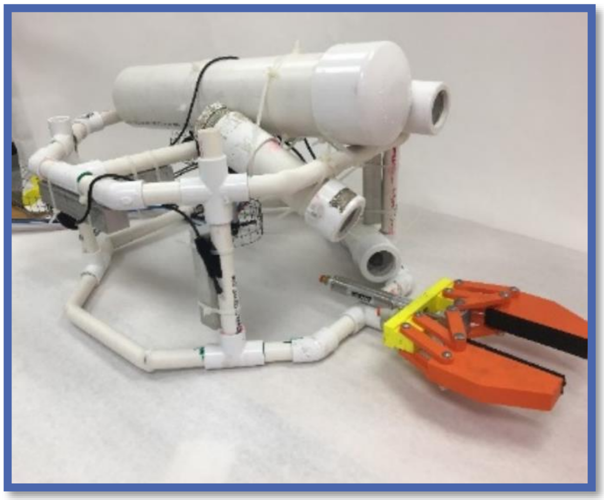
TECHNICAL DOCUMENT 2017

KNIGHTS OF POSEIDON: RANGER TEAM

Argo Community High School

7329 W 63rd St, Summit, IL 60501

ROV Name: Miracle



Mentor: Mike Cognetti

Team Member

Emily Dlugopolski	Melanie Eloiza
Grade 10	Grade 12
CEO	System Engineer

David Uraski	David Wojtkiewicz
Grade 11	Grade 11
Mechanical Engineer/ Pilot	Software Engineer

Brenda Escobedo	Daniel Herbert
Grade 12	Grade 11
Public Relations Officer	Mechanical Engineer

ABSTRACT

Knights of Poseidon, a first-year company, is composed of six members. Mr. Cognetti, our mentor, found out about this competition after one of his classes built small ROVs for a class project. Ecstatic that there was a competition specifically for building ROVs, Mr. Cognetti set up a team to participate in this competition. In four short months with a five-hundred-dollar budget, the company designed and built an ROV, The Miracle, which is capable of deep sea exploration and environment manipulation.

The Miracle is designed to be affordable yet efficient and easy to manipulate. While building our ROV, The Miracle, we kept in mind possible real-life scenarios, such as ocean exploration and environmental cleanup. The gripper on our ROV was created to interact with physical objects that are located underwater. The laser that was made is used for identifying different sediment samples when it is difficult to see them. And, if the one of the sediments is considered as hazardous, it can be removed from its location by using the tube that is place on our vehicle. In the end, we believe that that the ROV we have created can be helpful in making the ocean a clean and safe environment.

TABLE OF CONTENTS

DESIGN RATIONALE

FRAME

The first issue that came about when designing the frame was what material would best suit the requirements of a light weight and sturdy vehicle. When we first examined this problem, we found that a good place to start would be at the materials that were readily available; such as aluminum, acrylic, and polyvinyl chloride. After careful consideration, we decided on 2'' PVC pipe to create the frame of the ROV. This decision was made because the material was strong, light weight, noncorrosive in water, and easy to manipulate. The fact that we had an abundance of pipe also aided in the decision-making process.

After PVC pipe was chosen, the next step was to consider the shape of the frame. At first, we calculated the dimensions of a squared-shaped design that would fit in the 48-cm diameter size requirement. we found the length and width of the cube model to be too restricting. Soon afterwards we went back to the drawing board to find a new shape and came up with an octagonal frame instead.

Our first attempt to make the frame had 45-degree pipe fittings to insure a perfect octagon frame. Halfway through the building process, we realized that we did not have the number of connectors needed to complete the project. So, the remaining pipe was bent by hand instead of buying more fittings to save money. T-shaped fittings were still used for connecting vertical pipes that account for the height.

Another challenge presented itself after the frame was completed. We realized that the electrical housing needed more space on the frame. Due to this, the frame itself needed to be remade to accommodate the housing.

THRUSTERS

Our decision to buy the motors was based on the research that was done. During our time researching we found that the parts need to hand make the motors would cost as much as a store bought one. We also found that the time needed to make a motor would take up what little time we had. With this information, we settled on buying four 12-volt bilge pump motors.

