Cape Henlopen High School – Explorer Class
C3 Robotics, Inc.

Technical Report

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2011

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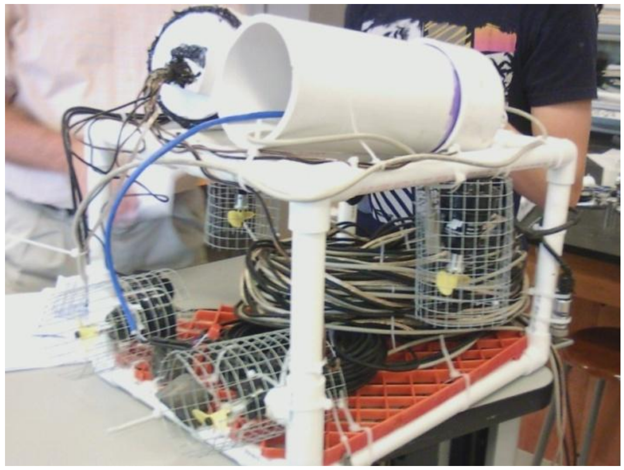

Figure 1: Complete, Intact photo of Our Robot

Abstract

A remote operated vehicle (ROV) is a tethered robot used for performing tasks in environments that would be dangerous for humans. Our ROV was built to navigate around the site of the Gulf of Mexico oil spill. Our ROV can move up, down, forward, and backwards, and turn to the right or left. It is equipped with one highly manipulative arm on its front, which clamps horizontally, and is operated by an electric motor. The arm is used in all four Tasks, because of its great versatility (See Our Mission). There are two underwater cameras on our ROV. The primary camera is mounted on the front and is used for forward motion and control of the claws; the secondary camera is mounted near the center of the ROV, facing downward, and is used for monitoring the temperature readout and other auxiliary functions. Our entire robot is operated using a Logitech controller operated by a Parallax program. Building this ROV

has taught us many lessons and the competition experience has given us some insight as to how real engineers work.

Expense Sheet

Receipts for Robotics 2010-2011				
Date	Vendor	Description	Amount	Balance
10/01/2010	N/A	Cape Henlopen School District Donation	+$1,000.00	$1,000.00
10/08/2010	N/A	The Lighthouse	+$100.00	$1,100.00
10/11/2011	N/A	Nicola Pizza	+$200.00	$1,300.00
11/02/2011	N/A	CNC Solar	+$250.00	$1,550.00
		Various Fundraising Activities	+$3,450.00	$5,000.00
11/8/2010	Scott Fraser	ROV control boards	-$250.00	$4,750.00
12/3/2010	Parallax, Inc.	Compass and Accelerometer parts	-$299.28	$4,450.72
12/14/2010	DigiKey Corporation	5705454 Kits for boards	-$687.34	$3,763.38
1/29/2011	Kelvin	Soldering practice kits	-$99.50	$3,663.88
1/30/2011	Radio Shack	Soldering Irons, Wire	-$49.90	$3,613.98
1/30/2011	Home Depot	PVC Tube cutter	-$25.96	$3,588.02
1/31/2011	PVC Fittings Direct	PVC fittings	-$52.97	$3,535.05
2/3/2011	Radio Shack	Solder, 0.032, 3 8 oz	-$29.67	$3,505.38
2/6/2011	Ace Hardware	3/4" valve stop	-$4.29	$3,501.09
2/10/2011	DigiKey Corporation	Cap .1uF 100V ceramic 399-185-1-ND	-$59.39	$3,441.70
2/10/2011	DigiKey Corporation	Cap .1uF 100V ceramic 399-185-1-ND (2nd	-$59.39	$3,382.31

