Remotely Operated Vehicle (R.O.V.) Aquatic Science Competition*

TECHNICAL REPORT
RANGER CLASS DIVISION 2006

The Titanic ROV Project
Presented by the "Roverboys"
of Cherry Creek High School

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Ben Miller, Alex Hill, Coach/Instructor: Jeffrey E. Keefe

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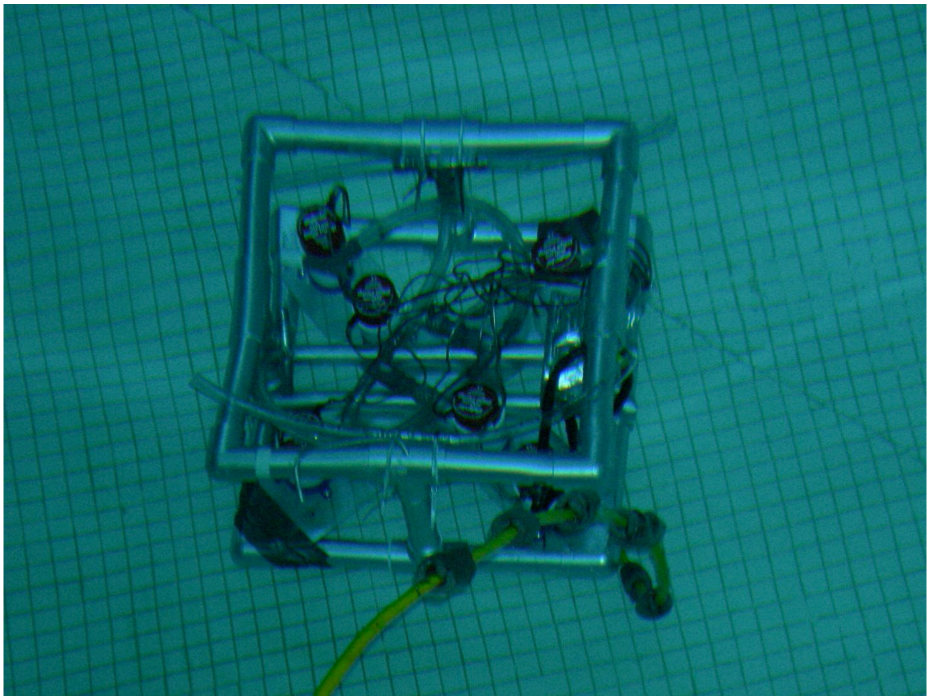
Marine Advanced Technology Education (MATE) Center

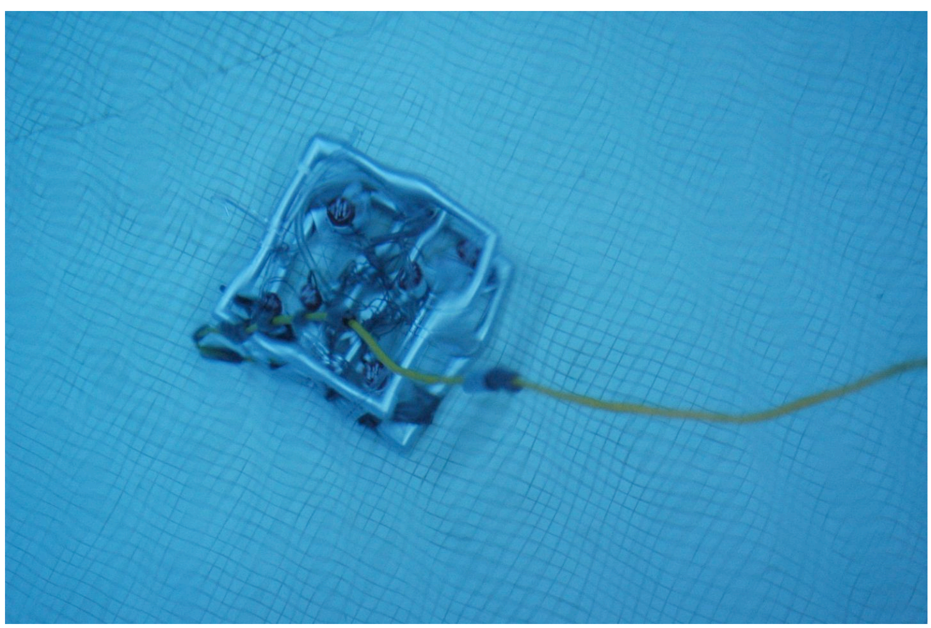
Abstract:

