Aquadore

An Underwater Remotely Operated Vehicle (ROV) designed by:

Tates Creek High School
Lexington, Kentucky

Team Members

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Katie Officer ('07), Alex Olson ('07)

Instructors/Mentors

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Barrett Steele, Research Engineer, University of Kentucky College of Engineering

Abstract

Remotely Operated Vehicles (ROVs) save time, resources, and possibly human lives. They can travel and reach places that are very dangerous. Current uses for ROVs are underwater exploration, ship repair, underwater repair, and even space exploration. Five students at Tates Creek High School in Lexington, KY have designed, built, and tested Aquadore, an underwater remotely operated vehicle created for three specific missions. These simulated missions include: a) repairing an underwater communication cable, b) closing a valve, and c) making modifications of the Hubble Space Telescope. Aquadore is assembled mostly of PVC pipe and was constructed in 3-4 days at the University of Kentucky's Department of Mechanical Engineering. The students at Tates Creek High School learned valuable skills in constructing a unique ROV designed to fulfill those three missions.

Aquadore

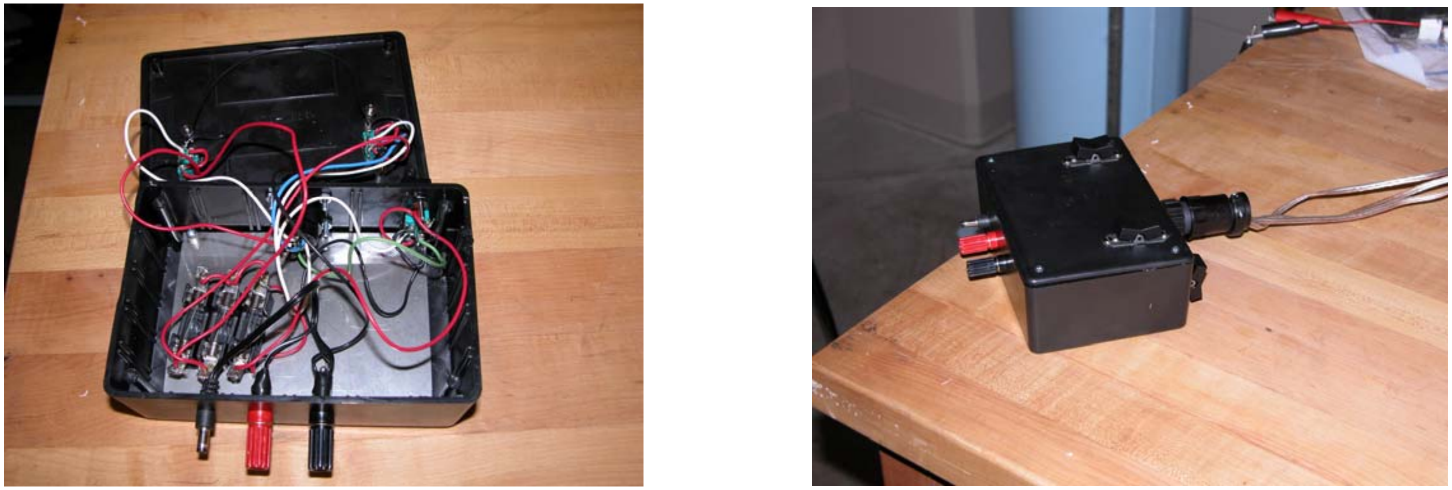

Figure A. Control Box

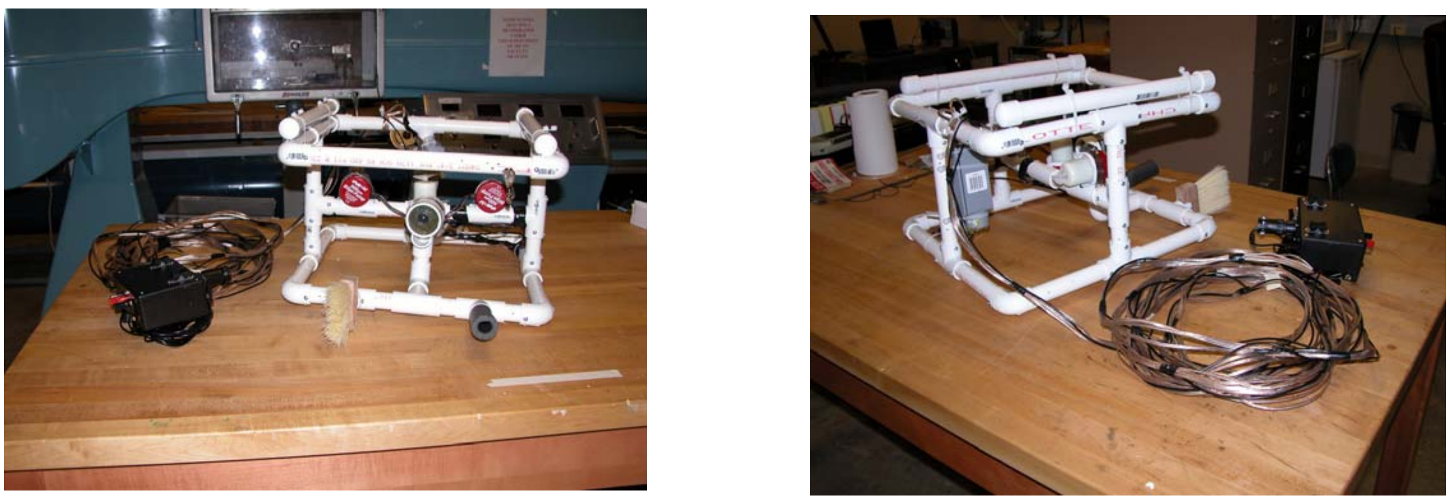

Figure B. Various views of Aquadore

Budget/Expense Sheet

School Name: Tates Creek High School

Instructor/Sponsor: Kevin Crosby

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Funds

Date	Deposit or Expense	Description	Notes	Amount	Balance
5/14/2005		**Starting Balance**		**$0.00**	**$0.00**