The mounting process involved making a slit into one of the vertical pieces of pipe and inserting the stationary end of the motor. The motor was then secured by drilling two screws through both the PVC pipe and the motor. This process was done once again to produce the two horizontal thrusters that control the turning motion of the vehicle. The vertical motor was placed horizontally across the center axis by using the same mounting procedure as the stirring thrusters.

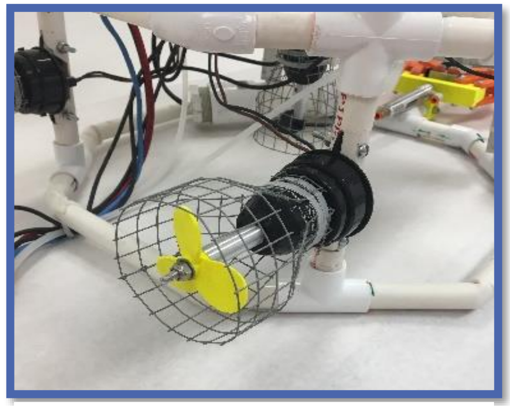


Figure 1: Thruster

To make the mounting of the propellers to the motor more secure we made a shaft adapter. The reason for this was because the shaft that is a part of the motor was too thin and short. Without the adapter, the propeller would have a greater chance of falling off. The adapter itself was made from aluminum because it is a durable and light-weight material. We were able to craft the piece by using a metal lathe machine that was readily available.

Figure 3: Shaft Adapter

After the adapters for the three thrusters were made we moved on to propeller design. By using the online website, TinkerCad, we could produce various designs with differing variables. We measured the variables of pitch, diameter, and number of blades. Each propeller was than numbered and measured for thrust given and amps used. With the information that we gathered, we could conclude that the best propeller was one with three blades, a diameter of 50 cm, a pitch angle of 23 degrees. Afterwards, we were able to print multiple copies at a low cost.

Figure 2: Propeller Prints

MANIPULATION

When discussing manipulation, we wanted the gripper to be a claw like mechanism. At first, we designed a prototype made of card board to get the idea of how pivots and rotation played a part. Later, we figured out how to produce a simulation by using an assembly on Inventor. During this time, we found that a parallel design would work better at manipulating objects underwater, since pressure would be applied at the center axis of an object.

Figure 4: Finalized Gripper Design

After the design was finalized, the fingers and linkages were 3D printed and put together by using nuts and screws. We then realized that there needed to be a base plate that connected the linkages to the frame of the ROV. We could create a design in Inventor that would able the gripper to be detachable. Then, the pneumatic cylinder was put in place in the base plate.

Figure 5: Pneumatic Cylinder Handle

The manipulator was powered by water that actuated through a tube. The tube was connected from a pneumatic, cylinder located at the ROV, to another one that was place on the surface. The cylinder that was positioned above the water was fitted with an acrylic glass handle to create a simplistic pull system.

CAMERAS

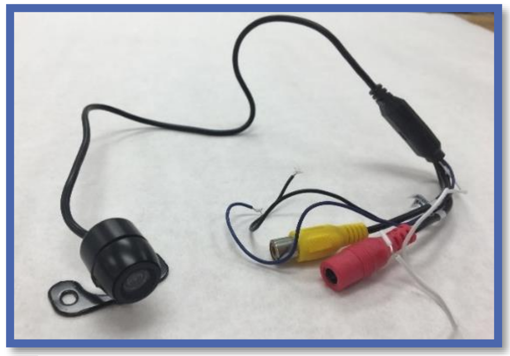


Figure 6: Wide Angle Camera

The three cameras on the ROV are wide angle cameras. We decided on these cameras due to both their 170-degree range of view, as well as their low price. The cameras out put the video to RCA cables which go to the surface, then to a multiplexor to be displayed on the monitor. The cameras were initially water resistant due to the plastic casing around the lenses. But to get the cameras ready for full under water immersion, the cameras were placed within a PVC housing with a clear acrylic front, and then sealed with silicon and epoxy.

