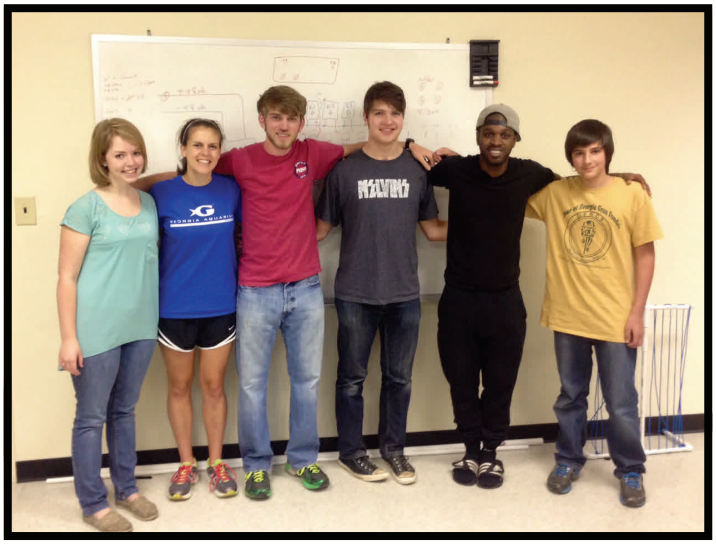
University of Georgia ROV Team

ROV Seadawg

Athens, Georgia, USA

Explorer Class



Employees	Major	Team Position
Evan Newman, High School Sophomore	Young Dawgs Program	Programmer, Electrical Engineer
Tyler Claxton, Freshman	Environmental Engineering	Engineer, Co-Pilot
Alex Orlowsky, Junior	Biological Engineering	Chief Design Engineer
Salu Smith, Senior	Biomedical Engineering	CEO, Design Engineer
Josh Sherrill, High School Senior	Young Dawgs Program	Pilot
Allison Fortner, Sophomore	Agricultural Communication	Communications Officer, Chief Financial Officer

Mentors

Dr. Noakes, Dr. Prasad, Dr. Woodson, Mr. Fortner

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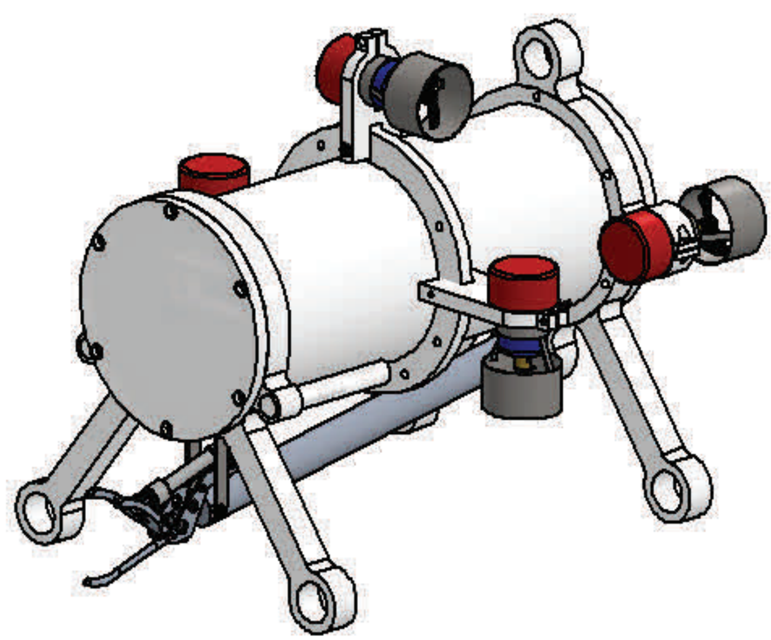
Abstract

The University of Georgia Remotely Operated Vehicle (ROV) Team designed and constructed the ROV Seadawg for environmental surveys and shipwreck exploration. The Seadawg's simplistic design is compact, but yet rugged to handle exploring inside and around shipwrecks. It is equipped with multiple thrusters to allow motion in all directions for maneuvering around obstacles. The forward mounted camera and operational arm allow manipulation of objects on the seafloor and potential sampling capabilities. The team consists of engineers and scientists trained to operate the ROV under multiple survey scenarios and will work hard to produce the results expected from a professional survey corporation.



