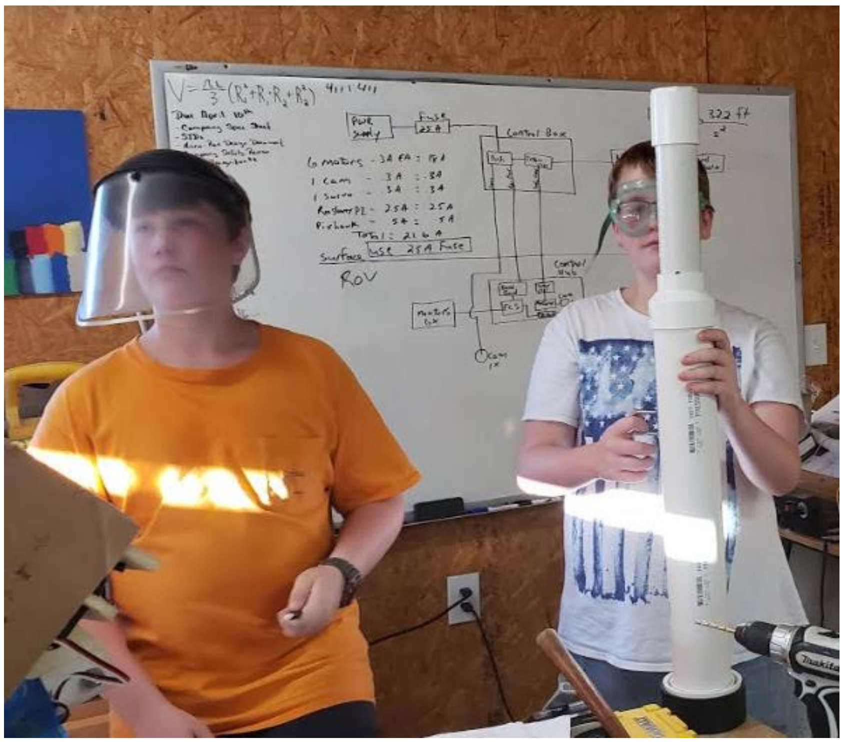

Figure 3: Grady and Cody discussing Design Options for Cannon Retrieval

To measure the diameters of the cannon, our two ideas were to use calipers or a triangle piece with measurements on the descending sides. The triangle design was chosen based on the ease of the build. When the triangle stopped inside or around the pipe, you would read the measurement on the side of the pipe. To measure the length of the cannon, we thought about a tape measure with a hook and using the lasers. Since the lasers were scrapped, our only design was the tape measure.

All of the ideas from each team member were incorporated into the designs in that ideas were built off of each other. Everyone had a part to play in the designing of the ROV. When designing the frame, we first planned out how the attachment pieces would mount. We first designed a square frame, but we since we were planning on using vectored thrusters to move side to side to scan the dam, we needed corners that would allow for easy attachment of the angled thrusters. This was an easy fix and we soon drew out an octagonal shaped frame. The thrusters could then be easily mounted straight to the corner support pieces. After competing for a couple years' prior in the MATE competition, we knew we needed to construct the frame of PVC. PVC is generally light and produces a decent amount of buoyancy and is fairly cheap.

We decided to build our frame instead of buying a new frame already built so we could design to our specifications and modify it over time. It was also much easier on the budget to build it ourselves. We had to purchase new motors because the motors from the previous years did not provide enough thrust required for the tasks. We also had the need of a new tether because our old tether could not provide enough power. We used an Xbox controller instead of a toggle switch for better mobility.