5/21/2005	deposit	$75.00 Gift card donated by the Home Depot		$75.00	$75.00
5/13/2005	deposit	Donated by Bluegrass Mailing		$125.00	$200.00
5/22/2005	deposit	MATE money for building costs		$100.00	$300.00
5/16/2005	donation	4- Dumas Boats 1-3/4" diameter Propellers ($4.00)	Bad Hobbies	$0.00	$300.00
5/16/2005	expense	4- Rule 500 GPH/1890 LPH Bilge Pumps	Granger	($63.80)	$236.20
5/16/2005	expense	4- HBL Specialty Switches	Granger	($46.72)	$189.48
5/16/2005	expense	4- Rosin Core Solders	Granger	($3.68)	$185.80
4/16/2005	expense	sales tax	Granger	($8.50)	$177.30
5/21/2005	expense	2- 3/4 in. PVC Pipe	Home Depot	($3.38)	$173.92
5/21/2005	expense	Orbit Sprinkler Tool Kit (PVC Pipe Cutter)	Home Depot	($8.00)	$165.92
5/21/2005	expense	Hyde Tools Wallcovering Paste Brush	Home Depot	($2.98)	$162.94
5/21/2005	expense	20 ft.- 22 Gauge Wire	Home Depot	($4.20)	$158.74
5/21/2005	expense	Crown Bolt 6x3/4" Screws	Home Depot	($2.97)	$155.77
5/21/2005	expense	Buchanan Wire Connectors	Home Depot	($1.99)	$153.78
5/21/2005	expense	3- Super Glue Expoxy Adhesives	Home Depot	($8.91)	$144.87
5/21/2005	expense	5- 3/4" Tee sxsxs Fittings	Home Depot	($0.95)	$143.92
5/21/2005	expense	7- 3/4" Fittings (Angled)	Home Depot	($3.22)	$140.70
5/21/2005	expense	8- 3/4" Fittings (90 Degrees)	Home Depot	($1.92)	$138.78
5/21/2005	expense	2- 3M General Use Vinyl Electrical Tape	Home Depot	($1.10)	$137.68
5/21/2005	expense	Ideal Terminal Strip	Home Depot	($5.08)	$132.60
5/21/2005	expense	2- Ideal 300ss Clamps	Home Depot	($2.12)	$130.48
5/21/2005	expense	2- Murray Gold Seal Clamps	Home Depot	($2.12)	$128.36
5/21/2005	expense	Carol Speaker Wire (250 ft.)	Home Depot	($25.00)	$103.36
5/21/2005	expense	2- Fluidmaster Bol-wax No. 1	Home Depot	($1.78)	$101.58

