# Operation Submergible ROV

Clatsop Underwater Robotics Team

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Team:
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# Abstract

Clatsop Community College's Underwater Robotics Team built a submergible ROV to compete in the Marine Advanced Technology Education (MATE) 2005 National Championships. The ROV was built with the capability to perform a few simple operations. These are: to drop a line into a hole, connect Velcro pieces, and turn a lever. These tasks simulate connecting a cable, repairing a satellite, and closing a fuel valve. The ROV is adequately equipped to perform these tasks because of its design. The cameras monitor activity when the ROV is under water, and the propellers allow it to move vertically and horizontally. The ROV also has a stationary "arm" which the team uses to push objects around. The team left room for improvement by leaving an opening in the PVC pipe where a mechanical arm (or another accessory) could be attached. Through this experience we learned some troubleshooting skills, and the importance of organization. Michael Wilkin and Jon Graves, from OGI School of Science and Engineering, and Steve Sanders, an Automotive Instructor, acted as mentors for the Clatsop Underwater Robotics Team. With their direction, and the effort we've contributed, the ROV is ready for the competition.

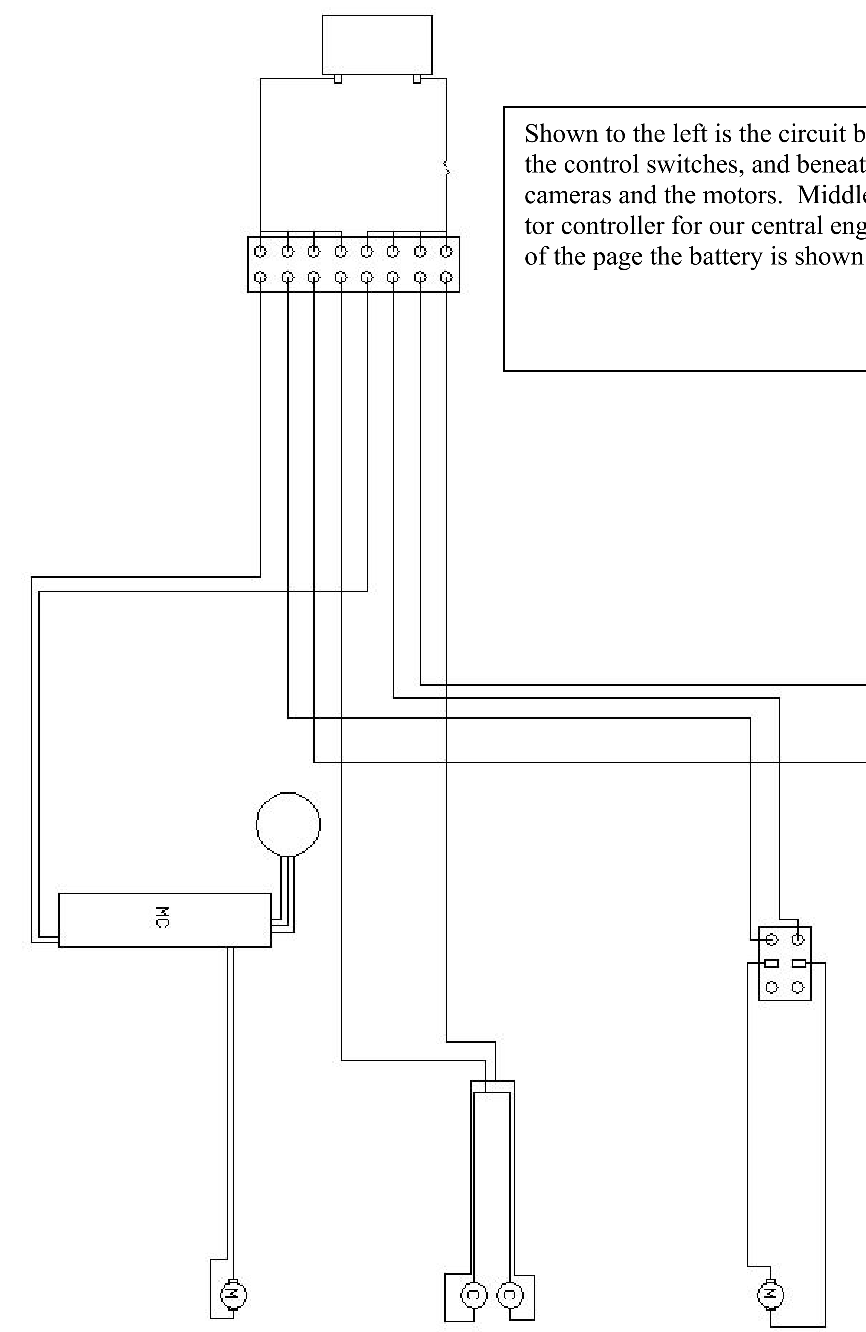
# Budget/Expense Sheet

| Date | Trans. | Description | Notes | Amount | Balance |
|---|---|---|---|---|---|
| | Deposit | Funds | MATE | $100 | $100 |
| | Deposit | Funds | Jenson Corporation | $500.00 | $600.00 |
| | Deposit | Funds | Rochester Trust | $800.00 | $1,400.00 |
| 2/13/2005 | Expense | 1 Plastic Prop | A-Train Hobby | $2.69 | $1,397.31 |
| 2/16/2005 | Expense | 4 3/4" PVC | Astoria Builders Sup. | $1.44 | $1,395.87 |
| | | 1 Cutter PVC Pipe | | $12.49 | $1,383.38 |