The challenges which confronted CCHS's Aquatic Robotics team entailed building a submersible, remotely operated vehicle (ROV), designed to perform three tasks necessary to compete in the Marine Advanced Technology Education (MATE) 2006 International Championship. The missions are modeled after real world scenarios that rely on CRT monitors for feedback so no direct observation is possible. An “electronics” module must be dropped inside a frame at the bottom of the “sea”, followed by picking up a “power” cable and plugging it into the module. Finally, a pin is pulled to release an instrument package. Discovering how to efficiently complete these tasks requires an extraordinary amount of experimentation. Our team began this quest by selecting appropriate materials and modifying the design as observations from tests were made. The design of the PVC frame could easily be changed and further modifications made by adding air pockets or ballast to improve buoyancy and weight distribution. Experiments with the propulsion system centered on varying a six motor design, which attempted to combine speed with maneuverability. Four motors were used to direct lateral motion and spin, while two motors adjusted “altitude”. Accurately controlling our ROV is essential because stationary probes are used to latch onto the equipment, which is then moved by altering the position of the entire vehicle. Although the problem solving aspects of this project were engaging, the teamwork aspect was actually the most important. Overall, this project was fun and a great learning experience. We expect to continue both throughout the competition and anticipate this will influence the work done next year.

Photos of Completed ROV:



Underwater test in Cherry Creek Swim Pool



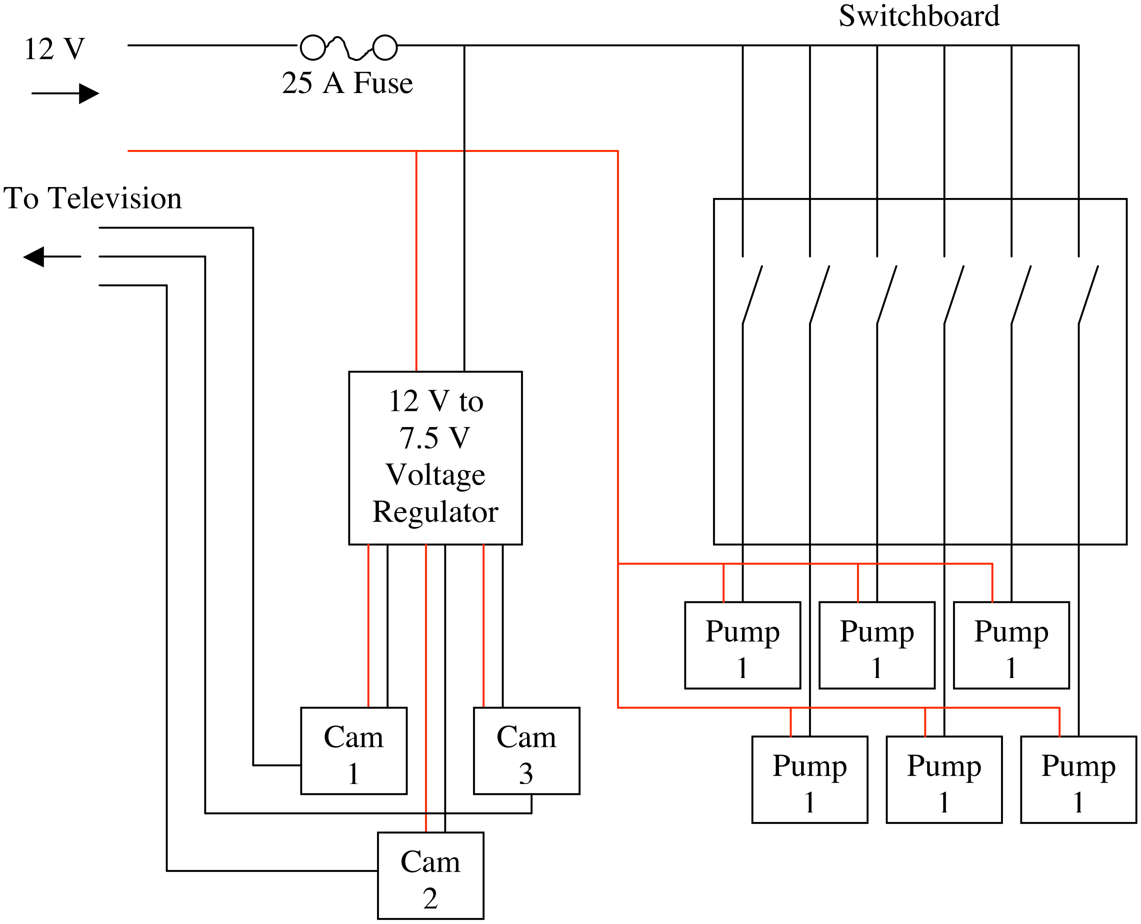
Budget/Expenses:

