SEAL INC.

Socastee High School in Myrtle Beach, South Carolina

Members:

Kyle Beale- CEO, Co- Pilot, Designer, Engineer. Graduates May 2012. Plans to attend Clemson University for Mechanical Engineering

Stephanie Hetzer- Pilot, Designer, Engineer. Graduates May 2012. Plans to attend the University of South Carolina for International Studies.

Peter Straus- CFO, Designer, Engineer. Graduates May 2012. Plans to attend the University of South Carolina for Chemistry and Education.

Christopher Hess- Designer, Engineer. Graduates May 2012. Plans to attend the University of South Carolina.

Timothy Young- Engineer. Plans to attend Naval Academy for Marine Engineering Graduates May 2013.

Michael Katalinich- Engineer, Plans to attend an undecided collage for aeronautical engineering and graduates May 2013.

Instructors: Christopher Weeks and Shannon Stone

Abstract:

ROVs, or remotely operated vehicles, are employed in the accomplishment of various underwater tasks. From monitoring ocean environments to sealing oil leaks, ROVs complete tasks in environments too dangerous and deep for human interaction. ROVs are widely used in combing shipwrecks. An ROV named Hercules surveyed the wreck of the Titanic using high definition cameras to provide documentation on the state of the Titanic not previously possible. We will build an ROV for the task of observing and testing the environment around a shipwreck. Our ROV will take measurements of the ship and map its orientation it on the sea floor. The extent of the wreck will be assessed using a magnet to determine whether the debris around the wreck is metal or non-metal. This information, plus the previously taken measurements, will be used to map the wreck. The mast of the ship needs to be brought to the surface. To do this, our ROV will first detach organisms from the hull of the ship and transplant them elsewhere. Then, our ROV can attach a lift bag to the mast and inflate it. Lastly, fuel from the wreck poses a threat to the environment and so needs to be removed from the site. An attachment on the front of our ROV will be inserted into the fuel tank of the ship, suctioning the fuel out to be brought to the surface. All of these tasks model real work that ROV’s do to clean up and monitor the condition of shipwrecks, making the environment safer for marine life.

Table of Contents

Background for 2012 MATE Mission:

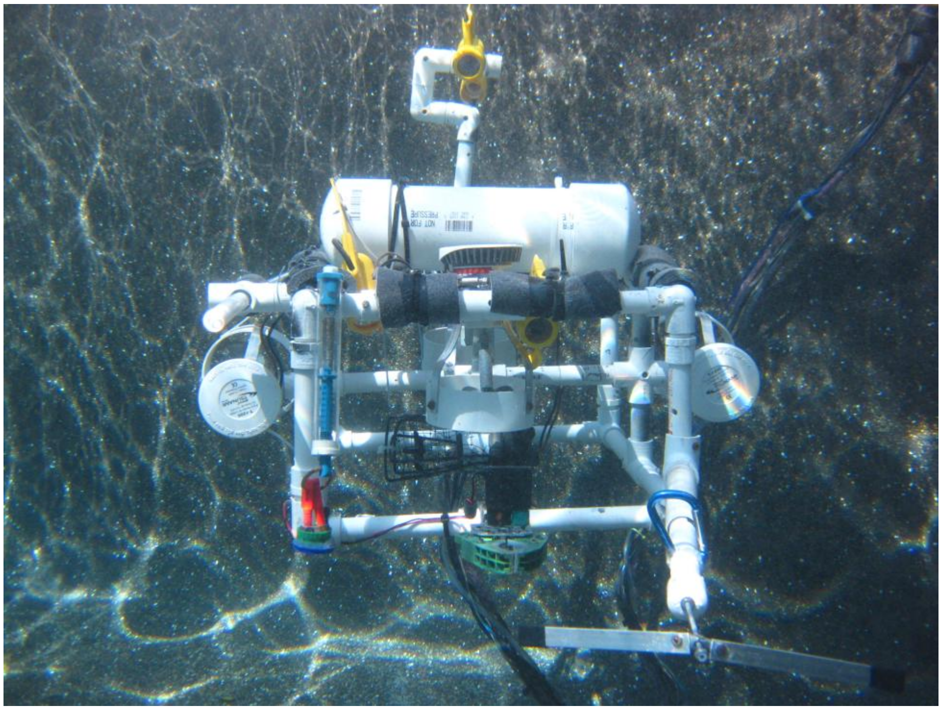
The National Oceanic and Atmospheric Administration (NOAA) of the US Federal government has estimated that there are over a million sunken wrecks in the world's oceans, seas, and major lakes. NOAA has catalogued over 30,000 of these shipwrecks. Of these, 6,300 are from World War II. These WW II wrecks are often oil-bearing, as the ships carried oil for their own propulsion or were transporting oil to fuel other vehicles in the war effort. NOAA has identified 255 shipwrecks, many sunk during WW II, in US coastal waters that it considers high risk for oil leaking.