5/21/2005	expense	1/2 FDN 3/4 In. Round Junet Box w/Cover	Home Depot	($4.75)	$96.83
5/21/2005	expense	Thomas & Betts Mounting Tie (7") 100 Qty.	Home Depot	($5.49)	$91.34
5/21/2005	expense	PVC Pipe Fitting	Home Depot	($1.75)	$89.59
5/21/2005	expense	sales tax	Home Depot	($5.26)	$84.33
5/22/2005	expense	Pipe Insulation	Home Depot	($1.75)	$82.58
5/22/2005	expense	4- 3/4" Cap Fittings	Home Depot	($1.08)	$81.50
5/22/2005	expense	4- 3/4" Fittings (90 Degrees)	Home Depot	($0.76)	$80.74
5/22/2005	expense	8- 3/4" Tee sxsxs Fittings	Home Depot	($1.92)	$78.82
5/22/2005	expense	Ideal 300ss Clamp	Home Depot	($1.06)	$77.76
5/22/2005	expense	SGL Robe HK	Home Depot	($1.69)	$76.07
5/22/2005	expense	sales tax	Home Depot	($0.50)	$75.57
5/22/2005	expense	NightWatch2 B/W Low Light Wired Camera with 60 ft cord	X10.com	($69.99)	$5.58
5/22/2005	expense	Shipping Fee	X10.com	($15.00)	-$9.42
5/27/2005	expense	PVC Pipe Fitting	Home Depot	($0.47)	-$9.89
5/27/2005	expense	sales tax	Home Depot	($0.03)	-$9.92
5/27/2005	donation	Television Monitor ($50.00)	student	$0.00	-$9.92
5/27/2005	donation	12 volt Battery ($50.00)	student	$0.00	-$9.92
5/26/2005	donation	Control Box/Wires/Switches/Fuse ($25.00)	University of KY	$0.00	-$9.92
5/27/2005	donation	Student Donation for Supplies	Student	$50.00	$40.08

Electrical Schematic

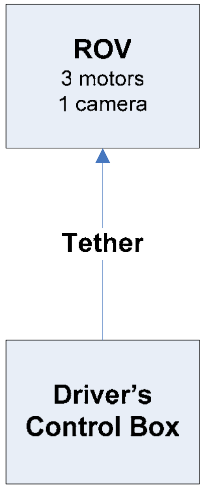

Figure C. A general block diagram of the wiring concept

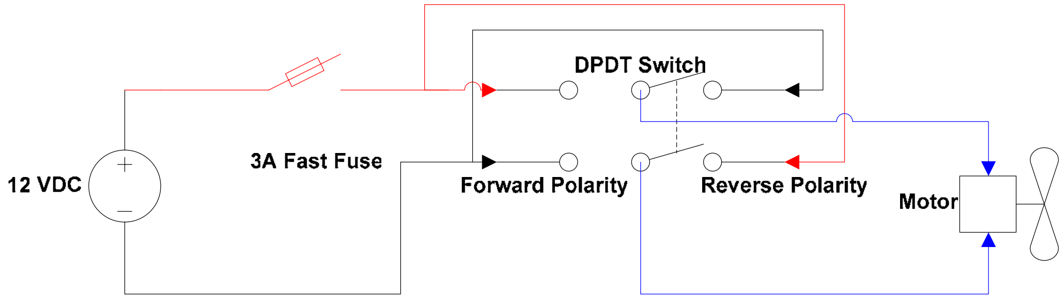

Figure D. Wiring diagram for each of the three motors

The blue lines are leads connecting to the motor, red lines are the twelve volt "hot" (positive) wires, and black lines are the twelve volt neutral (negative) wires. The DTDP is a double-pole, double-throw connection in which one switch can play the role of two. The DTDP switches two wires simultaneously between two circuits, completing the circuit and giving the motor(s) a clockwise or counterclockwise spin.