BALLAST

In the first tests the ROV was positively buoyant, so much so that our vertical motor was not strong enough to descend into the water. This excess buoyancy was due to the air trapped in the electrical housing, as well the air within the octagonal frame of the ROV. To release the air in the frame, holes were drilled in the bottom of the four T-joints that connect the PVC pipes together. When the ROV was still too buoyant, aluminum bars were added to weigh down the ROV until it was capable of vertical movement

CONTROL SYSTEMS

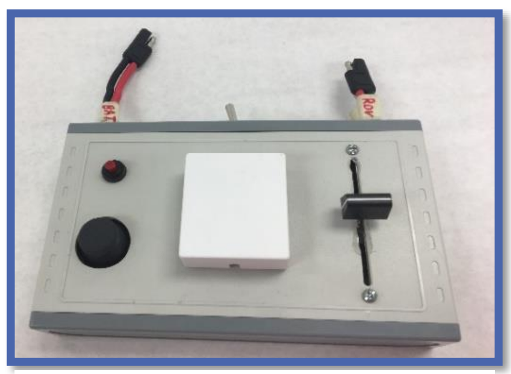
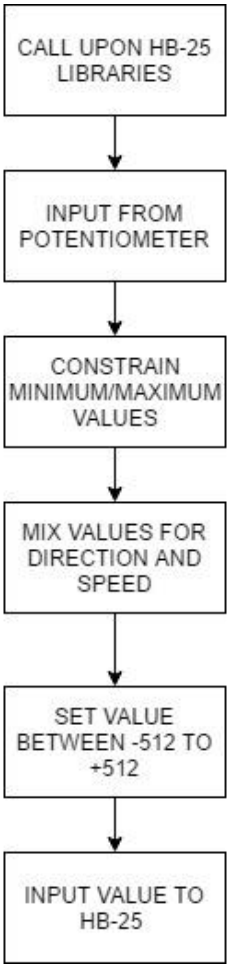


Figure 7: Control Box

The control system was designed with functionality and comfort in mind. The custom-built controller is designed to be easy to hold and is lightweight but feels sturdy. The ROV is designed to be operated by two people, one for steering the ROV and another for opening



and closing the parallel gripper. The ROV controls are designed to be simple and intuitive. The joystick is used for moving the ROV forward, backward, left, and right. The slider potentiometer directs the ROV upward, toward the surface, and downward. the handheld controller can be oriented into the most comfortable position for the user unlike a more traditional desktop setup.

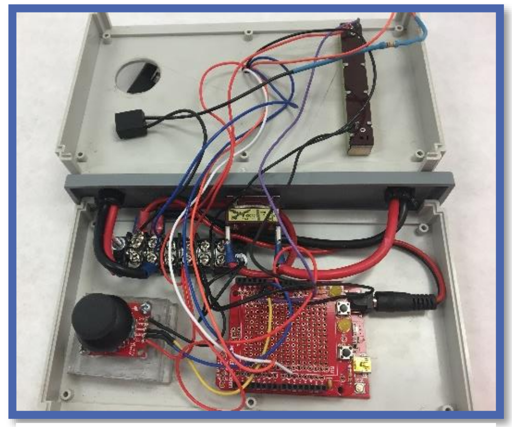


Figure 8: Inside the Control Box

The joystick and slide potentiometer feed into an Arduino inside the controller. The Arduino contains the programming required to take inputs from the controls and edit it into values the motor controller can understand. The HB-25 motor controllers can read values from -512 to +512. Positive values make the thrusters move forward and negative values will make the thrusters move backward. The value is created and given to the HB-25 motor controllers after being constrained and altered in the programming. After receiving the values, the motors will turn off or on based on the given value.

