PVC ROV 2004

ELHS Engineering Team

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Abstract

The ELHS Engineering Team began their project with setbacks–time constraints, few people, and conflicting commitments–yet, with their knowledge and dedication, their project went on. The team had to overcome their challenges to create the ROV. To do this, the team researched, planned and then set their plans into motion.

The team thoroughly planned each part of the ROV before its creation. They then tested the ROV systematically under imaginary and then real conditions to see how it would perform. With a completed ROV, the team plans to donate the ROV for research purposes. The team learned that it is quicker to build something on paper than it is to build it without a plan. The team also learned that ROV's are made for more than just research and that research ROV's are becoming friendlier to the environment.

Challenges Faced

The ROV project was very challenging in many ways, but our biggest challenge was to come up with a plan to make up for our very late start. This is our first year in the competition and we did not learn about it until late in February. We knew that our competitors had a considerable head start and many had experience from previous years. In order to be successful, we had to make up for lost time. We came up with a three-phased plan to achieve this goal.

First we decided to do very extensive research so that we had all the essential information at hand to help us best solve all the problems and tasks required to win the competition. We knew that we had to do our homework so that we were sure that any solution that we decided upon would be the best one possible. We didn't have time to make mistakes.

Secondly, we decided that to take whatever time necessary to create the ultimate plan. We did not have time to build and rebuild. We had to troubleshoot the plan and move lines rather than material so that our first shot at building the ROV would be our best shot, because it might be our only shot. We spent more time planning than building, and it proved to be the key to our success.

Lastly, we decided to use PVC piping and fittings for our building material, because it is quick and easy to assemble and easy to change and modify, if necessary, as well as very easy to work with using the few machines and tools at hand, as well as the limited experience in our group working with them. We used the PVC pipe and fittings like Tinker Toys, and it worked perfectly.

Design Rationale

We began the project by looking at our time constraints, tasks and the maximum size of the ROV. To allow quick customization of the ROV we decided to use PVC, which can be manipulated easily so that reliance on CAD designs was not crucial; parts and mountings could be modified quickly and easily in the school's machine shop. The next consideration we made was on movement. We decided on five motors to navigate the ROV. Two are mounted on the sides and provide fore and aft thrust; two are mounted fore and aft and provide thrust sideways; the fifth motor is mounted on the umbilical crossbar and provides vertical thrust. This allows forward, backward, side-to-side and up-and-down motion aided by motors. The only issue with five motors is the number of power cables going through the umbilical, but a few steps will be taken to reduce the number of cables. Each motor is a bilge pump purchased at a local store that we stripped down and fitted to customized PVC mountings. We removed the impellors and purchased propellers that we then fitted to the shaft of the pump. Then the shape of the ROV came into question; originally we wanted a round ROV, but because of building limitations we then decided on a hexagon; then again building limitations came into play, so finally we settled on an elongated octagon. The ROV is made of two upper octagons and a bottom platform. Because of the weight of the ROV, the top two rings will be filled with air and made watertight to add buoyancy and the bottom platform will be flooded. Upon final testing we will determine if the bottom platform should be fitted with weights to maintain stability underwater.

The ROV uses pneumatics in two ways; one is for the ballast tanks, and another is for the operation of a multi-purpose claw. The three ballast tanks will be positioned equidistantly on the top of the ROV frame. The two closest to the front of the ROV are connected to the same line using a t-splice and the rear tank is independently controlled of the other two. This allows the ROV to tip itself up or down if need be, and still be balanced during normal operation. The ballast tanks are fed from an airline sourcing at the surface and can be filled with air or drained of air from the surface. A hole in the bottom of the ballast allows water to enter and exit as air is taken from or put into the tank. This operation is similar to how submarines operate.

To complete each task, we had to look carefully at the timeframe of the competition. We want to be able to complete as many tasks as possible in the shortest time so we decided to keep the ROV underwater for as long as possible to minimize the number of resurfacings required. To do this we decided to be able to collect all samples in one go rather than resurfacing each time a sample is attained. We therefore made several fixed stations on the ROV capable of completing the tasks. To place the markers we devised a spring-loaded claw that can place a marker as well as collect all required fish specimens at once. In case of failure of the device we also mounted fixed stations on the ROV capable of doing the same tasks. To collect the mineral samples, the ROV is equipped with a scoop and a containment device so the rocks go in without easily slipping out. The towfish hook is held by an attachment facing forward on the ROV. The attachment is designed to easily release the hook once it is firmly attached to the towfish, but not fall out of the attachment with little provocation. The barrel patch may be held with the same attachment or with the claw.

