Graham High School
The Fighting Falcon

Skyler Gist, Sixth Grade
David Major, Senior
Stephen Major, Senior
Stephen Persinger, Junior
Chad Rockey, Senior
Anthony Ward, Senior

Instructor: Mrs. Rose

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Figure 1: Forward view of the Fighting Falcon ROV

Abstract

Ohio is a state of "Firsts." The Wright Brothers are acknowledged as the inventors of the first airplane in Dayton. An Ohio native, Neil Armstrong, became the first man to walk on the moon. In 1962 Ohioan John Glenn was the first American to orbit the earth. And now, Graham High School, St. Paris, Ohio has entered the first Ohio high school ROV team in this International Competition. Our ROV is the product of considerable design and research. Constructed from an assortment of PVC tubing and fittings which form the skeleton of the robot, our ROV has PVC ballasts attached to the frame to maintain neutral buoyancy and to allow for stability and control without relying solely upon our thrusters. Attached to the frame are six modified bilge pumps which turn the propellers. This allows for ample thrust in all directions, providing speed and maneuverability. A camera mounted on the ROV will allow our team to assess underwater movement and help perform tasks at hand. We have devised a pneumatic-powered arm that will allow our ROV to grasp and release the door and lid to our first task. This arm will also aid in pulling the pin in the second task. All systems are controlled via wiring routed to and through the joystick. This allows for the ROV complex operations to be accurately controlled by team members who will be operating the ROV.

Budget/Expense Sheet

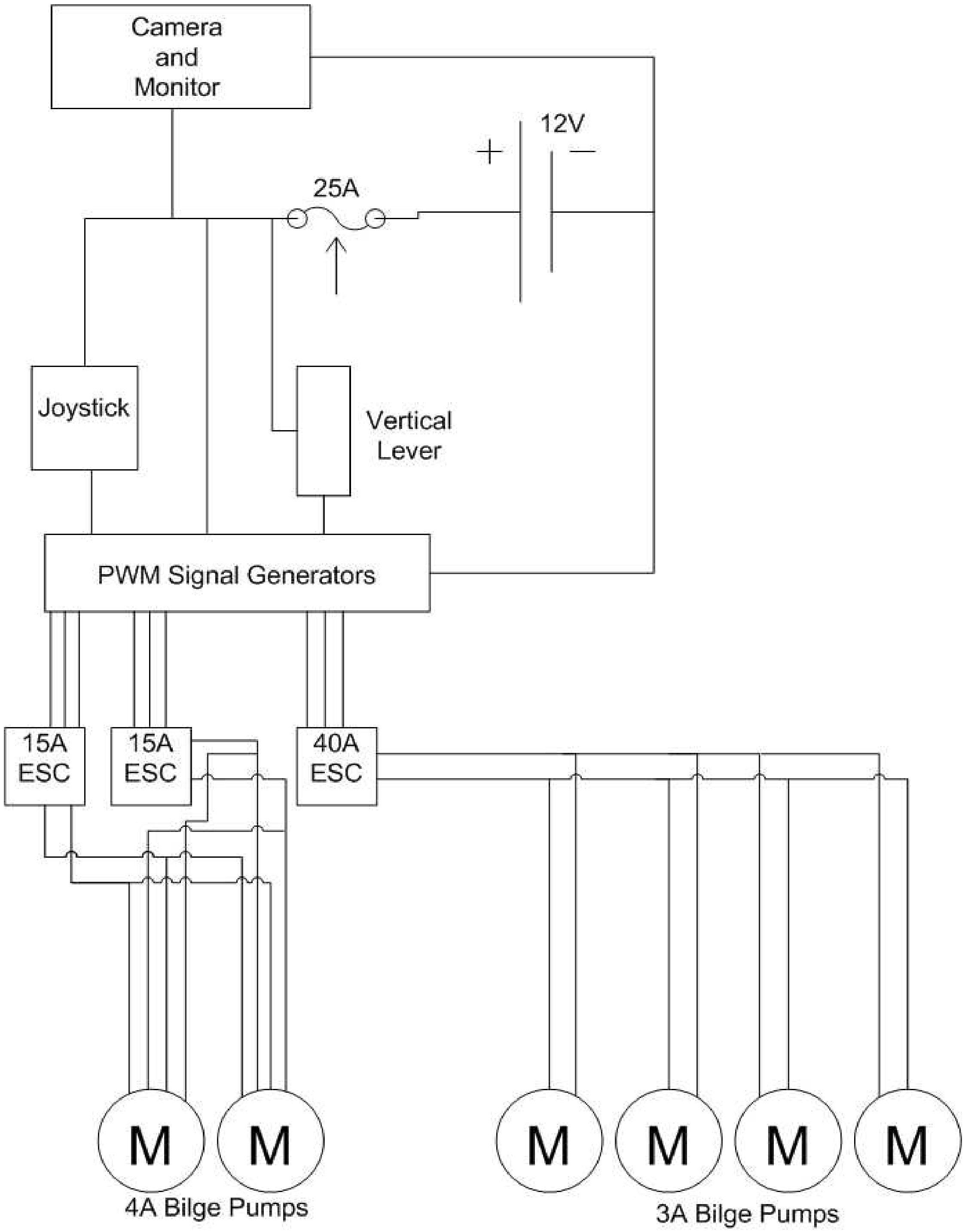
Item Purchased	**Price per Unit**	**Quantity**	**Total Price**
Bilge Pumps	$20.00	6	$120.00
Boat Propellers	$4.50	6	$27.00
Epoxy	$4.20	2	$16.39/shipping
PVC Assort-ments	N/A	N/A	$45.23
Electrical Tape	$3.97	1	$3.97
Electrical com-ponents	Assorted	21	$26.77
Breadboard	$9.20	1	$9.20
Antistatic Strap	$4.20	1	$4.20
Joystick	$2.12	1	$2.12
Air hose, fit-tings, gauges for pneumatic system	Assorted	49	$223.52
TOTAL COST:			$478.40