SAFETY

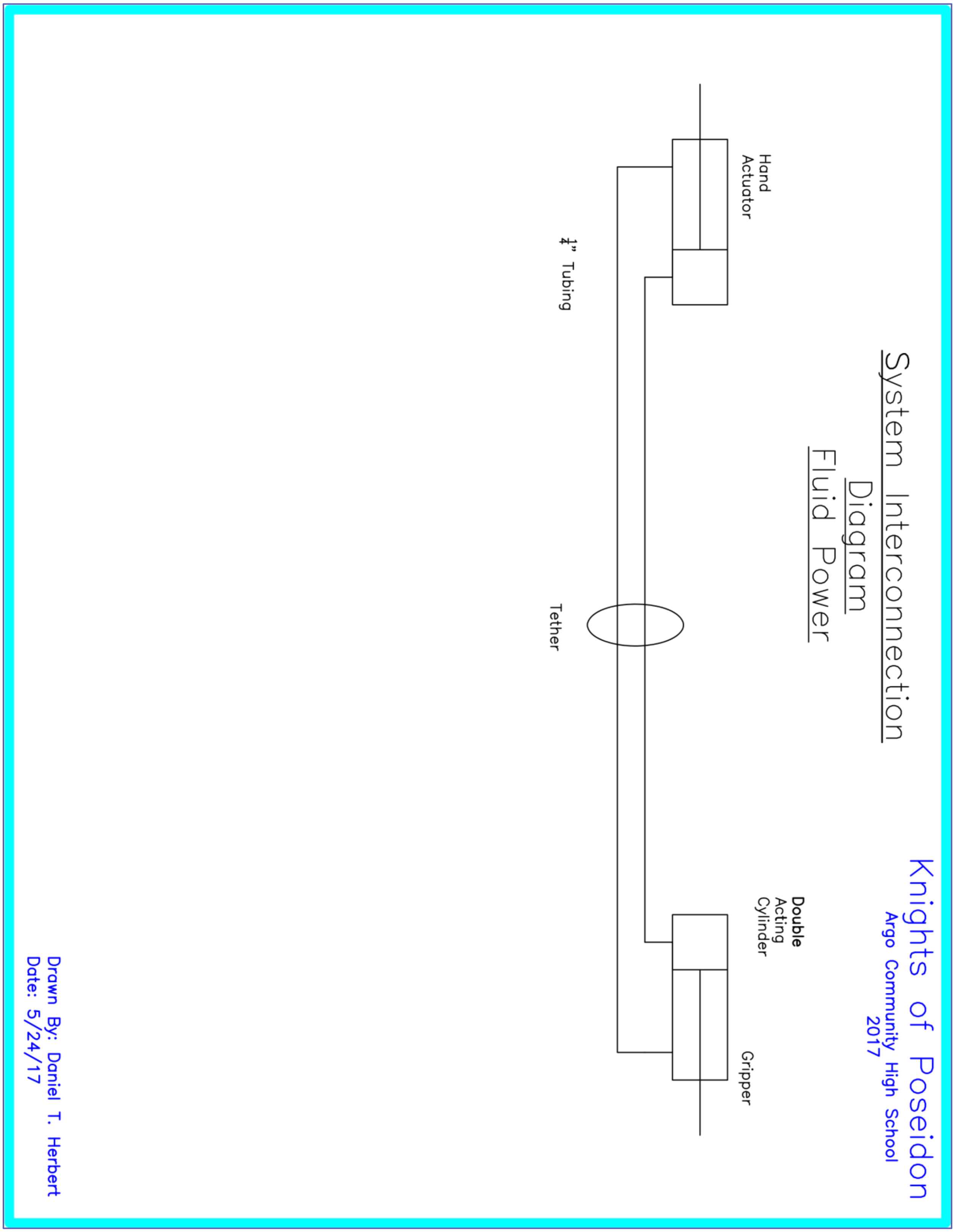
After placing the zip ties on the cameras, tether, and electrical housing we noticed the danger of having the sharp cuts from the zip ties being exposed. To eliminate this problem, we had to melt the ends to make them less of a hazard.

