Franklin W. Olin College of Engineering
ROV Team

Codename: Frank

Kevin Bretney 09 Captain
Ana Karimi 09
Joe Kendall 09
Andrew Tsang 09
Ryan Hubbard 08

Mentor: Brian Bingham

Abstract

An ROV (remotely operated vehicle) is an unmanned underwater vehicle used to collect objects and data (pictures, video, samples, measurements, etc.) from remote places in the ocean, for various reasons. They have evolved into retrievers of artifacts, mappers of the ocean floor, and even platforms for cameras recording material for documentation and research.

The Olin ROV team has worked hard over the past several months to produce an ROV for this competition. We started from almost scratch and built our vehicle to complete all of the tasks. We not only worked hard to produce a fully functional vehicle, but w created a fly functional team. We overcame the hurdles of creating a new club, recruiting new members, and raising funds. This year has not only been a difficult mission but a difficult journey. However we not only built a vehicle for this year, but we built an infrastructure to help in future years. We gained valuable knowledge about ROVs and the design process as well as logistics and time management.

Design Rational

Our ROV considered several main component areas: the frame, manipulators, thrusters, tether, electronics and control system, and camera.

FRAME

Our ROV's frame is a modified box frame constructed out of .0159 m outer-diameter, .0127 m inner-diameter PVC pipe.

We chose a box frame because the box shape is versatile with many possible contact points for equipment (ie: camera, grabber) and a relatively easy control system. Beginning with a basic box, we looked at the mission requirements and modified the box to fit our needs. For example, we added slots below our frame to hold the mission's electronics module. We also repositioned some of the horizontal bars for added structural strength and repositioned other horizontal bars for better equipment and thruster mounting options. Finally, we added "X" connectors to most of the places we thought we would want to mount thrusters to support both sides of the thruster and provide strong mounting platforms. To reinforced the thruster's mounts, we mounted the thrusters to angled aluminum, and then too the PVC frame.

We decided to use PVC because of its structural strength, ease of machining, and availability. Also, since PVC piping is component based, using PVC and PVC connectors allowed us to easily test multiple options and modify our design when necessary, which turned out to be very important as we progressed from the design phase through the building and testing phases.

MANIPULATORS

Since there are essentially 2 tasks to complete we have a specially suited manipulator for each. For the first task, installing the electronics module, we have a set of sliders underneath our vehicle that the module slides into. The module just sits in on the rails as we bring it down, and then to get it out, we simply 'scrap' it off by inserting it into the base and driving forward, the module will catch and slide out and into place. We went with this method since it has worked in the past on previous ROVs at the competition with relative success, and it requires no additional moving parts, making it one of the simplest methods to use.

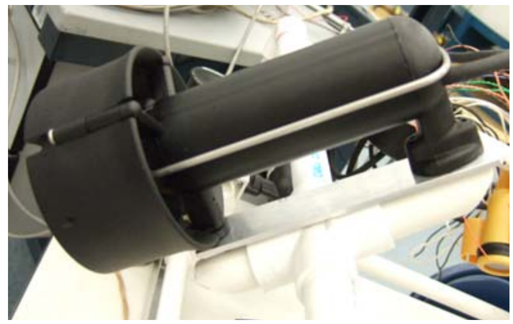
For the second task, opening the door and inserting the connectors, we have a

gripper mounted on the front of the vehicle. We are using just one gripper to both open the door and to pick up and carry the connectors to make things simpler. The jaw on the gripper opens in parallel to a width of over 2.5cm which is more than enough for both the ½" PVC for the door and the U-bolt on the top of the connectors. The jaws have a foam rubber on them to compress around the object we are picking up to keep it steady by providing a molded grip. The gripper is powered by a servo to provide adequate torque in a simple form factor and an easy interface. The servo is waterproofed by detaching the feedback system and filling the electronics half with a silicon adhesive to protect the components. This sealing method works well, keeping the servo running after multiple test runs.

THRUSTERS

We are using four Seabotix BTD150 Thrusters to propel our ROV through the water. Each thruster weighs 754 grams dry and runs nominally at 28V DC with a max thrust of 25N of thrust with a current draw of 4 amps. The thrusters can also be run at lower voltages, but the power output is reduced by almost half at 12volts. With the higher voltage shore power is required, increasing the size of the tether but the additional thrust more than compensates for it.