The SS Jacob Luckenbach sunk in 1953, 17 miles west southwest of San Francisco in 180 feet of water. It was loaded with 457,000 gallons of fuel. In 2002 the US Coast Guard identified this wreck as the source of several intermittent mysterious oil spills including the Pt. Reyes Tarball Incidents of winter 1997-1998 and the San Mateo Mystery Spill of 2001-2002. In 2002 the US Coast Guard removed much of the oil and sealed the remainder in the wreck.

The SS Gardner is identified by the NOAA, US Coast Guard, and US Navy as a "high risk sunken vessel". It sits 150 meters deep 30 miles northeast of Cape Canaveral, Florida. It is one of 40 ships sunk by enemy fire off the coast of Florida during WW II. Carrying 5 million gallons of fuel oil, it was targeted, hit, and sunk by a German U-Boat on Christmas Day, 1942. Because of its relatively shallow depth, its proximity to Florida beaches and the aging, rusting hull there is great concern it could become a major ecological and socioeconomic disaster. Oil has been reported sporadically north of Cape Canaveral, although the source has not been proven.

Remotely Operated Vehicles (ROV's) have been used to locate and inspect many WWII era shipwrecks. Further refinement of ROV technology will allow inspection of shipwrecks for oil leak potential, monitoring of wrecks, and possibly drainage of oil from those wrecks. In some instances, there may even be enough oil to generate a profit in addition to preventing a disaster.