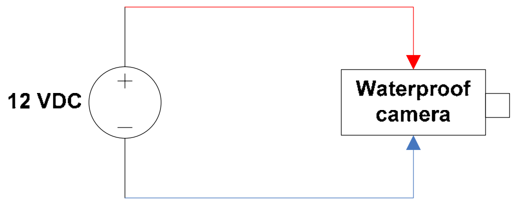

Figure E. Wiring diagram for the camera mounted on the ROV

The waterproof camera was created by mounting a normal camera in a 1½" PVC pipe and sealing it with epoxy. Again negative and positive leads connect the camera to the power source inside the control box.

Design Rationale

The following goals were used for the construction of Aquadore ROV:

1. To create a stable ROV that can move to a desired location without tipping, turning, or moving in any undesired way.
2. To maintain enough thrust to push a PVC lever closed within a certain amount of time.
3. To have the maneuvering accuracy to successfully repair a fiber optic cable by dropping a ½ inch PVC cap into a circular cup with a diameter of 4 cm.
4. To maintain enough forward thrust while upholding great accuracy to install a new instrument module on the Hubble space telescope with a 5 cm radius.

The Following designs were implemented to reach the above goals:

1. Stability and durability was insured by using ¾“ PVC pipe rather than ½“ PVC pipe. The height of the structure was limited to stabilize the balance.
2. Balance was maintained and greater maneuverability was provided by insuring a nearly symmetrical ROV. The two forward thrust propellers are symmetrical on each side to achieve constant and steady propulsion.
3. Two forward/backward thrust components were used so that the ROV could turn from left to right keeping the propellers in a locked position. Turning is achieved by varying the speed and direction that the propellers are rotating. For example, a forward thrust on the right propeller and a backward thrust on the left propeller would result in the ROV turning to the left. The concept is very similar to how a tank would turn (see Fig. F).

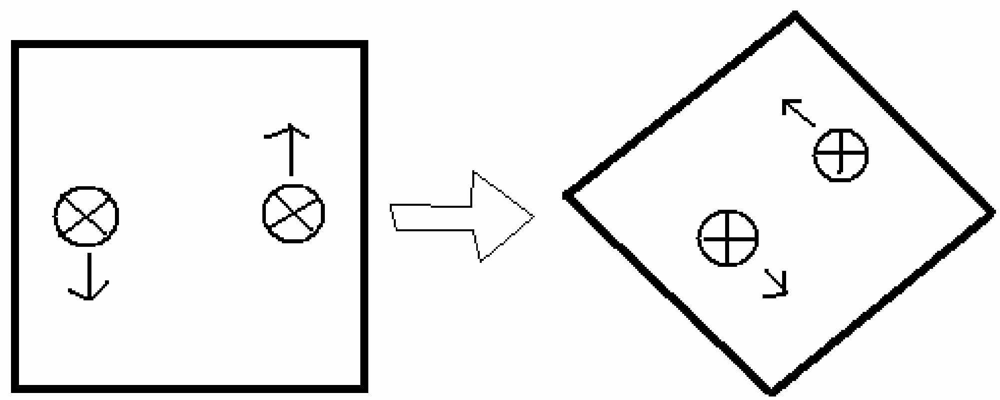

Figure F. Spinning (turning) motion created by opposing motor thrusts

4. Momentary switches were used on the control box to allow for greater accuracy and quicker respond time. Instead of using permanent switches which would require a definite turning off to stop thrust, temporary switches were used so a release of the switch would cut the power.
5. 18 AWG speaker wire was used in order to provide sufficient amperage to power each propeller. Each of the three propellers draws a maximum of 1.9 amps at 12 volts, totaling a maximum of 5.7 amps.
6. A wallpaper brush was installed to catch the lever so that there was no up or down movement. (See Fig. K) The brush would allow the Aquadore to push the lever closed in one swift motion.
7. A hook was used for the specific purpose of the fiber optic repair mission. The hook is meant to hold the hanging fiber optic cable so that it can be dropped at the precise location.
8. An arm extending outward is fitted with Styrofoam covering which is pushed into the inner parts of a PVC T joint. (See Fig. G) This foam is steady and will not move from its position. The Velcro piece of the "Hubble space telescope" will fit into the inner parts of the Styrofoam covering. The covering can also expand if needed.
9. Twenty-two AWG wire was used throughout the control box. The 22 AWG wire will sufficiently carry the power without getting hot, yet it is small enough to solder to the small connections on the switches.
10. The Aquadore is using a double-pole double-throw connection within three single rocker switches, which enables the driver to reverse the current (by connecting two different wires together, acting essentially as two switches) at will to cause the motor to spin in the opposite direction in case the Aquadore runs into a hurdle or gets fixated at a certain spot. (See Fig. H)