		order)		
2/11/2011	DigiKey Corporation	refund for overpayment	−$88.64	$3,470.95
2/15/2011	Michaels	Felt, Pipe Cleaners, Razor Saw, Balsa for props	−$28.70	$3,442.25
2/22/2011	Ace Hardware	Fasteners	−$4.08	$3,438.17
2/23/2011	Home Depot	Speaker wire	−$16.97	$3,421.20
2/25/2011	DigiKey Corporation	Cap .1uF 100V ceramic	−$20.17	$3,401.03
2/25/2011	Wholesale Marine	Bilge Pump Motors, 500 GPH	−$191.56	$3,209.47
2/25/2011	TurnerToys	misc kit	−$53.70	$3,155.77
3/1/2011	Michaels	Balsa wood, foamboard, pins	−$29.39	$3,126.38
3/1/2011	FunRCboats.com	Octura plastic props, various for Bollard testing	−$77.77	$3,048.61
3/2/2011	Home Depot	Plastic bags, corner braces, wood glue	−$14.46	$3,034.15
3/3/2011	Ace Hardware	Fasteners	−$0.88	$3,033.27
3/10/2011	FunRCboats.com	Complete drive dogs assemblies	−$98.41	$2,934.86
3/10/2011	PVC Fittings Direct	PVC fittings	−$65.58	$2,869.28
3/18/2011	Lowe's	PVC	−$41.72	$2,827.56
3/22/2011	Lowe's	Flex coupling, PVC	−$8.93	$2,818.63
3/29/2011	Lowe's	Grip'n grab	−$20.66	$2,797.97
3/30/2011	MATE Center	Competition Fee	−$50.00	$2,747.97
4/3/2011	Home Depot	Lid, 2 gallon pail, fittings	−$14.92	$2,733.05

4/5/2011	Lowe's	Fiberglass resin, quart, PVC	-$44.23	$2,688.82
4/6/2011	Parallax, Inc.	Humidity and Pressure Sensors	-$106.51	$2,582.31
4/7/2011	Home Depot	PVC, Cement, Cat 5 Cable, Speaker wire, zip ties	-$141.16	$2,441.15
4/8/2011	Lowe's	JB Weld	-$12.08	$2,429.07
4/9/2011	Ace Hardware	U Bolts and Fasteners	-$11.21	$2,417.86
4/11/2011	PVC Fittings Direct	PVC fittings	-$62.64	$2,355.22
4/15/2011	Spytown, USA	Speco CVC321WP and CVC320WP cameras for teams	-$602.70	$1,752.52
4/18/2011	Home Depot	PVC	-$14.74	$1,737.78
4/29/2011	Home Depot	Hardware Cloth	-$15.95	$1,721.83
4/29/2011	Ace Hardware	Kero "AA" Batteries	-$21.99	$1,699.84
4/29/2011	Home Depot	PVC Cap	-$7.35	$1,692.49
4/29/2011	Lowe's	Cable ties/ round steel	-$4.70	$1,687.79
5/9/2011	Lowe's	Speaker wire, grip'n grab, heat shrink tubing, duct seal	-$84.86	$1,602.93
5/13/2011	Lowe's	Fiberglass resin, quart	-$17.04	$1,585.89
5/13/2011	SpringHill Suites	Hotels for Regionals, Norfolk VA	-$440.31	$1,145.58
5/13/2011	SpringHill Suites	Hotels for Regionals, Norfolk VA	-$440.31	$705.27

5/15/2011	Walmart	2 Marine Batteries	-$164.21	$541.06
5/15/2011	Grotto's	Pizza for practice	-$42.47	$498.59
5/17/2011	Lowe's	Fiberglass, Fiberglass Resin, 1 gallon	-$44.48	$454.11
5/18/2011	Home Depot	Great Stuff, Duct Tape	-$10.92	$443.19
5/19/2011	Walgreens	Petroleum Jelly	-$13.47	$429.72
5/20/2011	Lowe's	Rope, Brass round	-$9.43	$420.29
		Total Cost	$4,579.71	