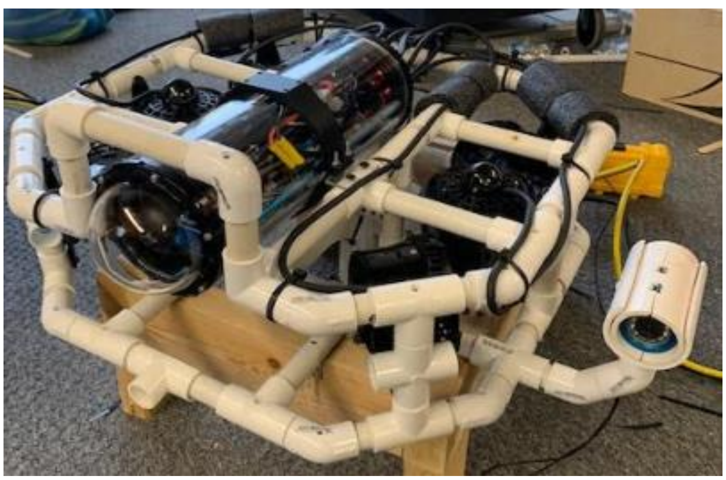

Figure 4: Early Design with Electronics

SID

The software we use to control our robot is an open source software that is provided by BLUE robotics that we can edit or program with ArduSub. The software is running on one of our laptops (Monitor) that is connected to our Tether control board located inside of the control box. Then from there the Tether control board is connected to a similar board inside of our control hub located within the ROV itself. The tether control is then connected to the raspberry pi using USB. From there the Raspberry PI connects to the main camera inside of our control hub and the Pixhawk, the Pixhawk is an autopilot that keeps the ROV stable when driving and controls our servo. For power we have a 12VDC Power supply with a 25A fuse going into the control box then to our exterior camera and our bread board, which from the bread board it then connects to the ECS, motors, and Pixhawk. We drive the ROV using an Xbox controller that is plugged into our control laptop (monitor) that the program is compatible with.

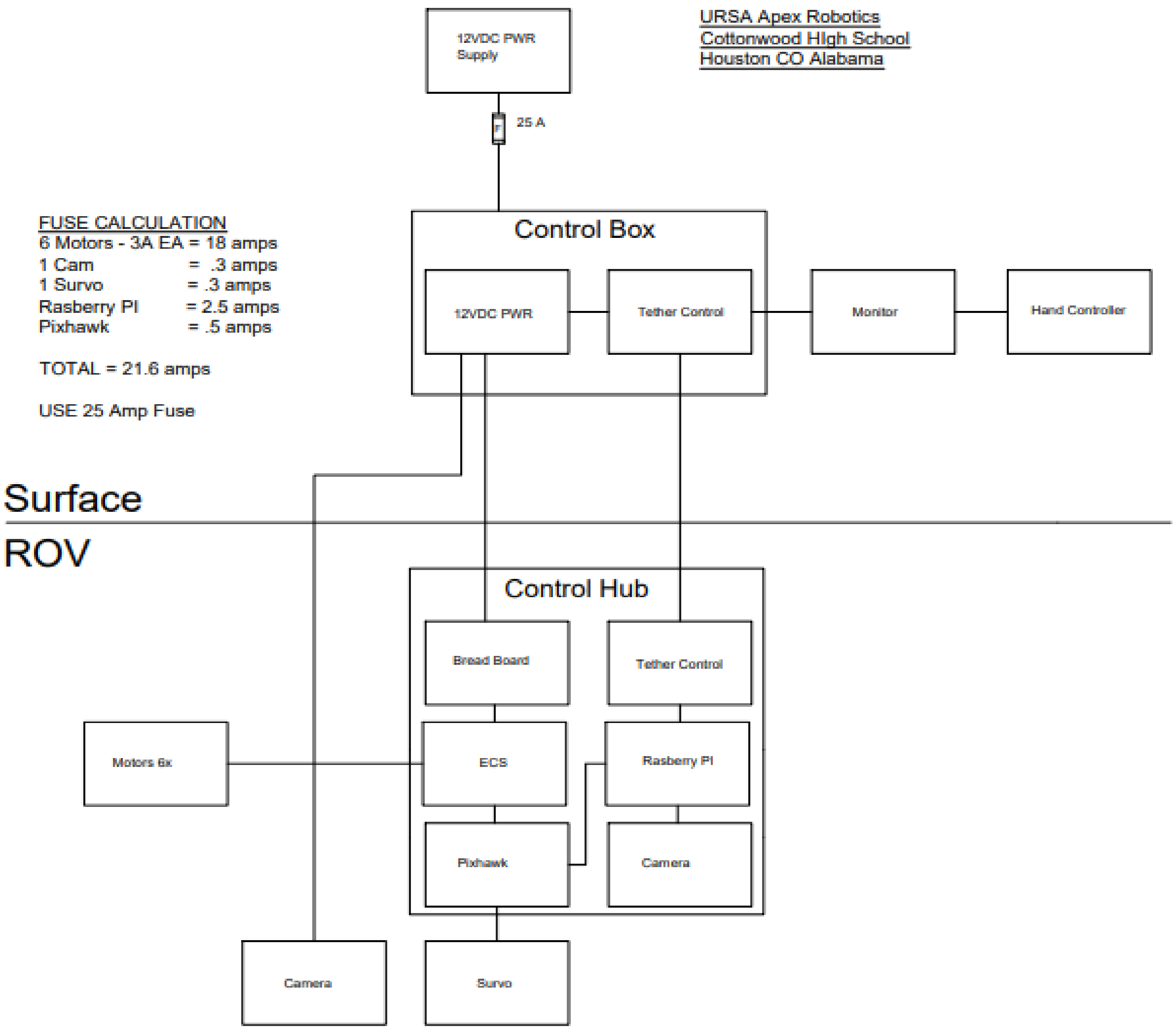
URSA Apex Robotics
Cottonwood HIgh School
Houston CO Alabama
12VDC PWR Supply
25 A
FUSE CALCULATION
6 Motors - 3A EA = 18 amps
1 Cam = .3 amps
1 Survo = .3 amps
Rasberry PI = 2.5 amps
Pixhawk = .5 amps
TOTAL = 21.6 amps
USE 25 Amp Fuse
Control Box
12VDC PWR
Tether Control
Monitor
Hand Controller
Surface
ROV
Control Hub
Bread Board
Tether Control
Motors 6x
ECS
Rasberry PI
Pixhawk
Camera
Camera
Survo