Figure G. Attachment arm

Figure H. DPDT switch used in the control box

Describe a challenge faced

After building the basic rectangular prism frame of our ROV, we began to see a problem. Where would we mount our propellers? The place where we thought they would be best suited was on a flat tube of PVC pipe. As we collectively thought about a solution, we considered attaching the propellers to the PVC pipe with more PVC pipe. We rounded out a T joint of PVC pipe to make a cradle for the propeller to sit on. We attached the modified T joint to the frame, set the propeller in its cradle, and fastened it with clamps. The modification for our propellers shows that we work through challenges to solve them.

Troubleshooting

When it came to placing the three propellers we knew that the two forward trust propellers would have to be symmetrical to one another so that the balance was not thrown off. We decided that the propellers would be all aligned on a single linear shaft. They are located at the center of the ROV with the vertical thrust placed in between the 2 forward thrust propellers. To solve the problem regarding fastening the propellers to the ROV we customized the PVC. We took a T joint of PVC and shaved out the perpendicular leg.

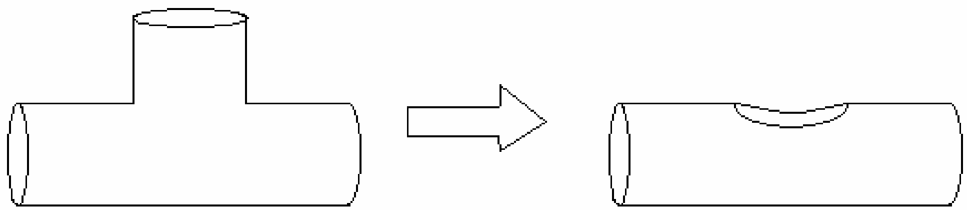

Figure I. Modified PVC joint

We fastened the round propellers to the concave part of the joint. We simply used a round metal clamp that can be tightened to hold it down.

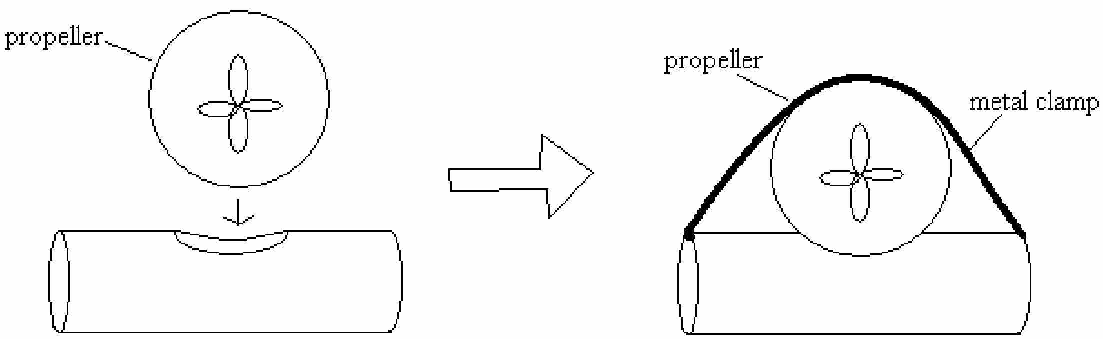

Figure J. Motor with propeller mounted in the 'cradle'

We also did not know how we were going to close the oil well. We thought of pulling it with a hook but we also considered pushing it. We came up with a simple idea that would stabilize the lever that is being closed. We thought that brush would eliminate movement from top to bottom which would not let the lever slip as it was being pushed.