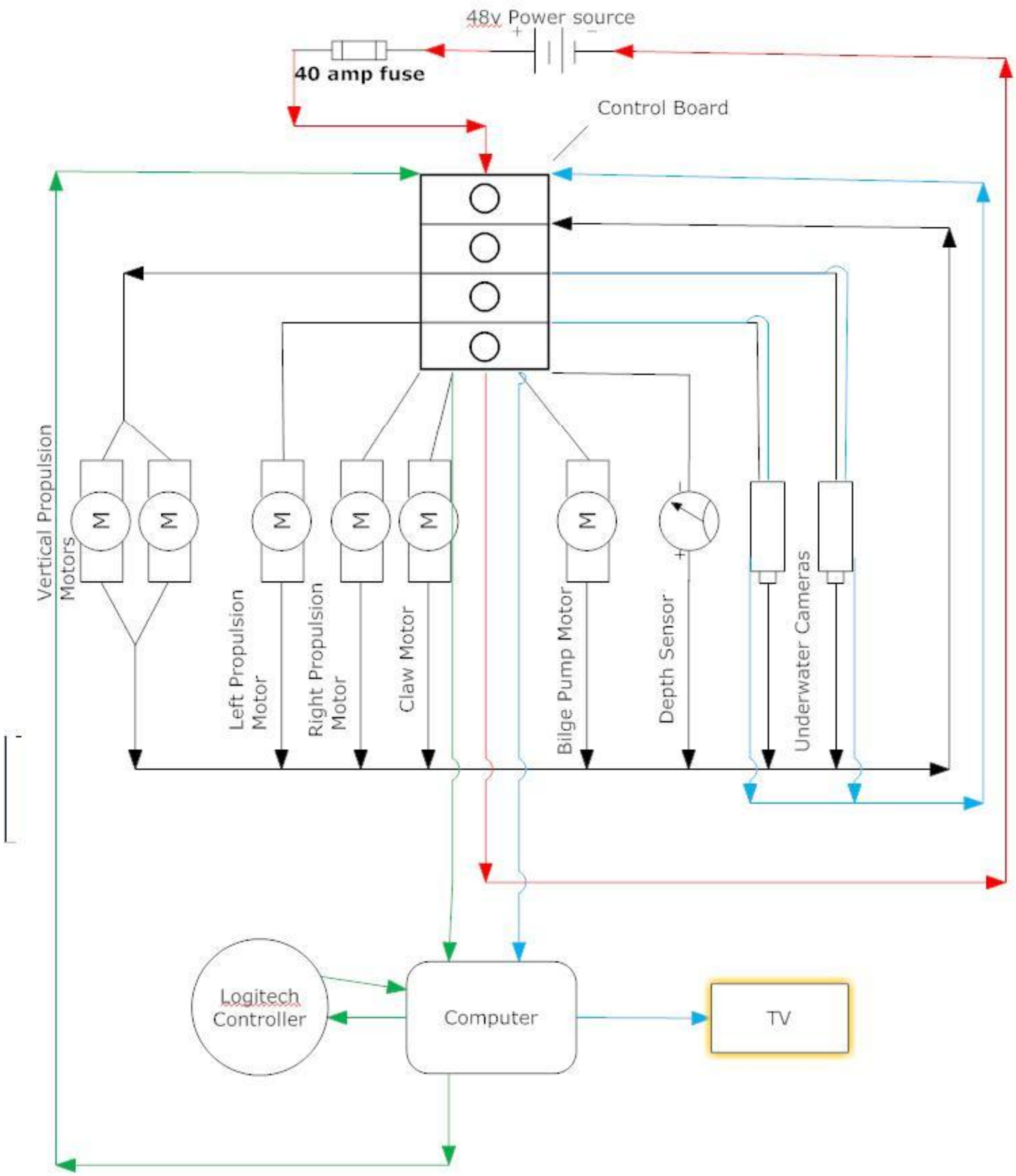

Figure 3: Electrical Schematic

Design Rationale

Structure and Buoyancy

We chose to use a rectangular prism because the simple shape allows for easy positioning and protection of payload tools. The materials we used for the frame, PVC, is a sturdy, reliable, and cost effective material that will be able to withstand the conditions of the competition. In addition, we have drilled holes in our PVC frame as an additional precaution to ensure the integrity of our frame, as it will be required to withstand the extreme pressure at the depths we will be working in. The possibility of structural failure is more likely if we left the frame pressurized, so by opting to have it fill with water, it will allowing us to work more easily with the components. For buoyancy, we have opted to use our pressurized Electronics Canister as the source of flotation in our device. The buoyant force of the Canister balances out the weight of the components of our ROV, making it neutrally buoyant. The aforementioned holes in the frame of our ROV also serve to eliminate air in the frame as another possible source of flotation. We also plan to put crab pot buoys at the top of our vehicle and a heavy weight at the front of our vehicle. Once we have completed the tasks in our mission, we will drop the heavy weight and allow our robot to float to the top of the pool.