Item Description / (Vendor)	Quantity	Amount Spent ($)	Total Spent ($)
Bilge Pumps (500 gpm) (Rule Industries)	6	Donated / Rule Industries	$ 0.00
Underwater Electrical Cable (Sound Ocean Systems Incorporated – SOSI)	60 ft	Donated / Sound Ocean Systems Incorporated	$ 0.00
Shipping (FedEx)	1	Donated / Science Dept.	$ 0.00
1" x 10' Plastic PVC Pipes (Home Depot)	2	$ 5. 25	$ 5.25
IP56 Weatherproof Security Cameras (Harbor Freight)	4	$ 159. 42	$ 164.67
Books: (1) How to Build Your Own Underwater Robot (2) Build Your Own Programmable Lego Submarine (Westcoast Words)	1	$ 33.90	$ 198.57
Tools: Pliers (locking & regular) Wire Strippers (Lowe's)	1 ea.	$ 26.81	$ 225.38
DC to DC Converter (12V to 7.5V for the ROV's cameras (PowerStream)	2	$ 31.50	$ 256.88
Shipping (UPS ground)	1	$ 8.17	$ 265.05
1/2" x 10' PVC pipes (Home Depot)	8	$ 13.12	$ 278.17
PVC pipe fittings (elbows, Tee's, 4-way, connectors) (Home Depot)	25	$ 33.23	$ 311.40
Tool: PVC pipe cutter/scissors (Home Depot)	1	$ 17.12	$ 328.52
Liquid Tape (glue) (Home Depot)	1	$ 6.16	$ 334.68
3/4" x 22' Tape (Home Depot)	2	$ 5.15	$ 339.83

Item Description / (Vendor)	Quantity	Amount Spent ($)	Total Spent ($)
Plastic Zip Ties (Home Depot)	1 pkg	$ 6.42	$ 346.25
Plumbing Wax (Home Depot)	2	$ 10.27	$ 356.52
25 OHM 3W Potentiometer (RadioShack)	1	$ 4.28	$ 360.80
9–18VDC Hi Speed Motor [propeller experiments] (RadioShack)	2	$ 11.35	$ 372.15
12VDC Motor [propeller experiments] (RadioShack)	3	$ 3.19	$ 375.34
Resistors 15 OHM 1/2 W (RadioShack)	3 (5/pkg)	$ 3.19	$ 378.53
Fuses 25A (RadioShack)	3 (3/pkg)	$ 4.80	$ 383.33
Fuse Holders (RadioShack)	2	$ 5.13	$ 388.46
Fuses 20A (RadioShack)	1 (4/pkg)	$ 2.67	$ 391.13
10K Linear Potentiometer (RadioShack)	1	$ 3.10	$ 394.23
Epoxy Glue and Epoxy putty (Ace Hardware)	2	$ 10.71	$ 404.94
Pipe Insulation (Neoprene) (Home Depot)	1	$ 6.32	$ 411.26
Pipe Insulation (Foam) (Home Depot)	2	$ 3.76	$ 415.02
3/8” PEX pipe [small flexible “pvc”] (Home Depot)	1	$ 11.30	$ 426.32
PVC Pipe Sealant Kit (Home Depot)	1	$ 5.88	$ 432.20