SolidWorks drawing of ROV Seadawg

Budget

Purchased Items

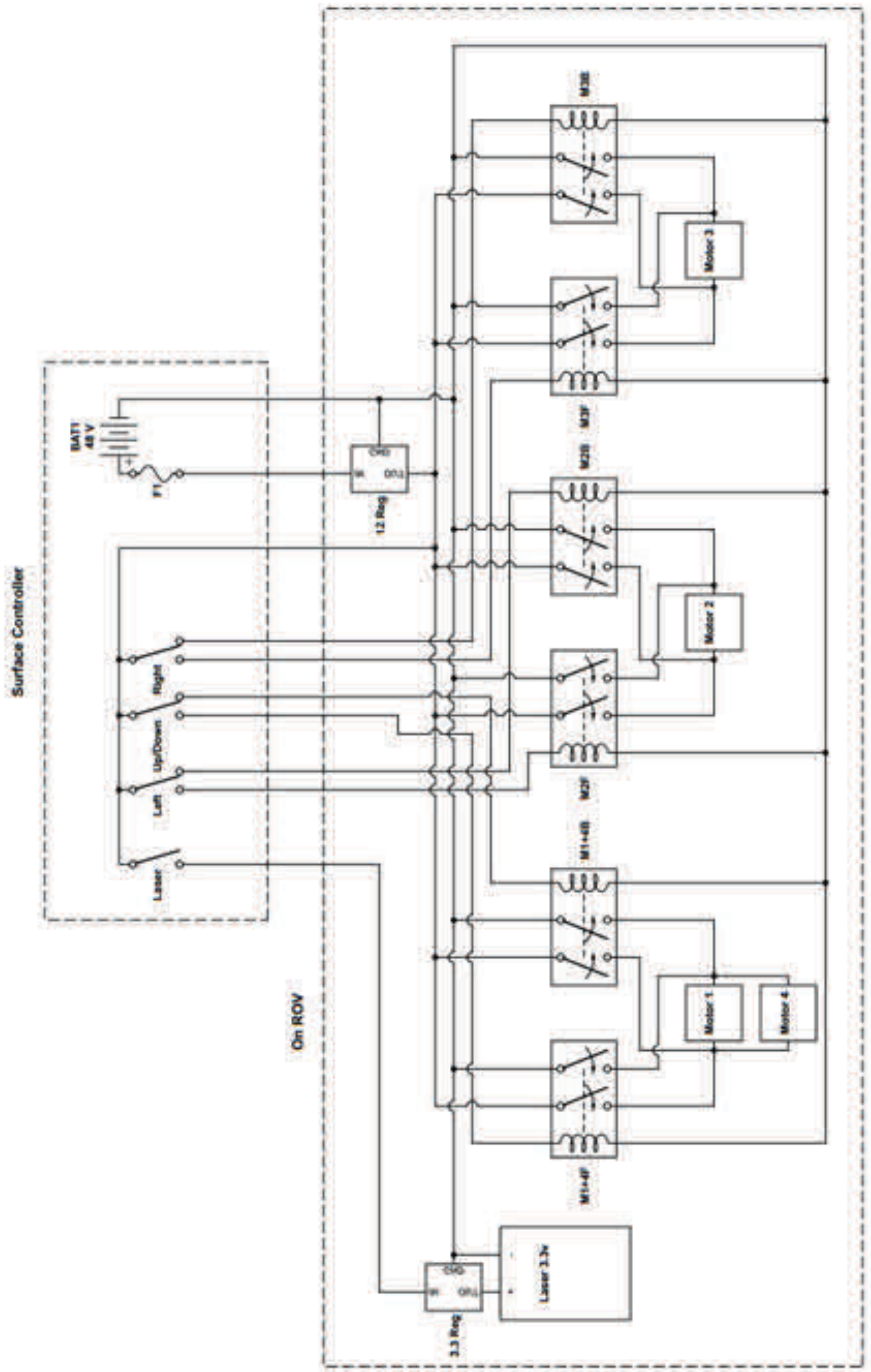
Item	Number of Items	Cost	Total
500 gal bilge pump	5	34.99	174.95
50 mm props	5	1.99	9.95
Lasers	2	25.00	50.00
Web Camera	1	75.00	75.00
Hose Clamps	5	0.75	3.00
Mini DC Converter	2	7.50	15.00
48 Volt DC Regulator	2	15.00	30.00
Switches and Control Box	5	14.00	70.00
TOTAL			**$427.90**