The thrusters are arranged with two controlling horizontal forward and reverse motion as well as pivot turns. Two other thrusters are positioned to provide vertical or downwards thrust as well as longitudinal rotation. These two thrusters are arranged in a "X" configuration which is controlled through the software and electronics to provide the different types of thrust, either vertical or axial. Through this combination of thrusters we can control the ROV along any axis.



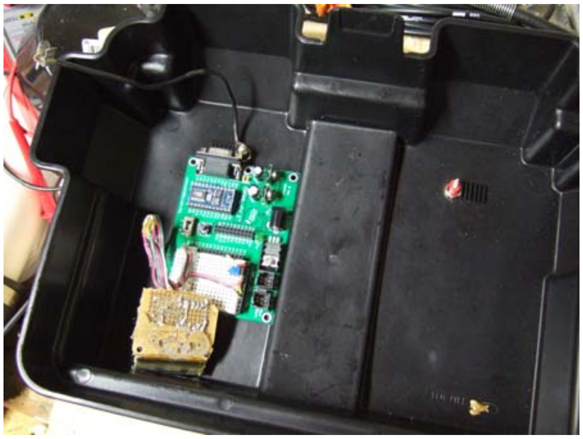
We decided to go with commercially produced thrusters because of both past experience and time; we wanted to be certain we had consistently strong thrust and we knew that hand-built or hand-modified thrusters, like those made from bilge pumps, were not always strong enough for the job. We also wanted thrusters that we could use repeatedly on later ROVs. We chose the Seabotix thrusters because they were designed to use an available amount of power to produce the necessary thrust for our mission.

TETHER

For the tether for the vehicle, we are using a 2 conductor 16-gauge speaker for power, and a cat-5 4 twister pair network cable for data and video transmission. We decided to use the speaker wire for power sine it was cost effective and easily available. 16-gauge was selected to provide both maximum flexibility and minimum power loss. The cat- cable was used since we need at least 2 conductors for data and video. We are using instead 2 each for a total of 4, to provide better signal protection. We have extra wires running down the tether since it does not require additional work, and allows for expansion later on if need-be. The tether is rather flexible and does not provide too much drag for the vehicle.

ELECTRONICS AND CONTROL SYSTEM

The overall system is a familiar system which Kevin has worked with in the past.



It has proven both reliable and easy to implement. It consists of a Playstation controller to control movement, a BASIC Stamp to interpret the controller, a Parallax Servo Controller on the vehicle to drive the systems, and commercial Speed controllers for the thrusters, and servos for manipulation. The Playstation controller is a good human interface since it is very familiar to everyone on the team making it very easy to just pick it up and use. The Stamp is used since it is a very simple and easy to program microprocessor with good documentation. It sends a serial signal down the tether to the PSC, which provides up to 16 PWM signals out to the speed controllers or servos. As far as the speed controller selection goes, we were somewhat limited since we had elected to use 28 volts to drive the thrusters we need a speed controller which went to over 28 volts. This narrowed our choice to pretty much the IFI Robotics Victor speed controllers. These have been used for many years in the FIRST competition and have proven themselves to be a good solution for speed controllers. The total current draw of the vehicle is a maximum of 20 amps if all of the thrusters are running at full speed and normally around 10 amps. 16-gauge wire is plenty to carry this current with minimal power loss along the tether. We are actually supplying 30 volts down the tether to take into account the loss and to make it easy to supply the voltage. We are using two 12 volt 18 Ah Exide Sealed Lead Acid batteries and one 6 volt, 12 Ah sealed Lead Acid battery to provide the 30 volts. This is the cheapest and easiest solution for a topside

power supply. We are also using a 3-cell Lithium Polymer battery with a normal voltage of 12.3 to provide power for the on-board electronics and camera.

CAMERA

We are using a commercially available underwater camera. The camera is very similar to an X10 camera, but it comes manufactured with a built in lighting system and a waterproof housing using o-rings. Six white LEDs positioned around the camera lens comprise the manufactured lighting system. We modified the housing of the camera for mounting and, after examining the waterproofing, left it as it came.