Tether

A tether is very important to our robot because it provides electrical power and gives us control. There are several cables running through our tether. First, there is an electrical cable running to the basic stamp, which powers the motors and the pressure sensor. Next, there are two video cables that run to each of the cameras mounted on the robot. Also, we will have a wire that is connected to our basic stamp to run the manipulator.

Safety Features

Our ROV had multiple safety features implemented into its design. The first safety feature was the use of chicken wiring around our motors to prevent any objects or body parts from being caught or damaged. We also included a series of water proof warning labels near the motors and on the control panel, to alert people that the motors can be dangerous and to be cautious of the power line. Another safety feature we incorporated into our design was insulated wiring to prevent short circuiting. On the tether, there is also a 40 amp fuse integrated into the cord that precedes the batteries. The purpose of this fuse is to regulate the flow of power and prevent the robot from shorting out.

Control System

The control system utilizes a Parallax Basic Stamp Computer Control Board. Power from the 48 Volt source enters the Control Board, giving all subsequent components power. The four motors which make up the propulsion system are controlled by the Control Board, which offers connections for up to four separate motor outputs. The two rear-facing motors are each attached to a separate output. The two downward-facing motors are connected to the same output, so that they are controlled simultaneously.

The Control Board is connected to a computer via an especially long serial cable. On the computer, a program written on Basic Stamp software allows the pilot to maneuver the ROV. To do so, a Logitech USB Game Controller is connected to the computer. Simple joystick controls allow the ROV to be maneuvered easily in any direction.