| | | 12 3/4" 90-elbow | | $3.48 | $1,379.90 |
| | | 24 3/4" Tee | | $11.76 | $1,368.14 |
| | | 5 3/4" 45-elbow | | $3.95 | $1,364.19 |
| 2/22/2005 | Expense | 4 3/4" 45-elbow | Astoria Builders Sup. | $3.16 | $1,361.03 |
| | | 4 3/4" 90-elbow | | $1.16 | $1,359.87 |
| | | 12 3/4" tee | | $5.88 | $1,353.99 |
| | | 6 3/4" PVC | | $2.15 | $1,351.84 |
| 2/28/2005 | Expense | 6 RUL 20A Pump | Englund Marine | $108.00 | $1,243.84 |
| | | 6 plastic clamps | | $3.00 | $1,240.84 |
| 3/8/2005 | Expense | 2 boat props | K & J's | $7.00 | $1,233.84 |
| 3/9/2005 | Expense | 1 20A DPDT SPG | Astoria Electornics | $4.49 | $1,229.35 |
| 3/9/2005 | Expense | 5 45Deg ELL | Astoria Builders Sup. | $3.95 | $1,225.40 |
| | | 3 3/4 90Deg elbow | | $0.87 | $1,224.53 |
| | | 2 3/4 90Deg elbow | | $0.58 | $1,223.95 |
| 3/10/2005 | Expense | 1 Shop cord | Fred Meyer | $26.99 | $1,196.96 |
| 3/30/2005 | Expense | 1 20A DPDT SPG | Astoria Electornics | $4.49 | $1,192.47 |
| 4/6/2005 | Expense | 1 Motor Controller | Carl's Electronics | $22.95 | $1,169.52 |
| | | UPS Shipping | | $5.95 | $1,163.57 |
| 4/13/2005 | Expense | 3 neoprene strip | McMaster-Carr | $15.39 | $1,148.18 |
| | | 500ft wire | | $38.95 | $1,109.23 |
| | | shipping charge | | $6.25 | $1,102.98 |
| 4/14/2005 | Expense | Unknown | Englund Marine | $4.50 | $1,098.48 |
| 4/14/2005 | Expense | 1 Bus strip | RadioShack | $1.99 | $1,096.49 |
| | | 1 Proj box | | $4.99 | $1,091.50 |
| 4/14/2005 | Expense | 1 3/4" adapter | Astoria Builders Sup. | $0.39 | $1,091.11 |
| | | 2 1" male adapter | | $0.98 | $1,090.13 |
| | | 1 red coupling | | $0.79 | $1,089.34 |
| | | 2 1x3/4 bushing | | $0.98 | $1,088.36 |
| | | 2 1" PVC adapter | | $1.58 | $1,086.78 |
| 4/16/2005 | Expense | 1 rust-oleum sp | Bob's Paint Land | $5.33 | $1,081.45 |
| 4/19/2005 | Expense | 1 3oz GLS White | Astoria Builders Sup. | $2.89 | $1,078.56 |