Item Description / (Vendor)	Quantity	Amount Spent ($)	Total Spent ($)
1/4” Threaded Rod (Home Depot)	4	$ 12.76	$ 444.96
1/8” x 4’ Metal Rod (Home Depot)	3	$ 6.38	$ 451.34
1/4” x 3’ Aluminum Rod (Home Depot)	1	$ 2.56	$ 453.90
“U” Bolts (Ace Hardware)	8	$ 11.48	$ 465.38
Assorted Nuts (for bolts) (Home Depot)	1 pkg	$ 1.05	$ 466.43
Toggle Switches (Mouser Electronics)	10	$ 19.60	$ 486.03
DC to DC Converter 12V to 7.5V (replacement for ‘blown-up’ one) (Broadway Electronics)	1	$ 7.00	$ 493.03
Logitech Attack 3 Joystick (Microcenter)	1	$ 18.25	$ 511.28
35’ of Coated Copper Wire (RadioShack)	1	$ 4.28	$ 515.56
Galvanized 19 gauge Wire (Lowe’s)	1	$ 1.34	$ 516.90
Metal Rings & Wood Dowels (Hobby Lobby)	2 ea	$ 4.03	$ 520.93
6’ x 1’ Wood (Lowe’s)	1	$ 1.05	$ 521.98
Silicone “Caulk” (Home Depot)	1	$ 5.34	$ 527.32
Sprinkler System Fittings Tee’s and Male Adaptors (Home Depot)	8	$ 4.64	$ 531.96
Vinyl Tubing (Home Depot)	3 ft	$ 3.20	$ 535.16
Clear (UV) Camera Filters (Camera Trader)	3	$ 20.00	$ 545.16

Electrical Schematic:



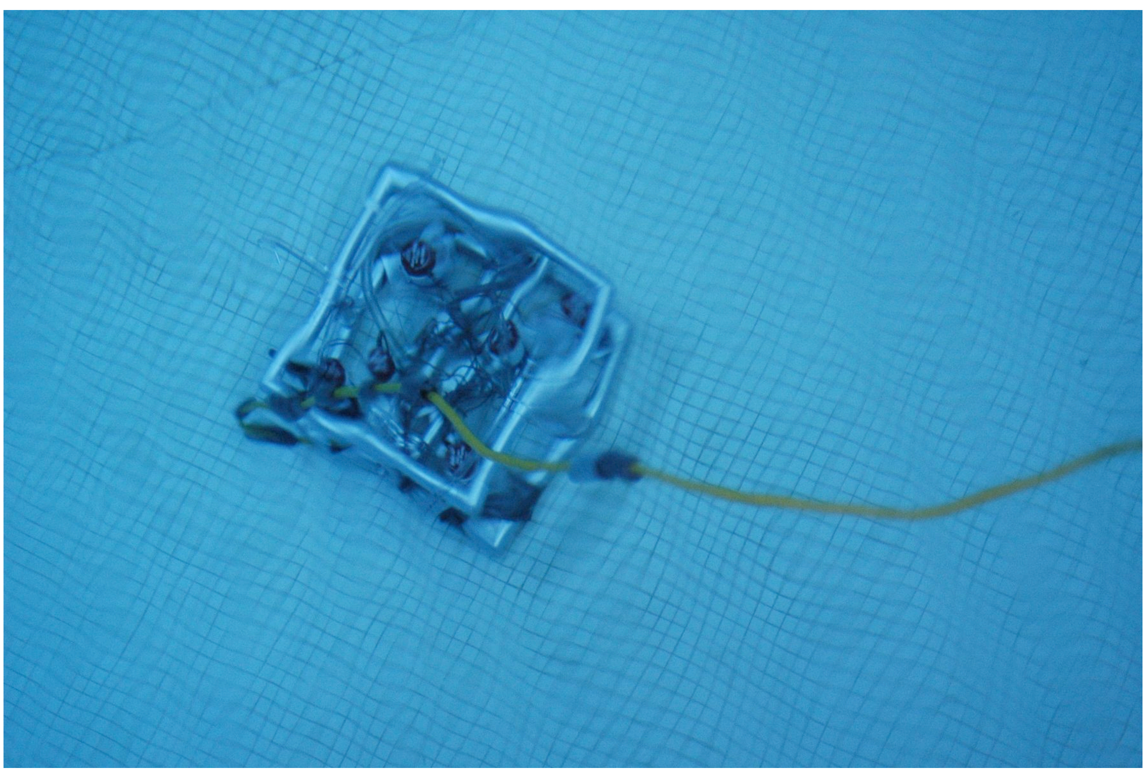
Design Rational:

Our design utilized a PVC structure for support and a bilge pump propulsion system. The PVC frame is a cubic design with lateral propulsion pumps located at each of the four lower vertices, two directed forward and two directed backward.

PVC was selected for its strength and availability. It is a material that is easy to mold and cut while also being available at local hardware stores. This allowed for rapid prototyping of the actual vehicle geometry. PVC was also selected for it low mass high volume qualities. This allowed us to control buoyancy through the use of ballast and empty PVC segments. PVC was also economically feasibility due to its relatively low cost.

Bilge pumps were selected for there high efficiency and cost effectiveness. Bilge pumps have the ability to focus their output through a small area thereby maximizing their energy output. Propellers, on the other hand, lose some of their energy to non-directional interference currents; lowering there effective lateral thrust capabilities. This translates into greater thrust force availability from bilge pumps than from propeller-based motors. Lateral control is obtained by two forward facing and two reverse facing bilge pumps. Turning is accomplished by firing one forward facing pump and its non-coiner reverse facing pump. Vertical control is obtained using two separate bilge pumps. Each of these two pump is connected two a triple T tube system to distribute the pumps force to each of the four corners of the vehicle. One pump and tube system is used to properly the vehicle down and one to propel the vehicle up. The four-point tube system was used to maximize vertical stability

Our manipulation system utilizes a series of hooks constructed from metal to hook and manipulate objects. This was chosen for its simplicity and effectiveness. Due to the none mobile nature of our manipulators, the vehicle relies on its navigational abilities to position of manipulators.



Challenges and Troubleshooting:

In building the ROV, there were several obstacles and challenges to overcome. These were the propulsion of the robot, the steering and control, and the buoyancy control. Once these three obstacles are complete, a basic ROV will be built. Then the team must design, build, and implement a method to complete the missions.

The first challenge that had to be completed was the propulsion of the ROV. Propellers or bilge pumps can propel the ROV. Both propellers and bilge pumps have advantages. The propellers can be used for both forward and backward motion with a simple switch of power. This allows for fewer motors to do the same job. Bilge pumps have the benefit of having a powerful stream of force that can be redirected to any direction with some tubing. That stream unfortunately is only a unidirectional stream and cannot be used to go opposite directions. There are a variety of propeller sizes and shapes that can be used; therefore, the wide variety of different propellers must be tested to find the one with the optimum balance between stability and force. To test for the best propeller, the force produced by each propeller shape and size must be recorded in a control environment. This can be done using force probes having the propeller pull on the probes adding additional force. The additional force is the force produced by the propeller. Propellers with diameters ranging from 2.0cm to 3.0cm and with 2 or 3 fins were tested. From this testing it was found that a diameter of 3.0cm and 2 fins was the optimal propeller to use for this application. There was variability in the results due to shaking of the motor and propeller during operation. There was also variability because of the imperfections in the propeller and the drive shaft mount**. If further testing is to be done, the propellers should be machined and the drive shaft should be more solidly mounted to the propeller.**