Challenges

Our team had several large challenges to overcome for this competition. College is a very busy for most people, and no one is busier than an Olin student. Finding meeting times where everyone could show up was an almost impossible task. This made it difficult to organize ourselves to design and build the vehicle in a timely fashion. We worked on this by designing individually and combining ideas at meetings, and building the vehicle in free time, everyone working on a part that needed to be done when they could. This was not a very good method to run the team since all of our target deadlines got pushed way too far back and we did not have as much time to practice as we wanted.

Another large problem was funding. As a club we have access to money through the student government, but it took a long time to get our request through. We wanted to wait on pursuing other sources until we found out how much we had from CoRe(the student government) We got all of our funding that we requested but it took much longer than we expected. We could not buy anything without money so since we were late in getting funding; we were late in purchasing components and building the vehicle.

Troubleshooting Techniques

One of the most important troubleshooting techniques was to test everything at various stages of development so that any problems could be identified right away. For instance with the thruster control circuit we tested the thrusters directly with the battery, with the speed control circuit directly to the STAMP, with the speed controller through an extended line, and finally connected through the entire circuit, tether and all. Many of the other systems were tested in such a manner as well.

Another technique was to use the trusty multimeter to check voltages and amperage draw on all of the individual devices so that any jumps in voltage or drops for that matter would alert us to any potential problems. We also worked with fuses less than the specified maximum so that we knew how close, or far, we are from the maximum allowed.

The most time consuming but effective technique is the method of elimination. If something happened to leak, we would put it in a shallow tub to find the location of the bubbles, if no bubbles then it must be a slow leak through a through-hull connection. We would seal off that entry point for water and see if that fixed the problem. We would continue in this fashion, eliminating different variables each time until we arrived at the underlying problem.

Lastly the most common would be trial and error. If a problem arose we would use method of elimination to isolate the problem, find out how to fix the problem, and fix it, keeping in mind the mistake so as not to make it again.

Lessons Learned and Skills Gained

Each team member lacks certain skills. Some of us have never touched a soldering iron before, others have never programmed, others never picked up a pen to draw a blueprint. However, we discovered the value and skill of working as a team. We help each other learn, debate ideas, mull over plans, and execute the building as a collective unit. Some who had never learned to use a hand tool were taught and soon were assembling crucial parts of the robot under another member's supervision. Through this sort of relationship, the apprentice gains confidence in his own abilities, and the mentor learns how to teach another, to lead others to improve, and thus better the team as a whole. We regard this acquired skill of teamwork as one of our group's greatest strengths. It is how, despite our busy schedules and lack of time, that we are still able to effectively compete against other teams.

Future Improvements

There are a large number of future improvements that could be made. One improvement is in the area of sensors. As it is when we go down we have to rely on the camera to get our bearings straight, something we could do is to have a compass on board to determine our orientation. Another similar improvement is a gyroscope, we could have a pilot assist function which would keep the vehicle in a certain orientation or position so that the operator can concentrate on the mission instead of keeping the vehicle in place.