Donations

Sponsor	**Item Donated**	**Cost**
Buckeye Automation	60 foot of air hoses 100 foot Umbilical (CAT5)	$30
Ward Construction	Camera	$130
Mtroniks	Speed Controllers - 2 Viper 15’s Sonik Marine 40	$140
KTH Parts Industries	Electrical components	$20
TOTAL Donations		$320

Purchased $478.40	**Donated $320**	**TOTAL COST $798.40**

Electrical Schematic



Flow Chart of Software

No programmable software was used in the construction of the ROV.

Design Rationale

Structure

When designing the ROV, it was necessary to use a strong, lightweight material; therefore it was in the team's best interest to use 1.27 cm outer diameter PVC. This material is also very handy because it comes in many shapes and sizes. The team used straight PVC, "L"-shaped PVC, "T"-shaped PVC, and 45 degree PVC collectively to form the body of the robot. The size of the ROV results from fitting the required components of the ROV.

Pneumatics

The team decided to utilize pneumatics in the composition of the ROV. By doing so, the team avoids using as much electricity because four components run off of one air compressor. The four pneumatic components consist of the front ballast, right ballast, left ballast, and actuator.

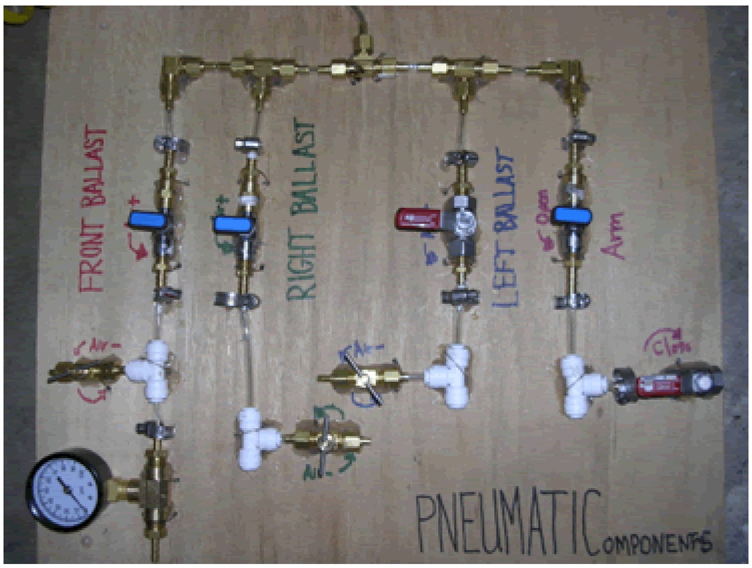


Figure 2: Pneumatic Controls

The front ballast is utilized in controlling the ROV's pitch. By increasing air volume in the ballast, the ROV's front slants upward, while decreasing air volume in the ballast allows the front to slant downward. This ballast is controlled from the top using a series of specialized pneumatic controllers. In order for the ballast to raise, air must be added. Air is added to the ballast by opening a ball valve. Closing the ball valve discontinues the adding of buoyancy to the ballast. In order to lower the ballast, air volume must be taken away by using a release valve. Air pressure is observed by looking at a psi guage. By testing the ROV before the competition, the team can find pressure measurements for the desired pitch of the ROV.