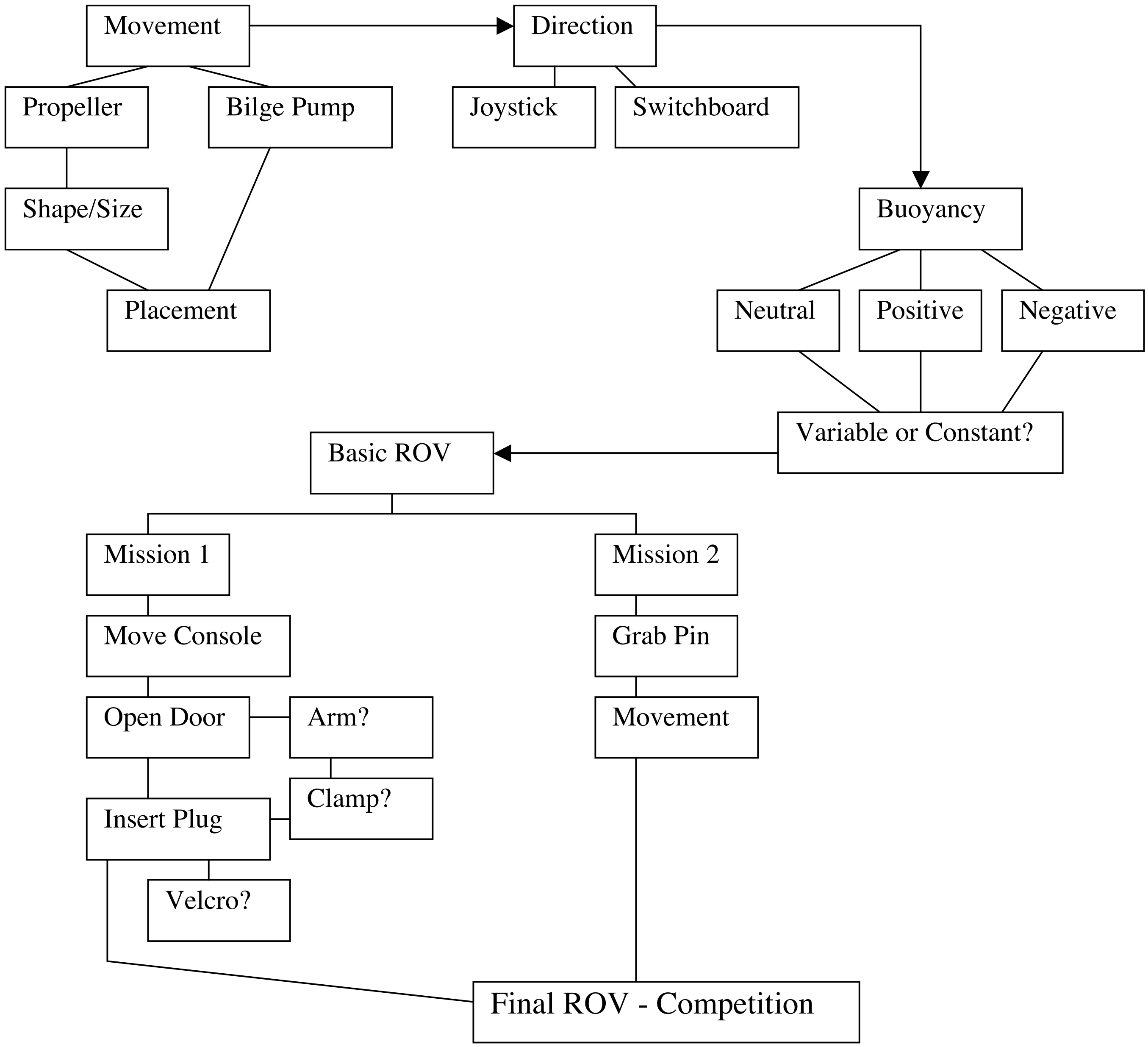
A second challenge our team had was in the coordination of testing, building, and organizing. Due to many factors it was difficult to find time to build and test our ROV. In order to test it in a sufficiently deep pool we needed to use the school pool in the diving end. Because of swim practice for boys and girls both before school and after school until late at night and swim classes during the day, it was difficult to find time to test the ROV in the deep pool. Our team overcame this problem by sacrificing time during the late nights or quick times in between practices on Saturdays to test the ROV.