Completed ROV



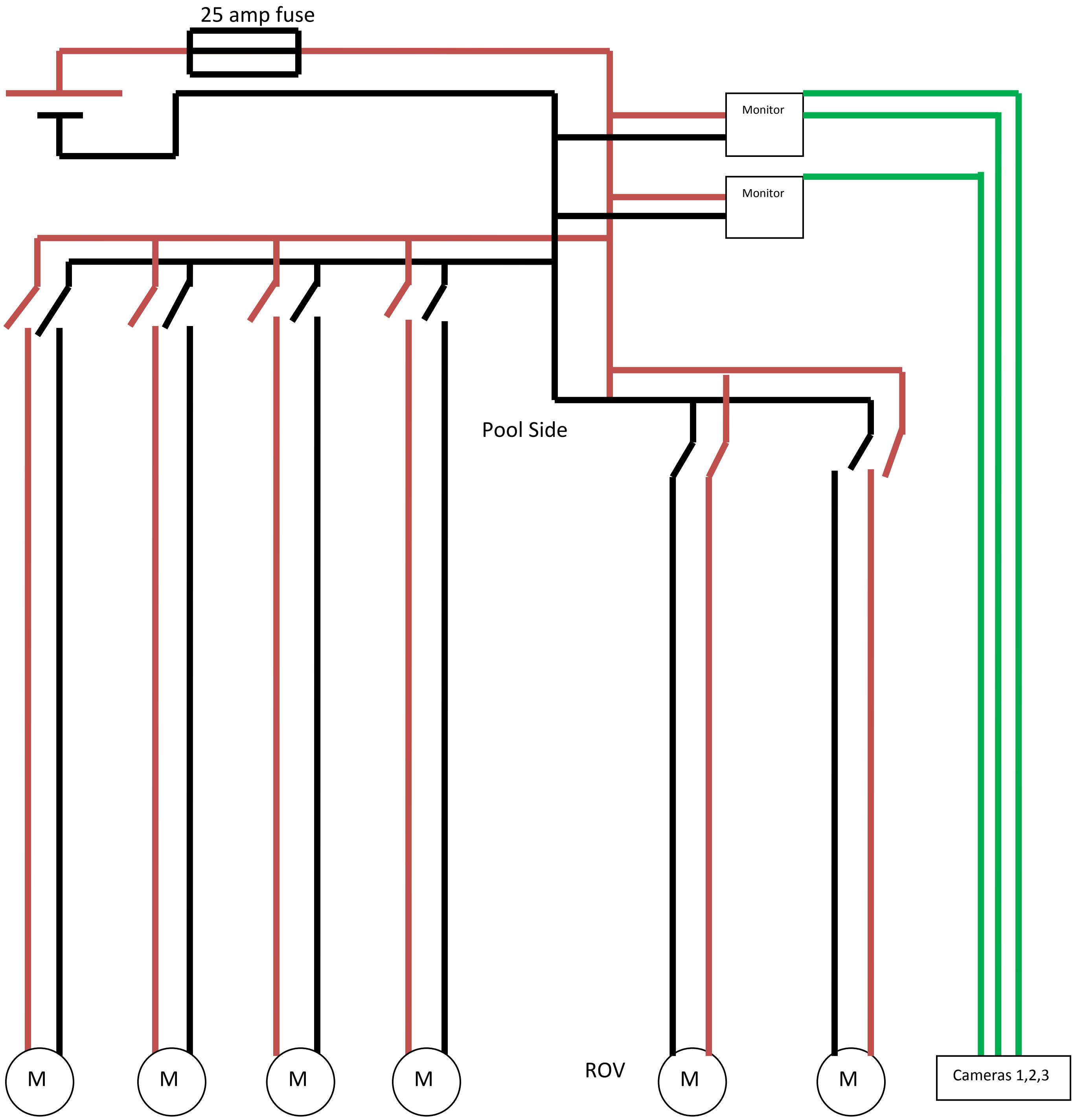
"The Sailfish"

Budget/Expense Sheet

Dates	Items	Quantity	Price per Unit	Total Price
1/23/12	Collet Prop Adapters for 3.2 Inches	4	$4.49	$17.96
1/30/12	Water Transfer Device	1	$4.99	$4.99
1/30/12	1.5 inch pvc coupling	1	$0.61	$0.61
1/30/12	3 inch x 1.5 inch pvc Coupling	4	$2.84	$11.36
1/30/12	Feet of 3/16 ID Vinyl Tubing	60	$0.21	$12.60
1/31/12	1/16 inch x 1/2 inch bolts and nuts	5	$1.03	$5.15
2/3/12	5m to 0.25 inch couplers	5	$18.00	$90.00
2/3/12	Vex Clutch	3	4.95	$14.85
2/3/12	Vex Manipulator	1	$19.99	$19.99
2/10/12	Collet Prop Adapters for 3.2 Inches	5	$4.49	$22.45
2/10/12	Vex 2- wire motor	7	$12.99	$90.93
2/11/12	Aluminum Spacers	4	$1.00	$4.00
2/27/12	3/8 inch Tubing connector	1	$2.34	$2.34
2/27/12	Compass	1	$4.99	$4.99
1/17/11	90° PVC Corner	4	$0.91	$3.64*
1/17/11	3 way PVC corner connection	8	$1.15	$9.20*
1/17/11	PVC T-joints	12	$0.57	$6.84*
1/17/11	4 way PVC cross joints	4	$1.50	$6.00*
1/17/11	½” Straight PVC by feet	11	$1.06	$11.66*
1/17/11	18 Gauge Speaker Wire 400’	1	$32.00	$32.00
1/27/11	Control Box	2	$4.50	$9.00
1/27/11	Double Pull Double Throw Switches	6	$2.00	$12.00
2005	Camera/Monitor	3	$25.00	$75.00*
	Total Cost			$355.22