The left and right ballasts provide vertical buoyancy as well as yaw. These ballasts are controlled independently from the top using two different series of specialized pneumatic controllers. In order for the ballast to raise, air must be added. Air is added to the ballast by opening a ball valve. Closing the ball valve discontinues the adding of buoyancy to the ballast. In order to lower the ballast, air volume must be taken away by using a release valve. To change the yaw, one ballast can increase air volume while the other remains unchanged. Yaw can also be changed by decreasing the air volume in a ballast while the other remains unchanged. To raise the ROV as a whole unit, both ballasts are filled with air; inversely, to lower the ROV as a whole, both ballasts are unfilled of air.

In order to achieve neutral buoyancy, the ballasts had to have enough air volume to equal the poundage of the ROV. Collectively, the front, left, and right ballasts as well as the frame have a total air volume of about 796.036 cm^3. This volume is equal to about 1.36 gallons. 1.36 gallons of air neutralizes a weight of 11.30 pounds. The ROV weighs about 18.00 pounds. To get the required air volume to acquire neutral buoyancy the team added a central closed ballast that has a total air volume of about 475.234 cm^3. This volume is equal to 0.81 gallons. 0.81 gallons of air neutralizes a weight of 6.76 pounds. Therefore, the entire air volume is equal to 1271.1684 cm^3. This volume accounts for 18.08 pounds, which is more than enough buoyancy to give the ROV neutral buoyancy

Actuator

The actuator is also controlled pneumatically. This arm was created using a small cylindrical air inflator. The coupler inside the cylinder, surrounded by an o-ring, had a one-way valve that was sealed. The air hose leading from the cylinder was converted to a free-flow hose so that air could flow both ways through the hose. By filling the cylinder with air, the pump leading to the coupler is extended. The top of the pump was adapted with a bar perpendicular to the circular pump handle. This bar acts as part of the arm that wraps around an object. Another "L"-shaped bar is attached to the outside of the cylinder. This bar acts as part of the arm to secure the object in a closed grasp. There is also a guide rail that runs through the bar and just into the cylinder. It also runs through the pump handle. Just above the handle, on the guide rail, a spring was added. This spring acts to close the arm around an object when air is released. In order to open the arm, air is added to the cylinder, compressing the spring.

Figure 3: Pneumatic Actuator

Propulsion

The ROV consists of six 500 gallon-per-hour bilge pumps. These bilge pumps were converted to propellers with the ability to rotate in two different directions. Four of these propellers are placed on the outer four bottom corners of the ROV. They are also positioned in a 45 degrees away of a vertical line. These propellers are used to raise and lower the ROV in addition to the ballasts. By positioning the propellers at 45 degree angles, the force created by the thrust of the motors is more centralized towards the center of the ROV. This creates greater stability. The two other 500 gallon-per-hour propellers are placed in the center of the middle left and right vertical PVC pipes. These propellers are used to turn the ROV left and right. The team decided to use more efficient propellers for the left/right movements so that two propellers would be enough thrust. Collectively, the propulsion system, created by the propellers, allows the ROV to move up, down, left, and right.

Figure 4: Modified Bilge Pump

Electrical

The electrical system was designed for variable, reversible control. Each of the four vertical motors is controlled in parallel. These motors are run from an Electronic Speed Controller, ESC, that measures its output from a servo testing circuit. This circuit is given a variable Pulse Width Modulated signal from a potentiometer located on a non-spring loaded lever. The steering motors are designed to take advantage of "tank style" controls. The settings for both forward and both backward are controlled by one speed controller, along with one potentiometer inside of the joystick (modified for more suitable potentiometers). To pivot left or right, the final ESC is controlled by the other potentiometer inside the joystick, this then rotates the ROV left or right, as one motor is wired in opposite to the other for the output of this last speed controller.