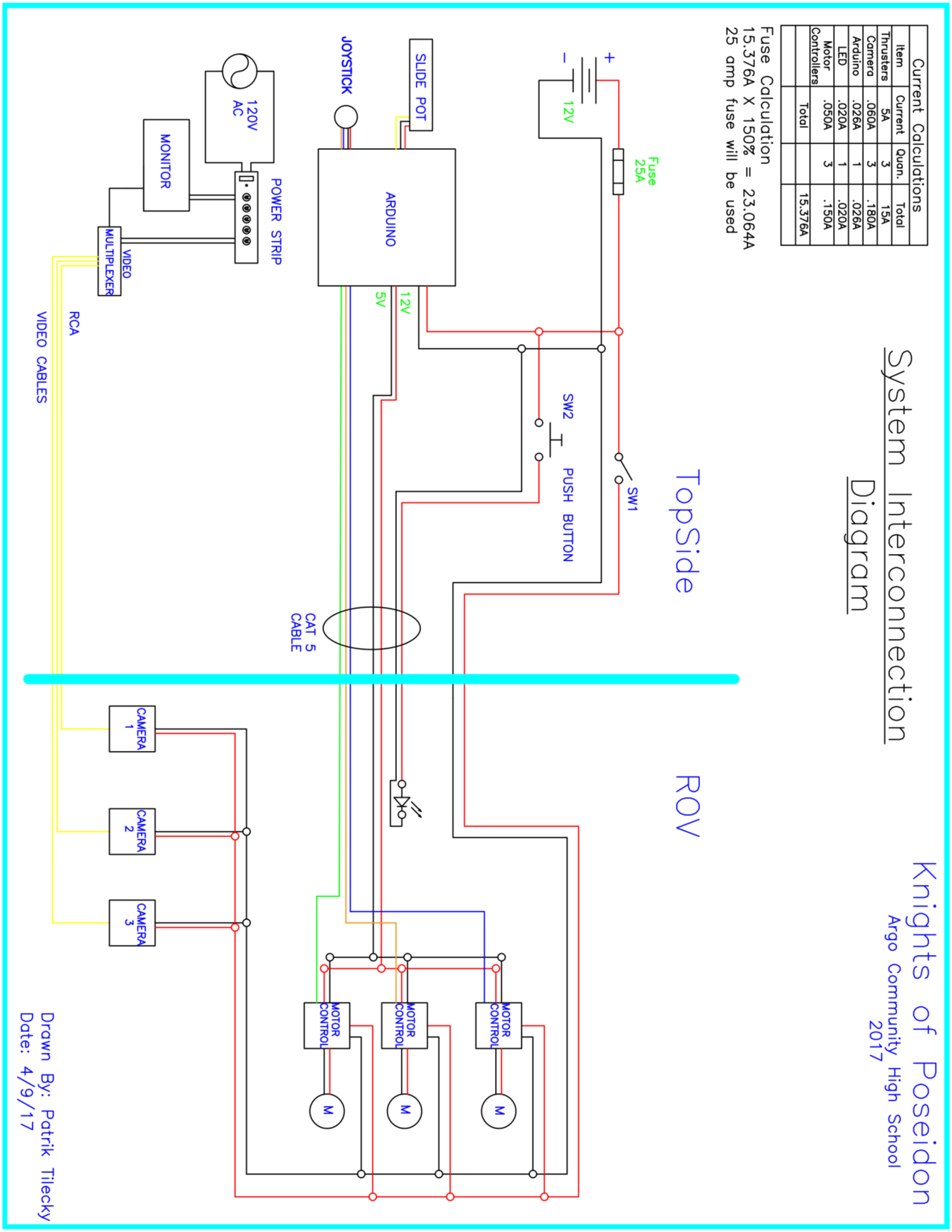
Electrical components are sealed in a waterproof PVC housing with one side glued shut and the other sealed with a plug. silicon was placed around the plug so that water does not make its way into the housing, but the plug is able to be opened if needed.

Propeller shrouds were made of hardware cloth that were shaped to surround the motor and the blades. This was done to prevent unintended objects from interacting with the propellers.