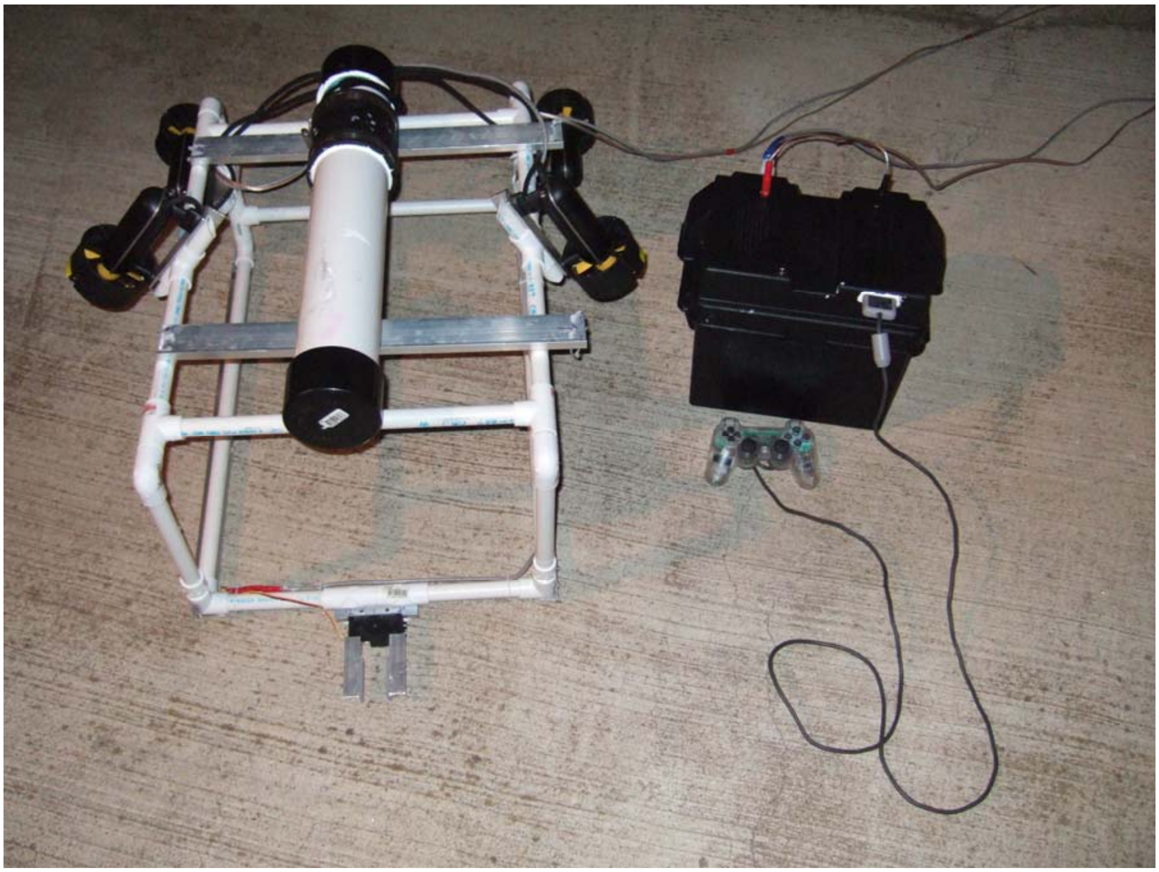
Another improvement would be a better tether. We could get a custom tether instead of the simple one we have now. We could also move to fiber optics for communication which would reduce the tether to a fiber optic cable and power. We could also go to on-board power. While the performance would be reduced, the tether could be shrunk and the vehicle would be more mobile.