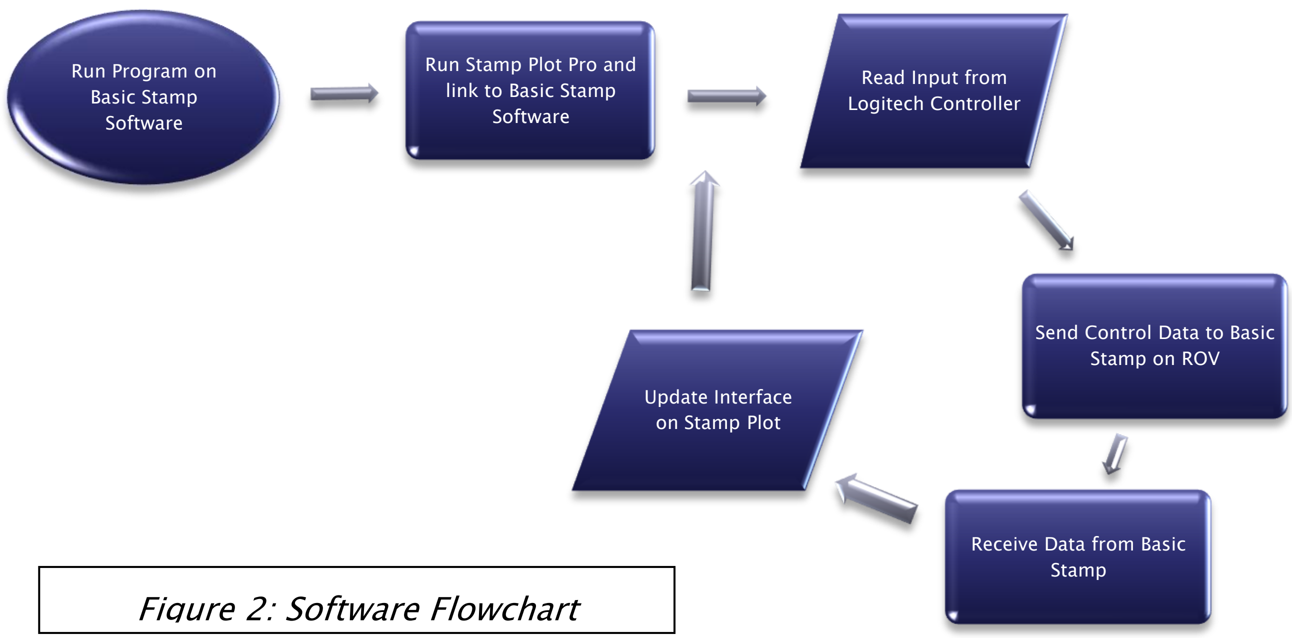

Figure 2: Software Flowchart

Challenges Faced

In building our robot, we faced many challenges. In building our ROV, we experienced several challenges. Most significantly, we had to deal with a considerable time constraint coupled with busy schedules. Nearly all of the members of our team were involved with sports and other extracurricular activities, and so it was difficult for us to consistently find adequate time to meet. To cope with this problem, we chose to have several periodic meetings in which our main purpose was to set up a schedule for the coming weeks. This helped each team member to be able to make a sound commitment to working on our ROV and to manage their personal schedules, well, so as to be able to come. The result was that we had at least half of our team at every single practice session, meaning that we were able to be productive and make progress.

Secondly, we had difficulty in creating a canister to hold our board that would one, be resistant to the pressure created about the level of depth at which our robot would operate, and two, be completely waterproof, in order to prevent our board from short circuiting. We ended up securing the board within a 5” PVC pipe, capped with a 5” PVC cap, and sealed them together using PVC cement, fiberglass, epoxy, and sealant.

Troubleshooting Techniques

While we were designing and testing our ROV, there were many problems that we came across that required troubleshooting. However we used a multi-step technique to help us solve the problem more efficiently:

a. Identify and isolate the faulty component
b. Repair or replace the part
c. Test to determine if the problem is solved

d. If the problem is not solved, try again or locate another defective component

Our team had to use troubleshooting techniques in designing our robot to overcome high incoming power of 48 volts. The original motors that we intended to use were rated for 12 volts; 48 volts would have quickly ruined these motors. To solve our problem, we decided to switch to 32 volt motors, which would handle and utilize the power better, so that we can maneuver faster underwater. This also helped to overcome the problem of depth by allowing us to raise and lower the ROV from and to the surface more quickly. To further solve our problem, we adjusted the Pulse Width Modulator on our Control Board to 60 percent capacity, thus reducing the 48 volts to 32 volts that the new motors can handle.

Payload Description

Our ROV is designed to best accomplish the four tasks for which it has been assigned. Each task has a specific tool for a specific purpose, however, many tools are able to accomplish a variety of tasks. Our company's tasks highlight the role that ROVs play in the offshore oil and gas industry and focuses on the challenges that they faced during the Gulf of Mexico oil spill,. Our mission is twofold: to restore the oil-well to its original functioning and to collect data concerning the oil spill. Our robot was built to specifically accomplish these four tasks:

Task 1: Remove the damaged riser pipe

Task 2: Cap the oil well

Task 3: Collect water samples and measure depth

To accomplish all of these things, we have four motors: these are 7571 lph bilge pump motors, mounted at the rear and middle sections of the robot for vertical and horizontal movement. Each of the rear-facing motors linked to the Basic Stamp, where they are then controlled on the surface by a programmable Logitech controller; this allows for both a wide range of motion and a stable robot.

Two cameras are mounted on the ROV. They are both commercially produced devices, specially designed for underwater use. They require only 2 lumens in order to function adequately. One of them is mounted on the front of the robot facing downward to see one of the hooks mounted near the bottom of the frame. The other is mounted just inside the frame facing forward, to be used as a gernal driving camera. The cameras are each connected to a respective one-hundred-foot video line culminating in a switch, near the control panel, that controls which camera is activated for use on our television screen at the particular time. Cameras are imperative tools because they allow excellent visibility while completing all of the tasks. The ROV has one claw which operates by an electronic switch.

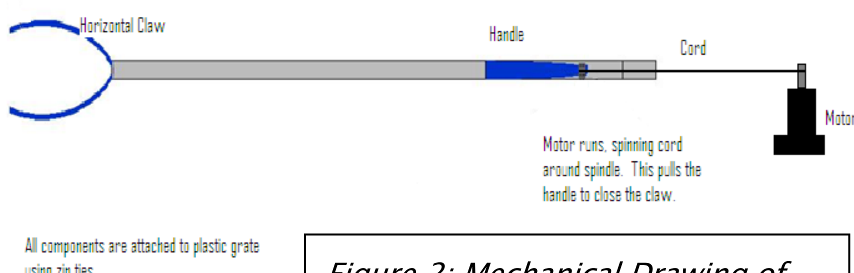

Figure 2: Mechanical Drawing of Manipulator Subsystem

The claw is a commercially produced trash-remover, with a handle at one end of the arm. This handle is pulled by a motor to close the claw. This claw is mounted on the bottom grate of the ROV using several zip-ties. Our ROV also is equipped with an electronic pressure sensor. This is used to measure the depth of the ROV. The sensor is mounted on the outer frame and is connected to the electronic control board, which then displays the measured depth on the computer screen.