# Budget/Expense Sheet Cont.

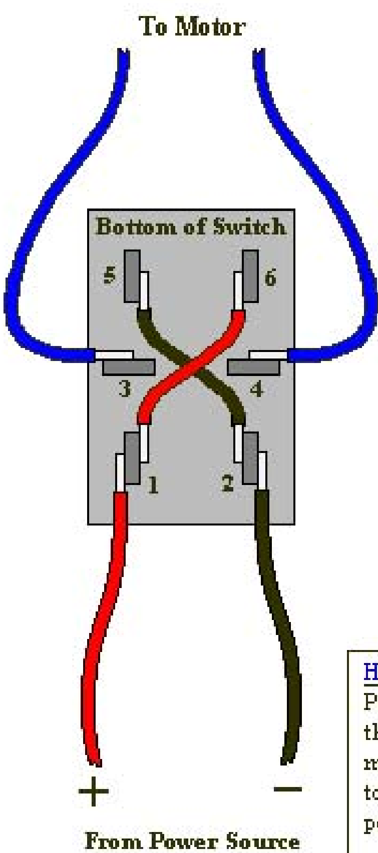
| Date | Trans. | Description | Notes | Amount | Balance |
|---|---|---|---|---|---|
| 4/26/2005 | Expense | 1 utility blade | Astoria Builders Sup. | $2.69 | $1,075.87 |
| | | 1 Purp Seal | | $4.49 | $1,071.38 |
| 4/27/2005 | Expense | Unknown | Englund Marine | $4.50 | $1,066.88 |
| 4/27/2005 | Expense | 1 micro perfboard | Astoria Electornics | $2.69 | $1,064.19 |
| | | 1 pk40 hex nuts | | $1.99 | $1,062.20 |
| | | 1 pk42 screws | | $1.99 | $1,060.21 |
| 4/28/2005 | Expense | 25 ID loom | Astoria Auto Supply | $12.25 | $1,047.96 |
| 4/29/2005 | Expense | 1 underwater cam | Amazon.com | $299.99 | $747.97 |
| | | shipping charge | | $20.00 | $727.97 |
| 3/15/2005 | Expense | Color Camera | Palm Video | $149.00 | $578.97 |

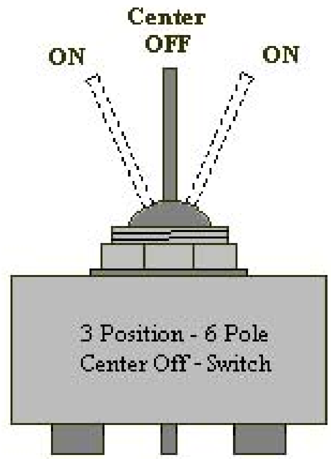
# Electrical Schematic



Shown to the left is the circuit board, below are the control switches, and beneath them are the cameras and the motors. Middle left is the motor controller for our central engine. At the top of the page the battery is shown.

# Electrical Schematic Cont.




How this set up works =

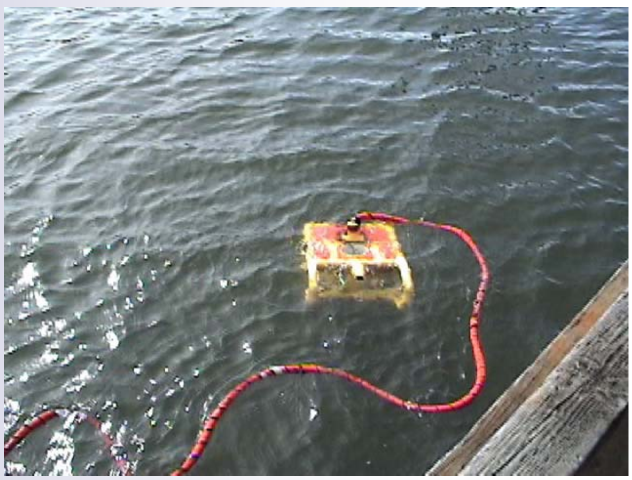
Power from the Source comes into Poles 1 and 2. When the switch is push Up this connects pole 1 to pole 3 and pole 2 to pole 4 which allows power to the motor in one direction. When the switch is pushed down this connects pole 3 to pole 5 and pole 4 to pole 6 and with the cross over wires from pole 1 to pole 6 and 2 to 5 this reverses the polarity to the motor.