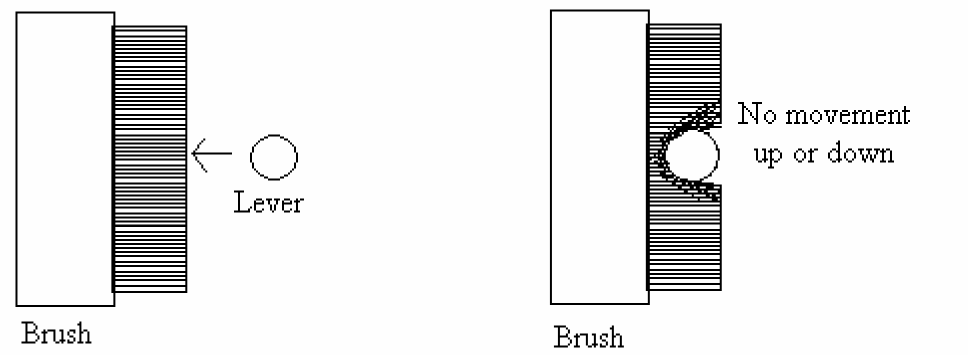

Figure K. Brush attachment pushing the end of the lever

Describe a new skill learned

During the designing and building of our ROV, our team learned several new skills. When building the electrical component, we learned the general concept of circuits. While we had studied electricity in school, building the ROV showed us an application. Most of our team had little experience with power tools before building the ROV. Afterwards, we were all proficient in the use of PVC pipe cutters, a Dremel rotary tool, hacksaws and drills. We used the PVC pipe cutters to build the frame and appendages of the ROV. We used hacksaws and the rotary tool to modify the propellers. We also used drills to strengthen the PVC pipe joints. Building the ROV taught our team useful skills, such as using tools and understanding electricity, which will come in useful in the future.

ROV Supported Areas

As technology advances, so does the need for remotely operated vehicles. There are already countless careers, organizations, and technologies that support the themes from this year's Underwater Olympics, but each year researchers are coming up with new ways to put ROVs to use.

Figure 1. Bathymetric map showing the layout for NEPTUNE. The dots connected by lines denote the backbone cable and locations of the seafloor science nodes, respectively. The dashed line is the approximate location of the US and Canadian Exclusive Economic Zone.

The NEPTUNE Gigabit Ethernet Submarine Cable System is a project currently being developed that will use ROVs on a frequent basis. It is headed by an executive Team, made up of representatives from the United States and Canada. The overall goal of these partners is to establish a regional ocean observatory amidst the Pacific Ocean. They plan to do so by wiring a 500 by 1,000 km area with a 3,000 km network of fiber-optic/power cables. These cables run along the perimeter of the Juan de Fuca tectonic plate for various reasons. When completed NEPTUNE will provide a "coherent system of high-speed, submarine communication-control links using fiber-optic/power cables that will connect remote, interactive experimental sites with land-based research laboratories and classrooms."

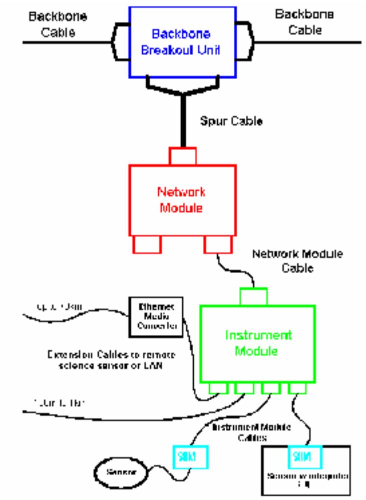

Figure 2. Sketch depicting the layout of a seafloor node.

Remotely operated vehicles will play a role in the NEPTUNE project when the network begins to operate sometime during or after 2007. At that time they will be used to remove, repair, and reattach damaged fiber-optic cables. ROVs will also recover equipment from the system for maintenance and/or upgrading. Since ROV assets were anticipated, the NEPTUNE infrastructure was designed to be maintained by underwater crafts. ROVs will bring equipment to the surface by first disconnecting any instrument modules, then, attaching a lift cable to the unit, and finally, hoisting it to the surface by the spur cable. ROVs are a beneficial alternative to trained specialists because they are faster, more efficient, less expensive, and do not endanger a living being. In the future, ROVs will be essential in keeping the NEPTUNE system running properly.

Resources:

- http://www.neptune.washington.edu/pub/whats_neptune/whats_neptune.html#Anchor-The-49575
- http://www.neptune.washington.edu/pub/documents/Comms.Oceans2001.pdf

Discussion of Future Improvements

Future improvements that could be made are:

- Earlier Starting Time. This would allow for more planning and practice.
- Better Camera: Color and night vision or underwater lamps would allow for better visibility
- Stronger Motor: This would allow for more thrust

Acknowledgements

The Home Depot, Lexington, Kentucky

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Bluegrass Mailing