*denotes donated items

Electronic Schematic



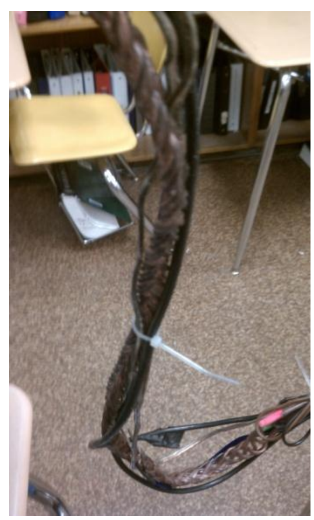
Electrical: We used a hardwire approach only because we followed Murphy's Law: What can go wrong will go wrong. We knew that troubling shooting when running live code is a lot harder then just tracing the wires to the switches. Also two years ago at the Hawaii international competition it rained at the pool and all the teams using computer software had to quickly break down their equipment, and all we had to do was put a towel over out control box with all the switches. Another reason we chose to do a hardwire approach is because we saw a team at internationals that had a software problem which caused them either to see through their cameras or drive their ROV but they couldn't do both at the same time.

Design Rationale:

Frame: ½ " PVC was chosen to construct the frame because it is a readily available material that is lightweight and inexpensive to purchase in large amounts. PVC comes in many premade corners and adapters that allow for it to easily be shaped into any form desirable. PVC is a material that is very easy to cut to different lengths, which was a big plus in choosing it as a material.

Buoyancy: Too keep our ROV neutrally buoyant we used 2; 3" diameter PVC capped segments. These segments have the ends capped to keep trapped air in them this will provide the positive buoyancy for the ROV. To balance that out we have placed washers inside the bottom pieces of PVC to add negative buoyancy. By trial and error we found the correct amount of washers needed and the correct placement of them to allow the ROV to sit level in the water. PVC is a very strong material so we knew we wouldn't have any problems with compression at competition depths.

Tether: Speaker wire was used for our tether because different gauges are readily available, which allowed us to control the power flow to each of our motors. We used 18 gauge wire because it was thinner than 16 gauge wire which made our tether a neater and more manageable size, and it gave us more pounds of thrust than 20 gauge wire (which only gives 1 pound of thrust over a 100ft tether). The speaker wire was also chosen because we could purchase it at a very low price compared to other wiring. The tether consists of a braid of the four wires leading to the four main

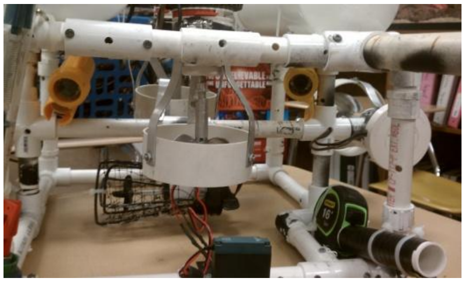


bilge pumps, three camera wires, and one wire for the lateral thruster, and one for the manipulator.

Propulsion: We used 5 bilge pumps outfitted with Octura 78mm RC boat props. We used Tsunami 1200GPH bilge pumps. The stock impeller was taken off and replaced with a 3.2 mm to 5 metric prop adapters. Attached to the prop adapter is a custom made 5 metric to 1/20 threaded coupler. We tapped the boat props using a 1/20 tap then threaded the prop and coupler together using a 1/20 screw. This was used on our main 4 thrusters, 2 for forwards/reverse and left/right. The other 2 are used for up and down movements. The 5th thruster is used for lateral movement, it is a 750GHP bilge pump fitted with a 55mm RC boat prop. This thruster is smaller so that we can have more fine movement by using this thruster.