Keep in mind this setup ONLY works with DC Current.

# Design Rationale

Before construction began on our Remotely Operated Vehicle (ROV), we had three major points to consider.

- First, the competition challenges and size limitations. The three challenges vary just enough that one attachment won't work in every situation. Also, the limiting of how large a ROV we can submit changes the ultimate shape of our entry.
- Secondly, we looked at how similar needs are currently met by existing ROV's in our size range. This gave us examples to base our design on.
- The third major point for our team to consider was our budget. Starting with $100.00 made creative engineering solutions necessary.



*ROV being tested in the Columbia River*

P.V.C. is an inexpensive, non-conducting, and easy to work with material that suited our needs. The elbows, T-junctions and other joint pieces allow easy construction, and as our design changed, we were able to modify our ROV to overcome our challenges. We painted our ROV yellow so that it would be very visible, even in murky water. The small size that we chose allows for easy transport to remote locations.

Buoyancy, we found, varies greatly on the thickness and placement of the tether. By wrapping our tether in neoprene taken from a diving suit, we took the strain of the tether off the ROV, allowing the tether to float. We added weights to the interior bottom frame, which stopped our rolling problem. We also added buoyancy to the top to achieve neutral buoyancy.

# Description of Challenges

Building a ROV presents many difficulties and challenges. When they came to our attention, we found was to overcome them. One of the first challenges we faced was getting the ROV to be stable in the water. As we tested the ROV, it would either sink, or fail to submerge. Because we had this problem with positive and negative buoyancy, we had to adjust the amount of Styrofoam we used. We also had to drill holes in the PVC pipe to attain the best buoyancy. This has been a constant struggle for us as we continue to make improvements and modifications to our ROV.

Another major challenge was finding time and people to work on the project. Most of the team members had jobs and classes to work around. Most of the people who initially worked on the team stopped doing so because they couldn't remain committed. This resulted in a lack of manpower. There was a lot of work and only a few people to do it. Our team member, Brian, ended up with the bulk of the work.

We also had challenges with the propellers. The first set we used weren't as effective as we wanted. The angles on the blades were not designed to go in reverse, so we ordered ones that are similar to those found on boats. These new propellers (shown at right) increased our maneuverability and speed control.

The control wires attached to the ROV became a challenge for us as well because they consisted of a long, heavy line that caused unneeded drag. It created tension on the ROV when we submerged it, and that manipulated its movement. We also had a problem with the line sinking. To overcome this obstacle, we wrapped it in neoprene. This eliminated the drag caused by its weight. The line is now able to float in the water, allowing the ROV to move freely (Interview).

# Troubleshooting Techniques

During our troubleshooting periods, if we had to think over something for about ten minutes and couldn't figure anything out, we went to our mentors for guidance. They gave us many suggestions, but never any answers. When we experienced problems with our ROV sinking, we added Styrofoam in different amounts until it remained stably buoyant. The control wires connected to the ROV also sank, and we were in a little dilemma until one of our mentors suggested wrapping it in neoprene. That was a simple solution that was extremely effective (Interview).

*Submersion test in the Astoria Aquatics Center*

# Skills Learned

The main skill we learned from this was to have a plan before embarking on such a large-scale project. We had no structure, no "road map" when we started, or designated job descriptions for everyone working on the ROV. We initially had eight people involved in the project, but through mismanagement of time and resources, ended up with only two. This probably could have been prevented by scheduling a regular meeting time. We could have organized ourselves better for maximum participation and continued interest. Toward the end of the project the lack of manpower hurt our chances of completing the ROV. There were too many tasks and trials to run without the time or people to finish them.

We also failed to designate a team leader at the beginning. We believe if we had designated someone to keep us on track, we would not have had such a lack of organization. We also never made a project outline, which would have enhanced our performance by organizing and delegating responsibilities. We never assigned specific tasks to team members either. The work would have been more efficient and organized if we had planned the process thoroughly before we even began fabricating the ROV (Interview).

# Future Improvements

There are several things we would like to change for the development of a more technically enhanced ROV. For future improvements we would start by installing smart sensors for depth reading. This feature would be especially practical in murky water, where the ROV would disappear due to the water conditions and depth.

We would also like to add side bilge pumps that would increase our control of its lateral movement. Currently we can only move it vertically, but if we could move the ROV from side to side, we could manipulate it more easily.