Acknowledgements

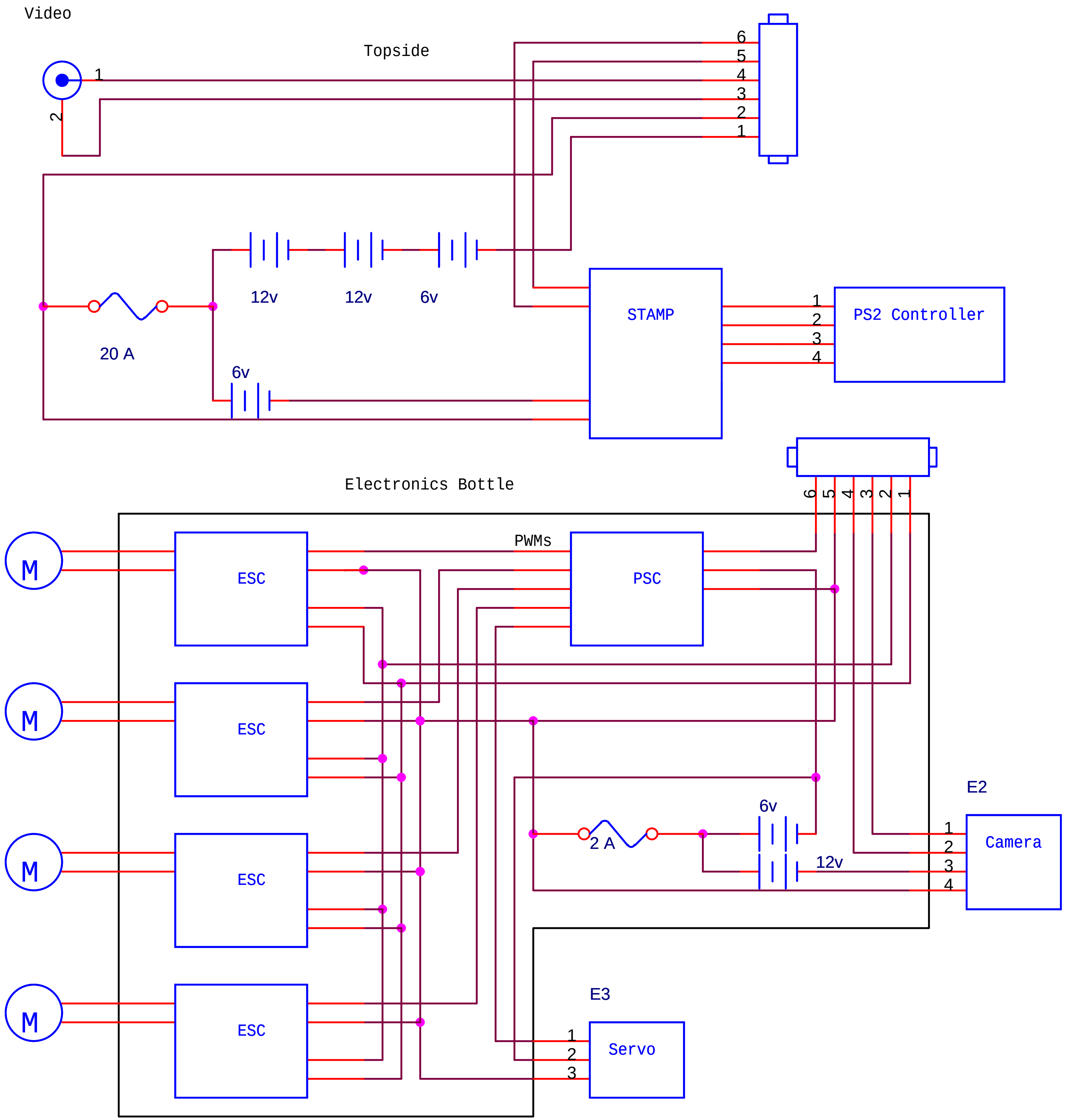
We would like to acknowledge Franklin W. Olin College of Engineering for allowing us to do this competition, specifically the use of AC426 for construction of the vehicle and the ME and ECE Stockrooms for easy access to electrical components and material stock. We would also like to thank the mailroom for dealing with all of our large and frequent packages. We would like to thank Brian Bingham for being a mentor and helping us through the process. We would like to thank Babson College for allowing us to test in their pool. We would like to thank CoRe for giving over $2200 for the project.

We would like to thank Seabotix for discounting their thrusters so we could afford them. We would also like to thank the Needham UPS store for packaging and shipping our ROV. Finally we would like to thank MATE for continuing and improving this wonderful competition.

System Picture



			Expenses	Assests
Given by CoRe				2435
Thrusters:				
Seabotix Main Thrusters	333.75	4	1335	
			1335	1100
Electronics:				
Basic STAMP	39.99	1	39.99	
PSC	44.9	1	44.9	
ESCs	152.96	2	305.92	
misc electronics	100.83	1	100.83	
batteries	12.99	6	77.94	
			569.58	530.42
Camera:				
Color camera and casing	68.99	1	68.99	
			68.99	461.43
Frame:				
PVC	99.21	1	99.21	
			99.21	362.22
Manipulators:				
Gripper	37.45	1	37.45	
			37.45	324.77
Tether:				
Tether	50.2	1	50.2	
			50.2	274.57
Shipping:				
to/from competition	100	2	200	
			200	74.57
Total:			2360.43	74.57



Video
Topside
1
2
6
5
4
3
2
1
12v
12v
6v
STAMP
PS2 Controller
1
2
3
4
20 A
6v
Electronics Bottle
6
5
4
3
2
1
PWMs
M
ESC
PSC
M
ESC
M
ESC
M
ESC
E2
Camera
6v
2 A
12v
1
2
3
4
E3
Servo
1
2
3