The last major consideration of the design is how to operate the ROV. We began by looking at digital cameras but rejected them because the digital signal would degrade through the length of cable needed. We then began looking at analog cameras; the signal for analog is significantly better. We then looked at setting them up on the ROV. Because the space in the ROV is close, we can only fit two cameras; one fore and one aft. The aft camera will be focused close to maneuver the ROV near its task objectives with more precision. The fore camera is focused for navigation. Each camera will be mounted in a watertight PVC container with a Plexiglas front. The control deck will be comprised of two television monitors and the control board for the ROV. The control setup is user-friendly; on the left are four buttons–the top is forward, bottom is reverse, and left and right are for strafing, respectively. On the right, the top button makes the ROV rise, the bottom makes it go down, the left button makes it spin counterclockwise and the right button makes it spin clockwise. In essence, one person can control the ROV's motors with two hands, similar to using a keyboard. Another person is needed to operate the ROV's pneumatics.

Troubleshooting Techniques

Our group troubleshot the performance of all components and task stations on the ROV by testing them under simulated competition conditions and by visualizing the ROV and a particular task station under imaginary test conditions. We would then analyze the test results and assess whether or not we would succeed in accomplishing the task in the competition and if we would achieve the maximum score. If we were not satisfied that the test results would achieve our goal, we would analyze what was good about the design, what was bad and what needed improvement. We would then brainstorm possible solutions through drawing sketch plans of possible design changes and totally new designs. Our group would then decide upon the best possible solution; we would make a detailed drawing, build the new design or modify the original, and re-test the build-out. Should the test results still be unacceptable, we would repeat the process as many times as it took to achieve our goal: complete all tasks and achieve total points.

Future Improvements

After rigorous testing concludes, we may need to revise any of the systems of the ROV. One foreseeable step is to modify the motor mounts for maximum efficiency. It is also our hope to be able to donate the ROV to the ELHS science department after the competition in order to further local marine exploration and learning. With the PVC frame, any number of post-production modifications can be made to outfit the ROV as appropriately as possible for any tasks it may face in the future.

Lessons Learned

As a team we have learned that it is easiest to accomplish your goals on paper before accomplishing them with final building materials. We decided on what had to be done and drew plans before building the actual ROV. We also found that designing something comes more naturally with a scale model to work with; sometimes a project gets so overwhelming it can be difficult to work with the whole visualization in your head. Tools such as scale models and CAD can further a team's ability to visualize how building a project should go and can make a tough task easier and quicker.

Present Use of ROV's in Marine Sanctuaries

Presently ROV's are used in a variety of ways. The two major sectors of ROV's are exploratory and commercial. Commercial ROV's are used in survey, repair, maintenance, inspection, construction and investigation.

With the development of better technologies, ROV's are now being designed to minimize their impact on the surroundings they explore. NOAA, C & C Technologies and scientists from FGBNMS, the University of Alabama and the Marine Conservation Biology Institute worked collaboratively to test a new type of ROV named "Innovator." They had great success using new techniques preserving precious coral and the small organisms that inhabit it. Scientist successfully used new capturing and collecting devices to bring up live specimens of colorful sponges and different algae species.

Budget/Expense Sheet

Category/*Source*/Materials	Application	Price
Expenses:		
ELHS Tech Ed Shop		-$5.00
Aluminum Rod		
Aluminum metal sheet		
Plexiglass sheet		
Home Depot:		-$122.88
PVC piping and fittings	ROV mainframe & attachments	
PVC primer & glue	Fasten PVC piping and fittings	
Teflon tape	Keep threaded fittings from leaking	
Brass fittings	Air hose connections and couplings	
Clear vinyl hose	Air lines to ballast tanks and claw	
Plastic valves	Air control valves	
Niantic Bay Marina:		-$53.00
5- ATT V500 bilge pumps	5 -12 volt prop motors to power ROV	
Radio Shack:		-$33.72
Misc. electrical components	Motor and video control & safety	
Tower Hobbies:		-$27.84
12- nylon props	ROV propellers (two sizes)	
Wal-Mart:		-$82.40
Total Expenses to Date:	4/21/04	-$324.84
Income:		
U. R. I. ROV Competition entry funding		$100
Connecticut Drive Right		$100
Kitchen Beautiful		$100
Nautilus Development Inc.		$100
Al Carbee (Faculty Advisor)		$200
Total Income to Date:	4/21/04	$600
Total Balance to Date:	4/21/04	$275.16