In addition to these, we would add a servo for the camera. This would allow the camera to move up and down, and therefore have a better surveillance range in clear water. Currently we have to adjust the camera manually for the desired picture in specific tasks.

A mechanical arm would be a definite improvement on our ROV. If installed, it could pick up tools and operate simple tasks more efficiently than the current methods we employ with stationary attachments. A couple of extra motor controllers could also be installed for better control of the ROV. These additions would greatly improve the ROV's performance level to potentially exceed the competition expectations (Interview).

# ROVs in Marine Sanctuaries

Originally developed for industrial use, remotely operated vehicles (ROVs) were most commonly used for non-scientific work, such as inspecting an underwater pipeline or offshore platform. However, they have since expanded their presence into the scientific community. Most ROVs are fitted with a camera and lights at minimum, but they may also be outfitted with other accessories, such as a still camera, a manipulator or cutting arm, water samplers, and instruments for measuring water clarity, light penetration, and temperature. These capabilities and the many benefits they provide have made ROVs invaluable tools in marine exploration and education.

*Remotely operated vehicles (ROVs) are essentially robots operated by a person aboard a surface vessel (Remotely 1)*

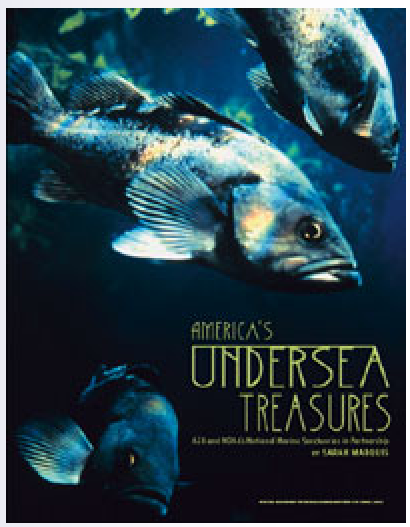

*ROPOS (Remotely 1)*

Although ROVs cannot match the detail of human observation, and their mobility is restricted by being attached to the ship, they more than make up for it in other ways. For example, they are much simpler to operate, due to the fact that they aren't as big as submersibles and can be monitored from the ship. Also, because ROVs are unmanned vehicles, they are much safer than launching a submersible or diving expedition. ROVs are often stored on ocean exploration vessels as a safety precaution. Should a submersible become entangled or lose power, a ROV can be used to assess the situation and possibly free the sub or return it to the surface. It is also the safest means of investigating a dive site before a submersible is launched (Remotely).

In 2003, the National Oceanic and Atmospheric Administration (NOAA) headed an expedition to survey more than 50 submarine volcanoes along the Mariana Arc volcanic chain, finding 10 of them to have active hydrothermal systems. In 2004, they led a second expedition (2004 Submarine Ring of Fire) there, using a ROV called ROPOS that enabled them to explore and collect samples from the hydrothermal sites. One of the first expeditions of its kind, it indicated that island arc hydrothermal systems vary in character (morphology, eruptive style, chemical composition) from ones along the mid-ocean ridge (Submarine 1).

# ROVs in Marine Sanctuaries Cont.

ROVs are also being used to educate the public. The Mystic Aquarium in Connecticut has dedicated a theater screen to its Immersion project. There, visitors can view live video imagery by controlling a camera-equipped ROV, which is based on Monterey Bay's ocean floor and transmits the imagery to the theater. The system, called telepresence, will also host a ROV in Florida Keys National Marine Sanctuary. The Immersion program is made possible through the partnership of NOAA and the National Marine Sanctuary Program and the Sea Research Foundation, for the benefit of sanctuaries, zoos, aquariums, and the anxious public. Says Daniel J. Basta, Director of the National Marine Sanctuary Program: "People protect what they know and love. AZA [American Zoo and Aquarium Association] member aquaria and zoos give millions of Americans the ideal opportunity to experience our national marine sanctuaries through exhibits, programs, and telepresence."




*Immersion promotional poster (AZA and NOAA 1)*

With the invention and implementation of the ROV, scientific marine studies have gained a whole new dimension. The ROVs' unmanned capabilities and multiple functions continue to propel our understanding of science through those scientific studies and public interaction alike.

# Acknowledgements

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# Works Cited

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