Donated Items

Item Donated	Donation made by:	Estimated Cost
6" Schedule 80 PVC pipe	UGA Instrument Shop	20.00
Air Cylinders	UGA Instrument Shop	145.00
Tether	UGA Instrument Shop	130.00
Tether Spool	UGA Instrument Shop	200.00
1" PVC Sheet	UGA Instrument Shop	66.85
1/2" Aluminum Plate	UGA Instrument Shop	10.00
CAT 5 Cable	UGA Instrument Shop	25.00
Screws and Accessories	UGA Instrument Shop	50.00
Electronic Wiring and Switches	UGA Instrument Shop	75.00
1/2" Clear Acrylic	UGA Instrument Shop	10.80
TOTAL		**$732.65**

Total ROV Cost $1,160.55

System Interconnection Diagram



Design Rationale

Frame:

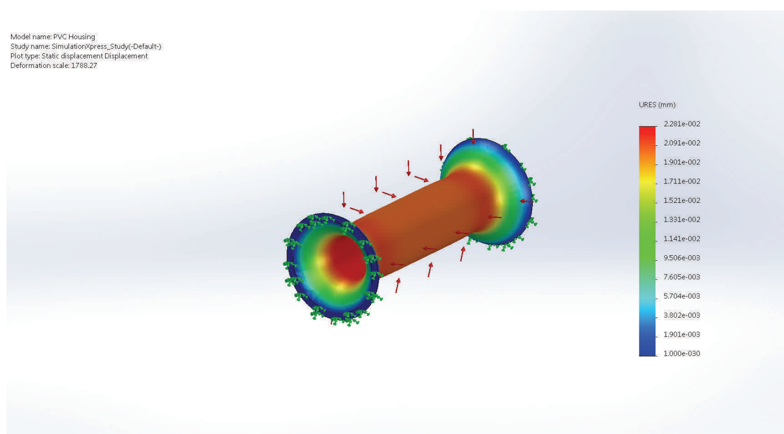
For our ROV, we wanted to design a vehicle that was both sturdy and able to move quickly through the water to accomplish the tasks. Because of time constraints, we needed to house all of the materials in a waterproof container without using excessive time to build the container.

The UGA ROV Team designed the Seadawg to be compact and rugged which allows for easy maneuvering in the water. Often exploration takes the survey vessels into tight quarters inside a shipwreck. The hull design is constructed of schedule 80 PVC pipe and serves as the main structure and pressure housing. The PVC is light weight, yet sturdy. It houses the electronics, wires, cameras, and any other necessities. End flanges were designed to incorporate the end cap mounts as well as struts to hold the housing off the seafloor. The front flange was designed to hold the lasers needed for measuring the size of the ship. The back flange holds two thrusters. These flanges were counter bored to make a step mount providing a positive seal when glued in place. The flanges were drilled and tapped to allow the end caps (clear acrylic on the front and aluminum on the rear) to be bolted in place. The caps were sealed by an o ring counter sunk into the flange. The total weight of the Seadawg is 15 kg and is neutrally buoyant in the water.

There is an additional PVC flange around the middle of the PVC pipe that has three thruster brackets. We have attached two thruster brackets that allow for vertical movement and one that allows for horizontal movement.

Pressure:

The durability of the ROV was tested using a built in program in SolidWorks. The program simulated the pressure that would be applied to the ROV in the water at a depth of 10 meters and then displayed vonMises stress and strain profiles. The ROV withstood the pressure applied to it during the simulation with the maximum displacement of the main body of 6.753e-007 mm (see attached displacement plot).



Design Rationale

Propulsion:

The Seadawg is powered by 5 reversible thrusters which are modified 500 gallon per hour bilge pumps. Two thrusters are mounted on the rear of the ROV which provide forward and reverse motion. Two thrusters are mounted around the middle of the ROV housing and provide up and down motion. Finally, a fifth thruster is mounted on the top of the ROV to provide left and right motion. Combined, these thrusters allow the Seadawg to move rapidly through the water. They also give the operator the dexterity to maneuver the Seadawg in tight places around a shipwreck. The controls have spring loaded toggle switches allowing brief pulses of power to be sent to the thrusters or can be held on for full power. The laser switch is spring loaded to avoid being left on accidentally.

Control System:

The control system consists of a hand-held control module, a laptop computer, a tether, and relay interface boards.

The Handheld Control Module consists of momentary electrical toggle switches for actuation and directional control of thruster motors, a momentary push button for laser actuation, and pneumatic valves for manipulator control.