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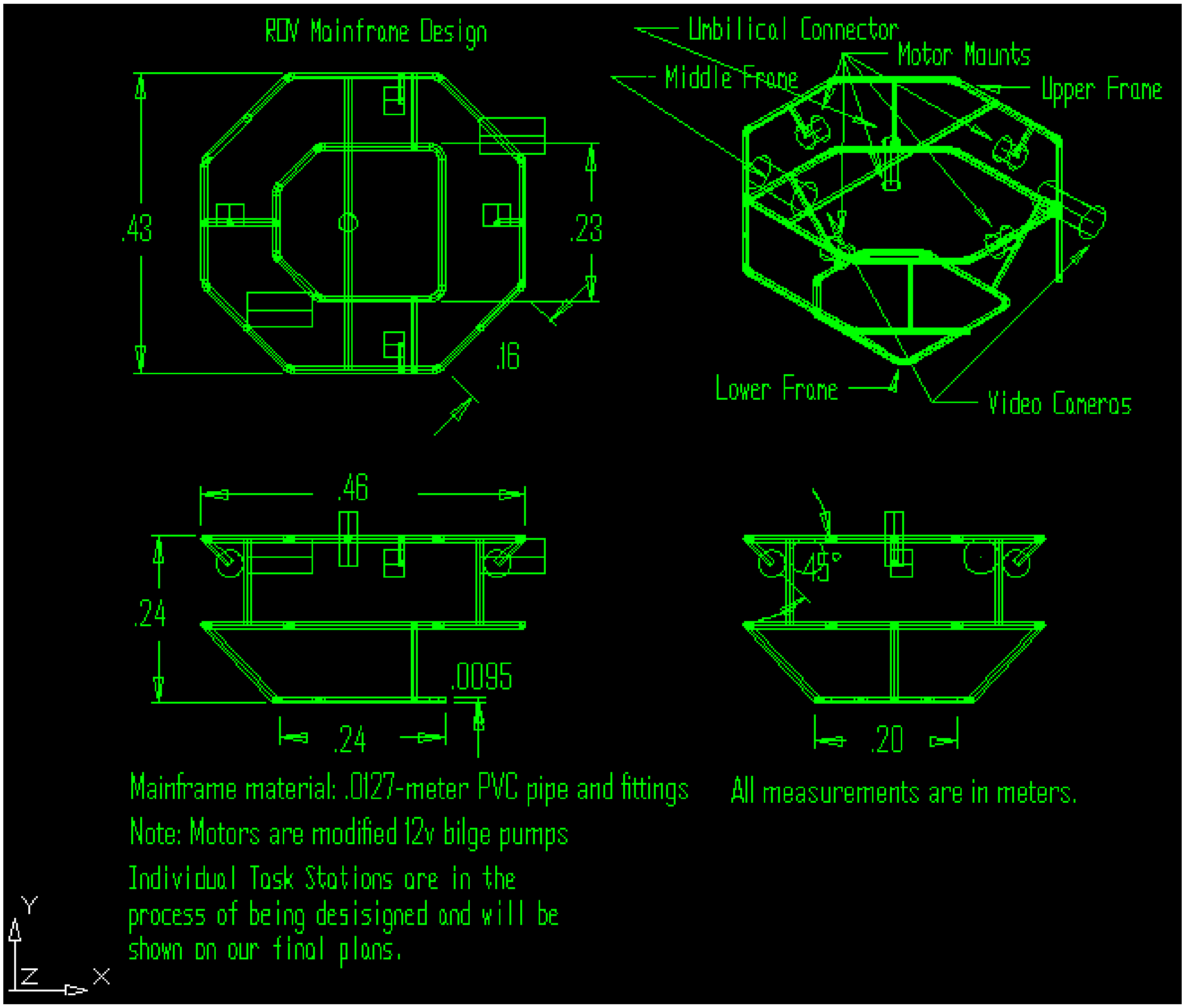
*The University of Rhode Island for hosting the competition and offering their services.