The final components of our payload system are two hook-shaped pieces of steel. One hook is positioned horizontally and the other is positioned vertically, facing down. They are both mounted on the front of the ROV near the bottom. We can use these passive tools to grab on to objects and pull them when necessary. These tools serve as both primary tools for certain objectives (such as releasing the damaged riser pipe) and as secondary tools in the event that our gripper claws malfunction.

Future Improvements

There are several areas in which we feel that we would improve our ROV. The first area is that of our payload, namely relating to our gripper claw. Our current system involves a motor turning to pull a thin metal cable, thus squeezing the handle of the claw assembly. In the future, we would improve this system by using a claw that more easily and securely grips the objects that it needs to. Also, we would improve the method of closing the claw from a motor to something more controllable and user-friendly.

In the future, we would like to improve the canister used to hold and protect our Control Board. Currently, the canister is very difficult to open for modifications. Earlier, it was susceptible to frequent leaks. To prevent these leaks, we had to hastily seal the leaks. These quick seals unfortunately led to the canister being even harder to open. It is still at somewhat at risk to leaks. Thus, we would like to improve our canister to hold a more secure seal and allow easier access.

One final area in which we would like to improve our ROV is in its size. We initially designed our ROV to be fairly small, for ease of maneuverability and other reasons. However, recent modifications to the size of the Control Board Canister and payload system have shown the need for a slightly larger structure. While we are currently unable to change the size of the ROV, a future improvement would be to enlarge the structure.

Lessons Learned

During this project, our team has learned how to work together. From the beginning of the project in November, we have been working together at different capacities: first in understanding Robotics as a whole, and later in the physical building of our robot. This teamwork has given each of us a taste of how engineers work together to accomplish their goals. We've learned valuable lessons in how important it is to respect each individual's opinions, while still working toward a unified goal: creating an ROV that can best accomplish the tasks set to us.

In addition, we learned about working with underwater electricity, a difficult and dangerous task. We learned a great deal about wiring and electrical connections, particular. Additionally, we learned how to solder, a great ability to have, especially for tasks associated with robotics. As an improvement from our robot last year, we have upgraded from using basic switches to using a controller which follows computer commands.

Reflections

This ROV has been an opportunity for us to experience a real engineering task. One of the most rewarding aspects of this experience was the being able to work as a team on a real life project. We were able to gain some background knowledge on an actual project and work towards and achieve multiple goals. There were some problems along the way but we worked together to solve the problems which also allowed us to gain a better understanding of our ROV. The best part was being able to see that all our hard work and dedicated time paid off in the end.

Teamwork

The success of our ROV is largely responsible for exceptional teamwork. Without active contributions from everyone, the construction, organization, and operation of the ROV would be near impossible. Jasmin Patel and Tanya

Munyikwa were largely responsible for the organization of our project. They kept the budget in line and helped provide important information relating to the competition. Tanya and Jasmin also contributed to solving technical problems relating to the ROV. Joe Esposito, Paul Jang, and Kyle Joseph were responsible for making sure the ROV was able to complete the tasks in a quick and efficient manner. Jasmin Patel and Kyle Joseph also worked together to operate the ROV during the competition. Paul and Joe were also responsible for the creation of our electrical schematic and helped relay technical information. Kyle and Joe also served to create the mechanical schematic of the pneumatic arm sub-system.

Acknowledgements

The C^3 Robotics company would like to thank our team advisor, Mr. William Geppert for dedicating his time to help us stay organized and providing funding. Secondly, we'd like to thank the University of Delaware for providing our printed poster board. Without the MATE Center, who sponsored this event, our team would never have gained these valuable experiences, nor would we have learned these fundamentals about computer science, physics, and robotics.