Figure 5: Seth and Hayden working on brain of the robot

Safety

Our Company's main priority when we are in the workshop is the safety of our employees. In order to maintain our safety, we are supervised by trained adults when our workers are using large machinery, we have a detailed safety briefing at the beginning of each of meeting to inform others of our safety protocols and our rules with machinery in our shop. Each employee is required to wear safety glasses to protect their eyes. Large machinery such as table saws were not allowed to be used by young members.

Our robot has its own safety measures to make sure no one is harmed while handling the robot. Sharp edges have been rounded off and taped to prevent cuts. Each of our motors were completely shrouded to prevent jamming your fingers in the motors. Hands must be completely taken off the controls before anybody is allowed to interact the robot.

Critical Analysis

To test the full ROV we reverted to trial and error techniques to figure out if the ROV could complete the required tasks. We took our different prototypes and ran them against the props they were designed to complete. We tested the new motors to check the power consumption and modified that to have them run at the right power to split the available power between the six motors by running them in a bucket of water connected to our power supply. Next was our main computer on our robot, we had to get the brain to run correctly in order to run all our programs without taking more power than needed.

We then had to design an appendage to lift heavy objects and move them to the side of the pool, we had multiple designs until we came up to the final design which was able to lift the simulated cannon and the tire and not allow them to fall off. Next was the movement, we had to make sure that our robot would float and was able to move in a straight path and turn on a dime, we had to redirect the motor direction, bend the frame straight, and add flotation devices to make the robot be neutrally buoyant. Finally, we had to make appendages to measures cracks and length, we attached a transparent circle to a piece of PVC pipe directly in front of our camera, this actually worked and was our first design. We also crafted a piece with two triangles to go over and in the cannon to measure diameter, but we settled on a measuring tape.

One significant technical challenge we had encountered was our robot was not neutrally buoyant and was more negatively buoyant. To counter it we used trial and error by slowly adding on more foam insulation to eventually make it neutrally buoyant. One significant interpersonal or organizational challenge we encountered was deciding on the frame shape, the process we used to solve this was listing the pros and cons of the different frame designs. Two designs that we were most debating on were a cube shaped and an octagonal shaped frame, the octagonal shaped frame was chosen over the cube shaped frame because we would have more room to fit future attachments, make use of the minimum size space that our ROV has to fit in, and help make our vector thrusting more efficient and effective.

Figure 6: Early Frame Design

We learned a lot this year due to the craziness of the season, we learned about the different types of programs that go into the robot brain and how to program and modify the software to our will, and power management. We also learned how to work around our problems using different strategies and figure out what idea will be used. We also developed better skills as scheduling, planning, working efficiently with one another, and getting stuff done quicker.

Future Improvements

As we attempted to complete requested tasks, we noticed our obstacle hook was touching the bottom which affected our driving. We also discovered a leak in the tube where the electronics are placed. So to fix those issues, we planned on putting stilts on the bottom of the robot so the hook didn't touch the bottom and also adding extra absorbent material to stop the leak. We can also pot the inside of the penetrators to help with preventing any leak. Positive pressure inside the tube may also work to keep water. We also talked about making the ROV out of a stronger but lighter material. We talked about putting water bottles that are filled with the right amount of water in order to keep it neutrally buoyant. Our team took a hydraulics and pneumatics quiz which enables us to use hydraulics or pneumatics. So we planned on using hydraulics to help with pumping in air to a container to help with buoyancy.

Figure 7: Noah working on waterproof housing

Accounting

As an established robotics company, we compete in land based and sea based competitions. After this year's land based competition, we were left with a starting budget of about $200 for this underwater competition. Alabama power donated about $2000. The DeLoach family donated $500. The team also sold delicious chocolate bars to help with funding. From selling these chocolate bars, the team raised about $800.

After competing at the navigator level, we decided to move up to ranger. So with competing in ranger, we had to order new quality parts. Approximately $2000 was spent on the 6 T-200 Blue Robotics thrusters and the waterproof compartment to hold all of our wiring, all the wiring, and the potting material to waterproof all the wiring. The $500 went to our brain which included a Pix Hawk, Raspberry Pi 3, and the tether control. The $200 was used for PVC to build our ROV frame and to build our props. So far, profits from the chocolate money helped with traveling expenses. Currently, we have approximately $500 in our account. Our ROV has a net-worth of about $2600.