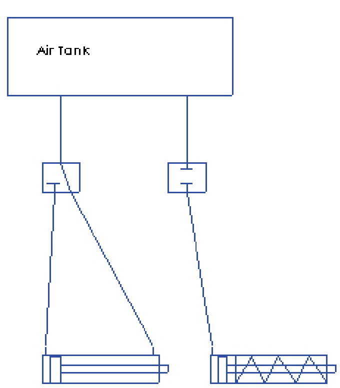
The laptop computer is used for video display and data collection

The tether provides for transmission of power, control actuation, and video transmission.

Relay interface boards provide motor control.

Manipulator:

The manipulator is pneumatically controlled and allows the fingers to touch the seafloor at full extension. The fingers have a small pneumatic cylinder that allows them to close on an object when encountered. The air supply is a pressurized tank stored on the surface and feeds air by tubing to the ROV. Surface controls allow the operator to extend or retract the arm as well as close the fingers to grasp an object.



Design Rationale

Control Housing

All of the control materials that we used are housed inside the 6” schedule 80 PVC pipe.

The lens that caps the front of the ROV is made of 13 mm thick acrylic. The lens is screwed into the front piece of PVC with 1/4-20 screws. There is an O-ring positioned between the front flange and the lens to seal the water out.

The back end cap of the ROV is made of 13 mm thick aluminum. The back end cap has ten 1/2 npt holes to run the wires into from the tether. The holes in the back end cap are waterproofed with rubber compression fittings. There is also an O-ring to seal water out between the aluminum and the back flange.

Tether:

The tether of the ROV allows for control from the surface to the ROV. The tether consists of three cables including and three air lines for manipulator actuation and the following:

1. 10 conductor 20 awg control cable
2. 16/2 so power cable
3. CAT 5 video cable

The maximum length of the tether is 20 m.

Electronics:

The ROV is powered by 48 volts from a surface battery pack. This allows for the system to be safely powered down in the event of an emergency. An umbilical connects the ROV and is used to transfer the voltage, video and air supply for the pneumatic arm. All through connections have strain relief incorporated to prevent wires getting pulled from the housing. Electronics are housed inside the pressure housing and include a 48 volt to 12 volt step down; relays to send power to the thrusters, a 12 volt to 3 volt step down to power the lasers; and a high density video camera. The electronics are all mounted on a tray which is fastened to the aluminum end cap. This allows all electronics to be removed at the same time as the end cap making for easier trouble shooting and repairs if necessary. Two 5 mW, 532 nm military grade green lasers are mounted on each side of the front for measurement digitizing.

Camera:

The camera used in the ROV is a Logitech B910 HD Webcam that is simply accessed through USB communication. We chose to use this type of camera because of the high quality image relayed to the surface from underwater and reasonable price. The camera is located inside the PVC housing of the ROV, directly behind the clear acrylic front end cap. We access the image through a webcam program on a laptop at the pilot’s station.

Safety

In constructing the ROV, we always wore safety goggles, long pants, and closed-toe shoes when working with machinery in order to avoid any injury to eyes, legs, or feet.

We designed five guards, one for each propeller on the thrusters. We made them out of 1/16" stainless steel. They are designed to guard the propellers from human touch in order to prevent injury from moving propellers. We wrapped a sheet of stainless steel to form a circle to go around the propellers. We spot welded a thinner piece of stainless steel to this piece and attached it with a hose clamp. These pieces are attached to the thruster motors.

There is a 10 amp in-line fuse at the positive terminal of the battery in order to protect the circuit in the event of an electrical short or overload. The thrusters are also waterproof, and all external electrical connections are potted to prevent electrical shorts. Strain reliefs are attached to all cables to prevent disconnection resulting from external forces.

Momentary push button for laser actuation was chosen to prevent lasers from remaining on when not in use. We also installed removable protective caps for lasers to prevent accidental exposure to laser beam. A team member also took the required laser safety course to ensure that we had the proper knowledge for handling lasers safely.

There is a tether coil that is convenient for transportation of the tether, and the coil also helps us keep excess tether length organized so that we can safely move around the tether without tripping at the poolside. This ensures that the ROV is not put in jeopardy by people moving the tether suddenly at the surface

Challenges

The primary challenge of the team was time constraints and team turnover. We did not foresee the regional competition being moved up so far in advance, so we faced a deficiency of time from the first team meeting. Also, the fact that this is the first year that UGA ROV has entered the competition or attempted to build an ROV presented a problem.

At first, we spent time getting to know each other so that we could evaluate each team member's strengths and where each person could serve best on the team. This learning and growing process presented a challenge because it took us a few weeks to become comfortable as a group working together and sharing ideas. This took away from the fleeting time that we did have to construct the ROV.