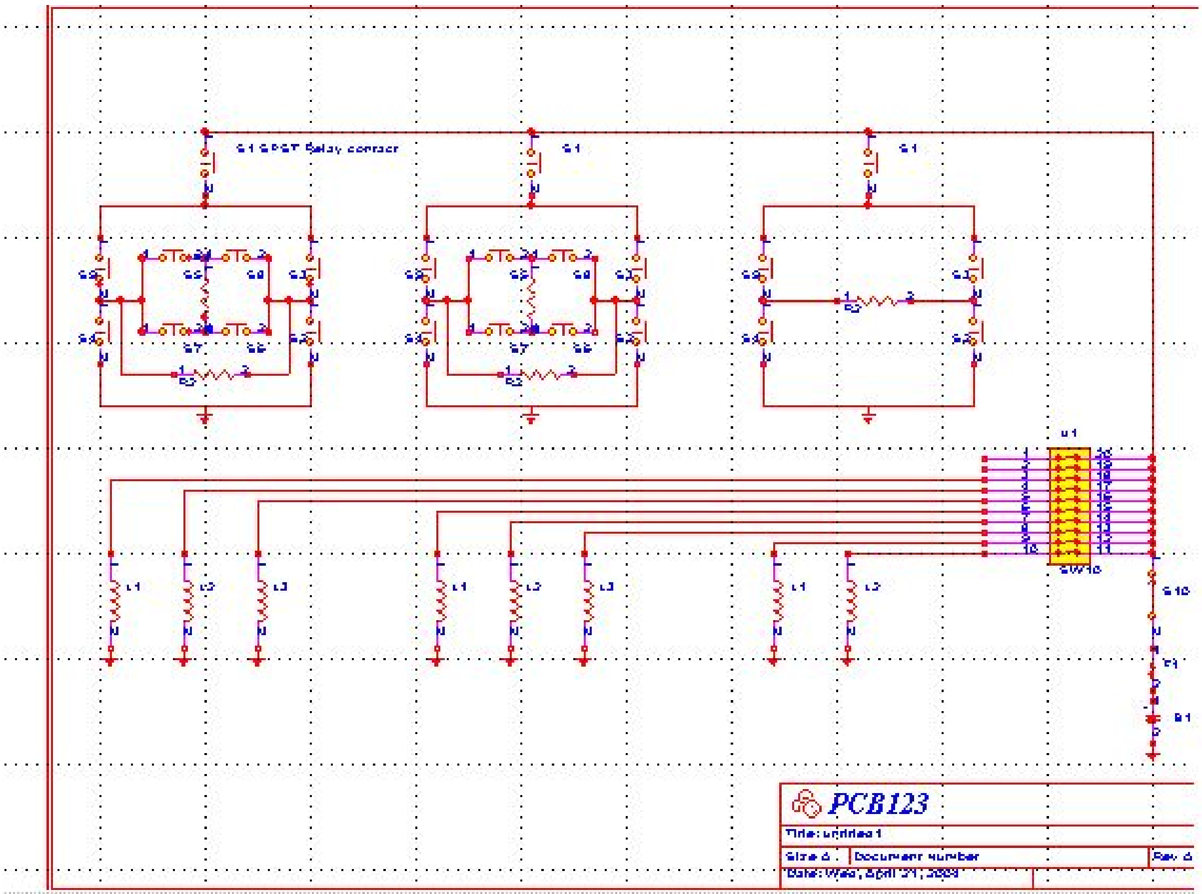
*Brennan Phillips for organizing and promoting the competition.

*The members of our team who spent their free time and remaining energy on making this ROV fly to the best of its ability.

*Al Carbee for helping us to get this project where we wanted it and for donating his time.

Pictures


ROV Mainframe Design
Umbilical Connector
Motor Mounts
Middle Frame
Upper Frame
.43
.23
.16
Lower Frame
Video Cameras
.46
.24
45°
.0095
.24
.20
Mainframe material: .0127-meter PVC pipe and fittings
All measurements are in meters.
Note: Motors are modified 12v bilge pumps
Individual Task Stations are in the
process of being desisigned and will be
shown on our final plans.
Y
Z
X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