Our team has learned many lessons and has experienced many situations during this project. Probably the most important lesson has been the development of our communication skills. This has become a very important aspect of building this ROV. We have all learned the importance of being able to communicate ideas and plans to other members of the group. Early on it was difficult for the group to get organized but as time went on we discovered the necessity for both email and phone calls to bring the group up to date. This skill also added in our ability to meet and plan things if someone couldn't make it to that meeting. In sum, communication is a very valuable tool that we will use for the rest of our lives.

Future Improvements:

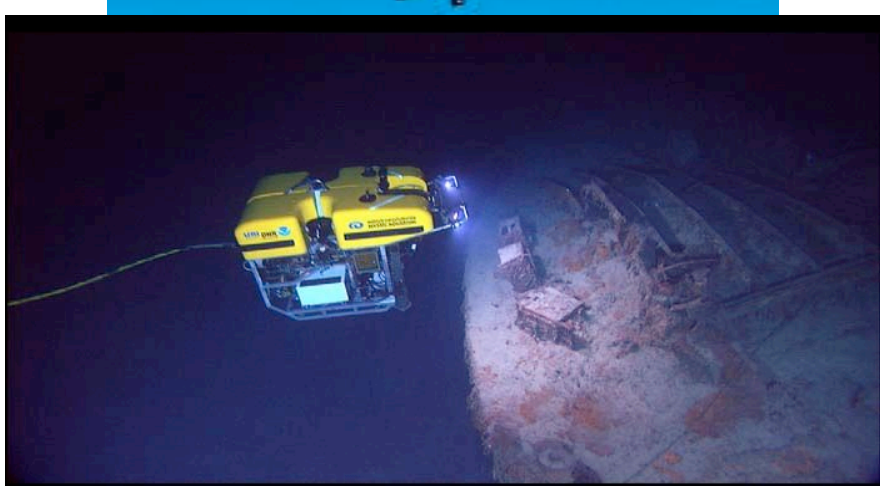
In order to improve the amount of control we have over our ROV the simplest change that might result in a significant improvement is to test a lighter weight electrical tether cable. The one we are using was graciously donated by SOSI (see budget) and works well, however, if we didn't have any financial restrictions there is a fair chance that it would have already been replaced (but we don't know until we try). The next biggest "bang for the buck" would be to upgrade our camera system. Financial considerations are again a limiting factor. There has also been discussion of using relays to activate devices on our ROV. This has several advantages, however, it also significantly adds to the complexity of our project and may make it less reliable.

ROV Flow Chart



ROV Use in the Oil Industry

In the oil industry, ROV's play a large role. The ROV's are utilized in areas which would normally be impossible for safe human travel. Some main uses of ROV's include sub sea construction, sub sea repairs, and oil drilling. The ROV's allow for work to be done in extremely deep water while humans control the robots from above. The use of ROV's has been increasing greatly, and the ROV's have helped many companies increase their revenue. For example, ROV's were responsible for 31% of Oceaneering International's revenue in 2005. The ROV's used in oil work come in multiple classes. These classes include heavy work, intervention work, and observation. The heavy work class performs construction at extremely low depths. The intervention work class is used to inspect pipelines and perform minor repairs if needed. Lastly, the observation class is used for exploration underwater to send back visual images of the surroundings. Overall, ROV's are very useful for work and exploration underwater. The repairing and constructing ROV's perform are similar to that of the competition tasks.



Acknowledgments:

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Jeff Schopperle ………………………………… Rule Industries
Lowe's Hardware ……………………………… Greenwood Village, Colorado

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Buoyancy Testing at Cherry Creek High School Swimming Pool