Cameras:

Camera 1- This camera is mounted on the back of the ROV giving a 3rd person view of everything. This camera also views the harpoon and water sampler. This camera gives a view of where the tasks are so that the pilot can quickly drive to them, and then switch cameras to see the other tools on the ROV



Camera 2- This camera is mounted on the left side of the ROV viewing the metal detector, compass, and the manipulator. This camera is used when we are close to a task and using the tools.

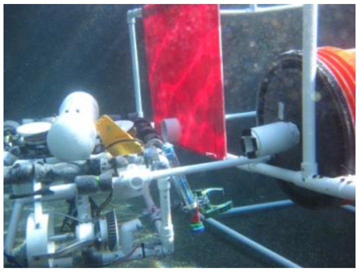
Camera 3 – This camera is mounted on the right side of the ROV viewing the tape measure, and another view of the manipulator. This camera also provides another view of the harpoon to further help the pilot use that tool.

The Harpoon - Drilling a hole through a PVC cap and sliding a threaded rod through constructed harpoon. The rod was held in place by the use of two washers and lock nuts tightened to each side of the cap. The cap was placed into a PVC pipe with a magnet taped to the inside of the opposite end of the pipe. A drywall anchor was screwed onto the top of the exposed part of the bolt and aluminum bars were added to each side of the drywall anchor to widen its overall reach. The drywall anchor was held in place by the use of nuts on each side. Loc-tite was used to ensure stability. Another piece of PVC was attached to the ROV with a magnet tapped to the inside. We slid a bigger piece of PVC pipe over the smaller one and secured to it the ROV. The harpoon slides into the bigger PVC and the magnets connect. The magnets hold the harpoon in place while performing other tasks. When the harpoon is pushed through the U-bolt on the mast, the bars are pushed back until it completely passes the U-bolt. The ROV is then able to back up and the harpoon will slide off the ROV. The Harpoon has a carbineer attached to it that allows the riser bag to lock onto the Harpoon which then locks on the mast, allowing the mast to be brought to the surface.

Metal Detector- The metal detector is constructed from a spring scale. The spring scale was then modified so at the bottom two neodymium magnets are attached. The way this tool works is when we approach the debris pile, if it is magnetic the magnets will attract to it stretching the spring and signaling the pilot that the pile is metal. If the debris pile is not metal the magnets will not attract to it, so the spring will not stretch signaling the pile is non-metal.

Tape measure- This tool is a tape measure with a hook bent at the end and PVC spacer. The hook is built so the pilot can attach the tape measure to the boat when the ROV is backed up next to the PVC pole. The PVC spacer is designed so that the end of the tape measure and the hook stick out from the front of the ROV making it easier to attach to the boat to measure the distance.

Water Sampler- The water sampler is constructed out of 5/16 rubber tubing, a large syringe,