During the brainstorming process, we had trouble because we were continuously debating about the design that would provide maximum efficiency. Since none of the team members had previous experience in constructing ROVs, the brainstorming and debate process took too long, and we finally had to settle on a simplistic and rudimentary design.

Finally, we faced another challenge in being able to come together as a team, provided class schedules and time allotted in the work space we have. Classes also took away one team member who was to serve as the Chief Electrical Engineer, causing us to fall behind on design because of a lack of knowledge of electrical engineering on the part of the other team members.

Because of these multiple obstacles, our ROV design is very simple; however, we feel that the ROV will hold up to rugged conditions inside shipwrecks. The simplistic and small design allows for maximum efficiency in moving in the water.

We constructed our ROV on a very rudimentary level so that we could begin pool tests and find out what could make it more efficient. After this, we used our remaining time adjusting the flaws we saw in the system. We had to switch the red lasers to green ones because the red was not easily viewed underwater. We also constructed protective covers to improve the efficiency of the thrusters. Finally, we found that the ROV needed more weight in order to reach an ideal buoyancy. We had to adjust the weight on the ROV accordingly.

Lessons and Skills Gained from Project

During this project, the ROV team learned the necessity of time management. As each member is new to the ROV design and building project, we had to get to know each other. This gave the project a slow start, and discussions were mainly abstract in the beginning of design discussions. We learned that complex designs do not conform to time constraints. Because of our struggle to get the project going quickly, we had to realize a simple design quickly and get to work designing an ROV that could simply make it into the water and be controlled.

We learned valuable teamwork skills in a professional setting that were more serious than that of typical group projects. Because of the technical and time restraints, we learned team member strengths from our struggles. We were able to assess the skills of other team members, learn from them and work with them.

A number of our team members gained the skill of learning the SolidWorks design program during this time. The engineers of the team had never used this particular design program. We worked with our mentors to understand how to work with the system to design the ROV. Though this took time, the engineer students ultimately gained a skill that helped us all see the ROV as a whole and piece-by-piece. The SolidWorks skills have the potential to be very useful and marketable in future careers for our engineering students.

Reflections on the Experience

Working as a first-time ROV team with people from various backgrounds was an exciting and frustrating experience. Because we all came with different skills, we had to learn to utilize them accordingly. Growing and learning with the rest of our team members has made this experience valuable. Though some of us never imagined being in a competition like this one, the unique nature of the project let us venture with our imaginations what we could build. Being able to imagine an ROV and figure out how to make it become a reality has truly been a rewarding experience. Though we became impatient at times, our team has truly become a solid group of individuals. We are proud of the work that we have put into making this ROV come to life. The first time we were able to put the ROV into the pool and test the mission tasks, we all felt immense joy at what we had accomplished. We are very excited to be competing in the international competition because it shows the leaps and bounds we have made since we first joined together as a team and how applying our knowledge can truly exhibit an amazing real-world result.