The propeller adapters are made to allow the propeller to attach to the motor without falling off. Hydraulic snaps keep the water tubes secured as well as keeping the water from leaking out. We glued the frame together since our frame is made of PVC we glued it to reduce the amount of dislocations. We opened the top of the frame to let water in to allow it to sink and drilled holes in the bottom for draining. We decided on a detachable gripper to meet the size requirement, but also to be able to change the angle of the gripper if needed. We glued one end of electrical housing shut to create a water tight seal.

On our controller, we have a safety switch to do system reboots or turn the system off in case of hazardous situations or malfunctions. There is also a removable connection to completely kill the power to the ROV.


System Interconnection Diagram
Fluid Power
Knights of Poseidon
Argo Community High School
2017
Hand Actuator
¼" Tubing
Tether
Double Acting Cylinder
Gripper
Drawn By: Daniel T. Herbert
Date: 5/24/17


System Interconnection Diagram
Current Calculations
Item | Current | Quan. | Total
Thrusters | 5A | 3 | 15A
Camera | .060A | 3 | .180A
Arduino | .026A | 1 | .026A
LED | .020A | 1 | .020A
Motor Controllers | .050A | 3 | .150A
Total | | | 15.376A
Fuse Calculation
15.376A X 150% = 23.064A
25 amp fuse will be used
+
-
12V
Fuse 25A
SLIDE POT
JOYSTICK
ARDUINO
5V
12V
120V AC
MONITOR
POWER STRIP
VIDEO MULTIPLEXER
RCA
VIDEO CABLES
SW1
SW2
PUSH BUTTON
TopSide
ROV
CAT 5 CABLE
CAMERA 1
CAMERA 2
CAMERA 3
MOTOR CONTROL
MOTOR CONTROL
MOTOR CONTROL
M
M
M
Knights of Poseidon
Argo Community High School
2017
Drawn By: Patrik Tilecky
Date: 4/9/17

MATERIALS

Donated	Constructed	Purchased
PVC Pipe	Propellers	Plug for Housing Tube
Aluminum	Shaft Adapter	Pneumatic Cylinders
Bilge Pump Motors	Gripper	Cameras
Zip Ties	Sediment Tube	
Hardware Cloth	Electrical Housing	
Outer Control Box	Controller	
Joy Stick		
Slide Potentiometer		
Wiring		
Ethernet Cable		
Motor Controllers		
Button		
LED		

BUDGET

Our ROV was built on a tight budget of $500, due to our late start and limited resources. The ROV was built primarily out of things we had at hand or what the Technology education at Argo Community High School had available. The aluminum and PVC pipe were excess from previous projects. The propeller adapters were made by team members to keep the cost low and to learn how to work the lathe and other machines that the Argo technology department let us use for the construction of ROV. The main reason that we could stay within our budget is because of the generous donations of extra parts, as well as finding things on sale or at discounted rates. Some of the material that we purchased were the T connectors, silicon, epoxy, and some wires. The three bilge pump motors donated by Mr. Cognetti saved us approximately $100. The propellers and the gripper were 3D printed with our school's 3D printer. We also received sponsorship donations that are helping fund the trip as well as extra parts that we need to make our company a success.

	Item	Quantity	Cost
Frame	PVC Pipe	140 in	$ 1.45
	PVC Fittings	21	$11.55
Thrusters	Bilge Pump Motors	3	$87.00
	Propellers	3	$ 1.75
	Shaft Adapters	3	$ 7.46
Cameras	Rear View Cameras	3	$33.00
	1-1/2" Tube	18 in	$ 0.63
	Fittings	9	$ 9.81
Gripper	Pneumatic Cylinders	2	$52.54
	Fittings	4	$10.64
Electrical	PVC Main Tube	18 in	$ 0.97
	PVC Fittings	6	$ 3.33
	Plugs	2	$ 8.47
	HB25 Motor Controllers	3	$147.00
	Terminal Strip	2	$ 1.98
Control Box	Slide Pot	1	$ 1.50
	Arduino	1	$29.00
	Switches	1	$ 2.98
	Video Multiplier	1	$29.98
	Monitor	1	$79.99
	Connectors	1	$11.06
	Enclosure	1	$ 6.95
	Joy Stick	1	$ 4.72
	Fuse Holder	1	$ 1.15
Miscellaneous	Zip Ties	50	$ 3.00
	Hardware Cloth	15 in	$ 0.60
	Epoxy	4	$15.80
	Silicon	1	$ 3.25
	Aluminum Sheet	8x12 in	$ 0.42
	Swim Noodles	10	$ 1.98