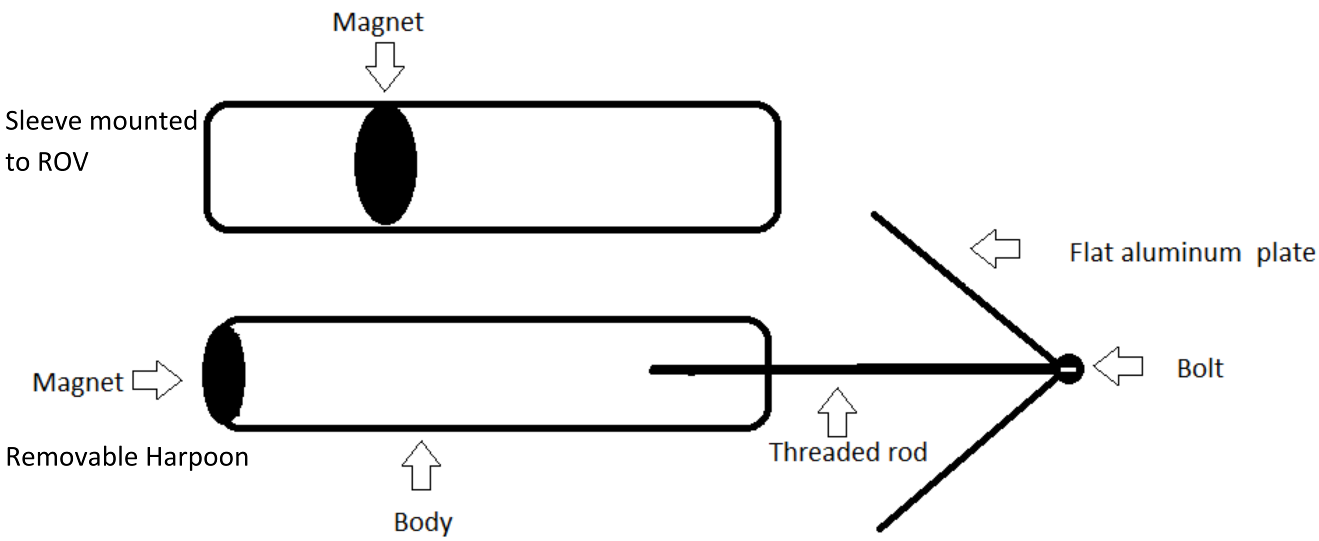


and PVC. The tubing is attached to the syringe at the surface and runs down the tether to the ROV. Once the PVC is inserted far enough in the fuel tank, a team member pulls the syringe on the surface drawing fuel into the tubing. When the ROV is brought to the surface the syringe is pushed back in forcing the fuel out the PVC.

Manipulator- The Manipulator was designed to remove the coral from the work surface of the ship and replant it in the grid next to the ship. We used a VEX manipulator, powered by a VEX motor. The motor is wired to a 5-speed controller so that it can be opened and closed at a speed that is controllable. The Manipulator is also important so that we can retrieve dropped items from the pool floor.

Safety- Our ROV was built with several safety features in mind. At the beginning of the tether we have a 25 amp fuse that will blow if there is any shorts in our electrical system. This allows us to know immediately if a short occurs due to power loss, instead of running the risk of causing harm to the divers in the pool. In the event that is fuse does blow we ran a rope through our tether allowing us to pool the ROV to the surface without having to put stress on any of our wires, or solder connections. Around any hazardous parts of the ROV, specifically the metal props, we put bright orange caution tape. This Draws attention to those areas so people know to be careful when there hands or fingers are close to there areas. Because we know our props can be so dangerous to people hands we established a signal when we bring the ROV to the surface so that the deck hand is safe. The deck hand will call “all off” when the ROV is within arms reach and the pilot responds “all off” indicating that all props are turned off so it is safe to pick up the ROV.

Infrastructure of the Harpoon



Challenges Faced:

Stabilizing the props was an obstacle that took weeks to overcome. Every time they were turned on they wobbled to the sides and hit the prop guards. This presented the potential for damage not only to the prop guards, but also to the props. This made the props uncontrollable and dangerous. The wobble additionally made the ROV un-drivable. Another problem we had was with our metal detector. The magnet we selected was so powerful that when it would attach itself with such force that the ROV didn't have enough power to pull itself away. We also had problems trying to wire our manipulator. And as soon as we finished wiring the circuit board and turned it on it smoked terribly and the manipulator did not move. We later discovered that this was because we had reversed the polarity, essentially destroying the entire board and causing us to have to start almost completely over again. We also had a challenge of space on the ROV. We decided to go with a more compact design for our vehicle, which left little room for our tools. Initially, we designed the ROV with just enough room for everything but when we had to change the size of our prop guards to a much larger 4 inches in diameter, we found that the ROV was no longer sufficient for everything to fit comfortably. Our camera views were blocked and we had to come up with new ways to attach our tools. One of the biggest problems we had was getting everyone on the team together to work on the ROV at the same day. Also scheduling pool practices that everyone could go to so we can test the ROV and get use to driving it.