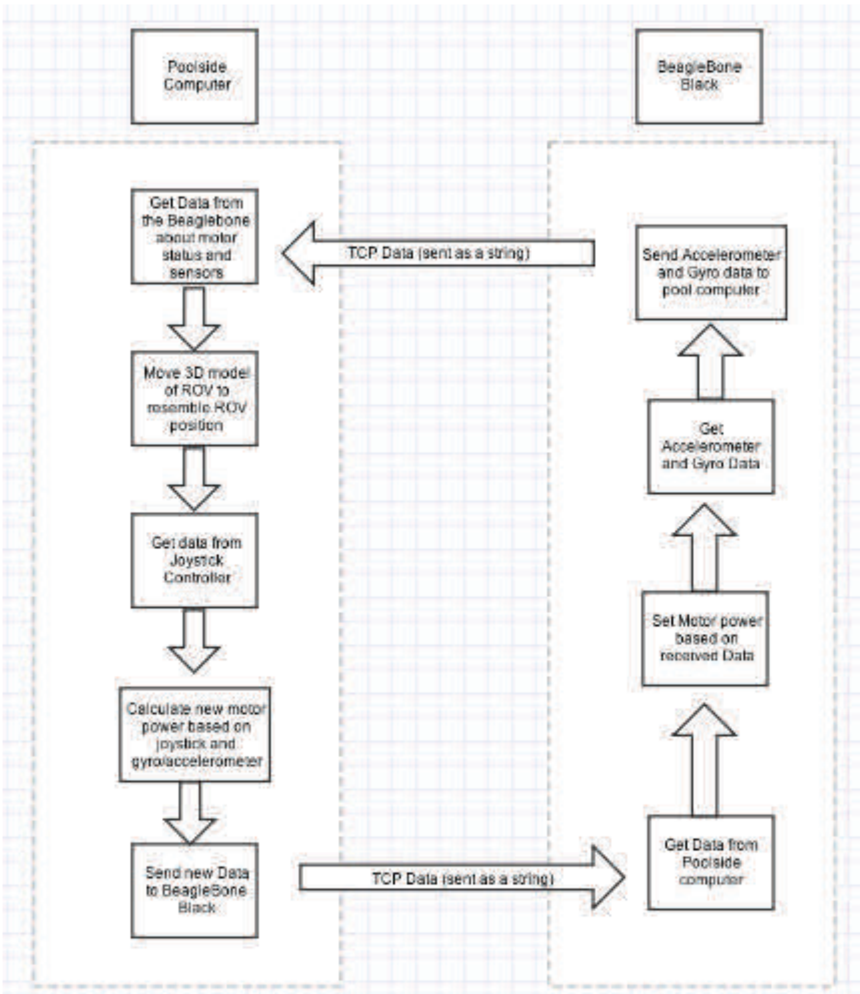
Acknowledgements

We would like to thank the MATE ROV Center for making this application of our knowledge and skills possible. We are honored to be able to compete in this competition. We would also like to thank Dr. Scott Noakes, Dr. Ravi Prasad, Dr. Brock Woodson, and Mr. Lewis Fortner for all of their help in making this ROV a reality. They brought us together with the idea of an ROV team and were willing to mentor us and address the many questions we had along the way. The University of Georgia Instrument Shop made construction of the ROV possible, and we would like to thank them for their immensely generous support. Additionally, the travel to this competition would not have been possible without the support of UGA's Center for Applied Isotope Studies, Engineering Department, and Instrument Shop. Thanks to all those who supported our ROV journey!

Room for Future Improvements

In the future, we would like to modify the control system by doing away with toggle switches and relays and changing to an onboard computer for thruster control and video transmission.

A preliminary flowchart is attached to display the design intent.



Mission Summary

The UGA ROV Team will explore the Thunder Bay National Marine Sanctuary and identify the shipwreck by using the following techniques applied to shipwrecks, science, and conservation.

Scanning:

In order to scan the wreck, we will use the camera and utilize the thrusters to position the ROV on the designated targets. This will require precision in positioning the ROV and exemplify the ability to keep it in one place in the water.

Measurement:

We will use the lasers for measuring the shipwreck. The green lasers are utilized for optimal visibility in the water. The distance between the lasers are fixed which allows digitizing software to use the laser dots for scaling. Once digitized, a photo of the wreck can be accurately measured. With the hull measurements, we will be able to better uncover the identity of the ship.

Photo mosaic:

By taking multiple pictures of the ship while holding the ROV steady in the water, we will be able to construct the photo mosaic with separate software. This will require precision in ROV positioning and skilled use of the camera that is essential for underwater exploration.

Object identification (prop, paddle wheel, mast):

We will be able to utilize the camera and ROV movement with the thrusters in order to identify if the vessel has a prop, paddle wheel, or mast. By knowing the rough shape of the objects, we will be able to easily identify them underwater.

Remove rope debris:

We will use the manipulator to remove the rope debris and access the inside of the shipwreck. This will require skill in controlling the manipulator and its pneumatics, as well as special control of the thrusters to keep the ROV in the correct position while operating the manipulator.

Enter wreck and look for date/plate:

After we have removed rope debris from the entrance of the ship, we will use the compact and rugged features of Seadawg to enter the shipwreck. Because Seadawg was designed to operate in small spaces, we will be able to maneuver fairly easily inside the ship. This will provide for easy identification of the plate and the date written on the inside of the ship. We will use the visibility of the camera to get close to the plate and find the date. The plate located inside the ship will need to be recovered in order to determine the vessels home port. These clues will help us uncover the ship’s identity.

Recover marine debris:

We will use the manipulator to pick up marine debris and bring it to the surface.

Deploy/Recover sensors

The manipulator arm will be used to take the new sensor array down to the seafloor. Once released, the old sensor array will be grasped in the manipulator and returned to the surface.

Open cargo hold to determine grain or coal

An important clue to the identify of the ship lies in the cargo hold. The manipulator arm will be used to open the lock on the cargo hold and then open the door. Once open, the cargo will be visible with the ROV camera. It will be important for the vessel identification to determine if it was carrying grain or coal.