	Aluminum Blocks	3	$16.18
Tether 50'	Wire	50'	$60.00
	CAT 5 Cable	50'	$14.98
	RCA Coaxial	3@50'	$22.89
	Tubing	2@50'	$ 6.28
		Total	**$690.29**

PROJECT MANAGEMENT

Our mentor, Mr. Cognetti, discovered this competition after creating an ROV as a class project with one of our team members. The team was established at the end of January with limited resources.

	Research	**Building**	**Testing**	**Programing**	**Designing**
Week 1	4 Hours				
Week 2	4 Hours				
Week 3	5 Hours				
Week 4	3 Hours				4 Hours
Week 5	2 Hours				5 Hours
Week 6		2 Hours			5 Hours
Week 7	2 Hours	4 Hours		5 Hours	2 Hours
Week 8	1 Hour	4 Hours		3 Hours	2 Hours
Week 9	1 Hour	7 Hours		1 Hour	1 Hour
Week 10	3 Hours	5 Hours		1 Hour	
Week 11		3 Hours	3 Hours	1 Hour	
Week 12			4 Hours		

CHALLENGES

LATE START

The late start of the company meant that we could not achieve all that we set out to do. Somethings were just not able to be done in the time allowed. We worked that much harder to achieve the priorities that were expected of us. Despite this drawback, we managed to complete a functioning ROV.

FIRST YEAR

Going into this project, our company members had little to no experience with ROVs, some not even knowing what one was. This itself was a drawback of our group. The company had to spend many hours researching what can and cannot be done with such a vehicle due to the rules set in place by MATE. We spent time researching what was the most efficient design for the tasks. Research had to be a main priority of the group to achieve our desired outcome. With it being the first year our school offers this club, we had a small group of only six students in the club. Maybe if we had more students join our club and contribute to creating our ROV, the time limit we had might not have been such a challenge.

LEAKY CAMERA HOUSING

The gripper camera housing cracked, letting water in. We fixed the leak by taking the cap off the housing and then filling the housing with silicon to prevent water from getting inside the housing.

BROKEN PROPELLER

Some of our propellers broke because of either being too tightly screwed to the adapter or when adding the shafts, we weren't careful on how we put the shafts on. We printed a new propeller as a replacement

LOW BUDGET

The company was given an extraordinarily low budget of just $500. This is another hurdle that the group had to overcome. To be below budget, we used the money that we were given wisely as to not spend on things that we did not need. We prioritized items that we could not realistically make ourselves, such as cameras.

LIMITED PRACTICE

Since we had a late start, we could not get a lot of pool time at our school because of school activities, such as water polo, that reserved the pool earlier.

ACKNOWLEDGEMENTS

SPONSORS

GE Mathis

Donson Machine

Argo Senior Class Board

Brooke Melendy

Valerie and David Wojtkiewicz

Frank Capodanno

Heather Hickman

Jemery Daughtery

JusTax

Kids from room 244

Francine Blake

Jim Kantzavelos

REFERENCES

Woodford, Chris. "Propellers." *Explain That Stuff*. N.p., 30 June 2016. Web. 22 May 2017. <http://www.explainthatstuff.com/how-propellers-work.html>.

AutodeskEd. "Autodesk Inventor Beginner Tutorial: Part 1 - Modeling Tire." *YouTube*. YouTube, 04 Mar. 2014. Web. 22 May 2017. <https://www.youtube.com/watch?v =lEheFEer5Is>.

"WHAT IS ARDUINO?" *Arduino - Home*. N.p., n.d. Web. 27 May 2017. <https://www.arduino.cc/>.