Troubleshooting:

In order to solve the wobble in our props, we tried utilizing lock tight where the prop was attached to the pump in order to secure it more thoroughly. And when we discovered the prop guards also vibrated, we employed a larger diameter PVC, now 4in, cut as prop guards and physically attached the guards to the ROV using aluminum bars in an effort to stabilize them. To inhibit the strength of the magnet, we attached two pieces of plastic to the bottom of the magnet, which would sit between it and anything it would magnetize to. For the manipulator, we needed to reverse the polarity of the wires soldered to the control board. We were able to switch the wires and replace the parts that malfunctioned due to the short. We found that the best place to mount the tools, which no longer fit in the center, is on the sides or the top of the vehicle except for the manipulator. We fixed the camera angles by positioning one on each side of the ROV with each able to see at least one tool and the manipulator. To solve our scheduling problems we established a build schedule at the beginning of the build, setting dates when we wanted the frame of the ROV done, when the manipulator done, when the propulsion system needs to be done. Along with creating these build goals every Tuesday and Thursday we went to the pool to test the ROV and all the payload tools and get use to driving it.

Skills Gained:

The company as a whole has learned many new skills that allowed us to design aspects of our ROV. We learned how to take everyday tools and convert them into useful components of our ROV. We learned how to use new tools, such as the dremel, which allowed us to shape parts of our ROV. While we built new parts of the ROV we got to experience first hand how adding different things to the ROV effects the tools that are already mounted to it. A big problem we had is the props vibrating so greatly the prop guards would hit the propellers. As a team we learned the importance of planning and meeting deadlines so that everything gets done on time. We also learned how to build a 5-5-5 speed controller which allows the motor to see the full 12 volts it needs to run but it turns the motor on and off very quickly so that the motor has slow RPM's but high torque. We learned how it must use the correct polarity in one of these speed controllers otherwise you experience components of it burning.

Future Improvements:

The props, which were selected for use, are unnecessarily powerful. They inhibit fine movement and while allowing the ROV to travel from the surface to the tasks in less time. This could be improved by adding an inhibitor to the bilge pump motors. This would decrease the power current to the props and would reduce their thrust, bringing it down to a more manageable level.

The prop guards also pose many difficulties. They had to be constructed larger than the originally intended design because the power of the props caused some shaking. This caused the props to hit the sides of the prop guards, potentially damaging them. The larger prop guards solved this problem but it created additional problems. It left little room within the ROV for monitors or the tools for completion of the tasks.

The location of the compass proved to be less than ideal with few options left for repositioning. The location was chosen because it was close to a monitor and was in easy view. However, the bilge pump on which it sits vibrates when running, which throws off the arrow of the compass. This could be easily solved by moving the compass to another location. However, the compass must be positioned so that a monitor can easily see it but there is very little room left in the monitors' views not already taken up by another tool. The best solution would be to experiment with slight changes to camera angles to find a view that will allow the compass to be seen, while still viewing the other tools needed to complete the tasks.

Reflections:

Peter: The experience this year, though more challenging because of our team's smaller numbers, was still phenomenal. In fact, this year presented more opportunities for me to take part in the building process because with fewer people, everyone had to do a larger share of the work. In previous years, other members often completed things before I had a chance to take a role in them. For example, in previous years the task of soldering wires was completed very early but this year the rest of the vehicle was built first, giving me the opportunity to learn how to solder. The people I worked with and the things I accomplished this year formed one of the best experiences of my life.

Kyle: This years ROV team has challenged me to become more of leader. Being the CEO I had to manage not only the building aspect of the ROV but also the paperwork portion of the ROV. I learned how to build and wire a 5-speed controller. Working with this year's ROV has driven me further to pursue a career in Oceanic Engineering.

Stephanie: This is my third year competing in the ROV competition and I have loved it every year. I have watched team members graduate and leave and new team members join but each team I have had the pleasure of being a part of has been great. We went to the international competition the previous two years that I competed and we had a lot of fun. Every year we have improved off of what we learned last year and as a result, I feel that this year's team is the strongest. We have become wonderful friends and I expect that I will keep as closely in touch with the members of this year's team as I have with those of the previous years. We faced new challenges this year and found new solutions. And despite the experience I gained from past years and competitions, I have not stopped learning.

Chris: This was the first year I had worked on the ROV. After all the new tools and devices I learned proper uses for the most exciting skill I developed was how to work a dermal. It's a tool generally used to sand and carve wood. However we can adapt this tool to sand and smooth our PVC in order to fit pieces together before cementing them together. I also used it to cut the holes in our control box to fit our manipulator switch and lateral prop switch. I view it as an important skill learned because I always get excited when I hear we are going to use this tool and it gets me pumped to make a new part for the ROV.

Tim: This is my first year building an ROV and competing in the ROV competition. I have enjoyed the experience so far and look forward to working on competing in the future. This year I have made new friendships working as a team to design and build the ROV. I learned how to work together by contributing my own suggestions and following through with input from other teammates in the group. I learned how to wire and solder the motors and other attachments on the ROV as well as build prop guards. Even though there a few frustrations along the way such as untangling the tether, the experience overall has been a learning process for improving myself and my abilities to work as a team and learning to listen to the input of others.

Michael: This being my first year competing in ROV I have learned many things about designing a successful ROV along with learning some of the skills necessary to operate the tools needed to build the components of the ROV. Through this process I have made several friends and learned skills valuable to my future job such as learning how to discus my own ideas as well as well as listening to others ideas and admitting when they are better then their own.

References:

- "Homebuilt Rovs." *Homebuilt Rovs*. 2 Dec. 2010. Web. <http://homebuiltrovs.com/>.
- "ROV Competitions!" *Welcome to the Marine Advanced Technology Education (MATE) Center*. MATE. Web. <http://www.marinetech.org/rov_competition/>.
- Roylance, Frank D. "WWII Shipwrecks Could Threaten U.S. Coast." The Baltimore Sun, 08 July 2011. Web. <http://articles.baltimoresun.com/2011-07-08/news/bs-md-shipwreck-oil-20110708_1_fuel-oil-fuel-bunkers-crude-oil>.
- "NOAA Researchers Investigate Shipwrecks and 'Mystery Oil Spills'" *National Ocean Service*. National Oceanic and Atmospheric Administration, 12 Dec. 2011. Web. <http://oceanservice.noaa.gov/news/features/dec11/mysteryoil_pt2.html>.
- Hampton, Steve. "S.S. Jacob Luckenbach Oil Spill." California Department of Fish and Game, 18 Jan. 2012. Web. <http://www.dfg.ca.gov/ospr/science/luckenbach.aspx>.
- "ROV Deployed on WWII Era Wreck." *Marine Link*. Marine Reporter and Marine News Magazines, 12 Oct. 2011. Web. <http://www.marinelink.com/news/deployed-wreck-wwii340874.aspx>.

Acknowledgements

The members of the Socastee High School ROV team would like to take a minute to thank a few people who helped guide us on the way. We would first like to thank Mr. Stone for his guidance in helping us to think our way through the build. We also would like to give a big thanks to Mr. Weeks for allowing us to use his room daily after school for work and storage of the ROV. And a big thanks to both for showing us proper techniques and uses of tools as well as providing us with any and most all resources needed to construct the ROV. We would also like to thank Mr. McIssac for providing an abundance of useful information before and after our initial attempt at building our 5-speed controller. When we experienced difficulties, he helped to locate the malfunction in as well as assist in the troubleshooting.