Challenges

A significant challenge was to devise a method to variable control the output of the motors. At first, we considered doing everything analog using variable potentiometers that would cut the current to zero in the middle of the cycle. We then found this unfeasible, so we decided to look for a preassembled electric wheelchair control box and joystick. However, of the units available in our area and price range, this idea also turned out to not be successful. Finally, we were able to control the motors variable using unmodified potentiometers, hobby speed controllers, and a PWM generation circuit.

Another challenge is that the majority of this team is Seniors, so there was much to work around to schedule work meetings. Besides the normal end of the year exams and activities, the team had to work around graduation festivities, parties and events. As a first year team, we had a lot to learn in a short amount of time. It was very important to divide the systems, research, design and think and then report back to the group. Communication was key and if a team member could not make a meeting, this was difficult.

Troubleshooting Techniques

When beginning work on the Servo Testing Circuits, we could not identify any signal being produced by the circuit. I used a logic probe and could determine that the signal was pulsating. When we connected a radio control hobby servo to the circuit, we could see that the signal was there, but incorrect. Using different capacitor sets, we modified the circuit to create different RC time constants. The servo then worked perfectly, but the speed controller did not. Connecting the speed controller to a 12v source and the control circuit to test a motor, the speed controller drew a lot of current and melted. Then we tested another speed controller, and this one did not draw the current or melt. Therefore, it looked as if the original

Lessons Learned and Skills Gained

Skill Gained: Teamwork
By: David Major

Teamwork is one of the many skills I gained as a member of our ROV team. In any group project there has to be efficient teamwork to be successful. It is more effective to have the ideas of five people and combine those ideas into one product. In result, all the teammates are happy with the product, and the product is improved. Another benefit of teamwork is a check system. With five minds working, it is easier to discover a mistake. Because of this, our ROV will have less error. Also, division of labor is an important benefit of successful teamwork. With the immense amount of work required to complete this task, having many hands is a great help. Teammates are divided into their area of expertise and are able to do their part with confidence. The reliance that our team has on each other is proof that we do not work as individuals, but as a team. The collectiveness and efficiency of teamwork has proved a vital component in the completion of our underwater ROV. The components of teamwork including more ideas, check systems and individual expertise help to develop a product to its full potential.

Lesson Learned: Patience
By Anthony Ward

Throughout this great experience of designing and constructing our ROV I believe that the biggest lesson I learned was patience. If it was waiting for supplies to be delivered or trying to construct a tedious part of out ROV, patience was always needed. I always tried to remain calm because worrying about situations would only create more havoc throughout the process. In the end all of my patience has paid off. We have finished our robot and our finally getting a chance to begin the fun part!

A Middle Schooler's Perspective
By Skyler Gist

Coming into this challenge I was faced with a variety of things. The International Remotely Operated Vehicles Competition is the first big project I've ever worked on. One of the things that I've learned is to always have teamwork. It is important to get the other team members consent and input before gluing a piece of PVC pipe or cutting a PVC pipe. I learned to be open-minded throughout the whole process from the rough draft to the practice model, and finally, the "real" thing. Another important thing about this challenge is that I'm the only middle schooler and the rest of the team are high schoolers. I've learned to listen to my older team mates and let them "mentor" me throughout this challenge. I've found that that if a listen to my older teammates I gain knowledge and better understanding about The Remotely Operated Vehicles Competition. After all the dust has settled, I think that I've come out of this experience with a better knowledge and understanding of robotics and how to mechanically make things work, whether we win or not. No matter what happens I've had a lot of fun creating this ROV with my teammates.

Future Improvements

This was a year of firsts; the first time anyone on our team had been introduced to remotely operated vehicles, the first time anyone had designed or built an ROV and the first time anyone had competed with a design built from scratch. As with anything, it only gets easier from this point. Further research on pneumatic arms to improve and develop our current design would be advantageous. Better use of time management would minimize minor problems turning into major difficulties. For example, selecting and ordering components with enough time to make substitutions if parts are unavailable or out of stock. It would be very beneficial to begin early in the school year. Near the end of the school year, there are many activities and responsibilities for students. Additional time would allow for more time in the testing phase to work out problems.

Mechanical Engineering: A supporter of ocean observing systems

By: David Major

Mechanical engineers research and develop new technologies in our constantly changing world (Wikipedia). They use their knowledge of math and science along with their ingenuity to create and improve upon things. Mechanical Engineers are well rounded; in fact, mechanical engineers are qualified to work in the fields of automotive, biomedical nuclear and robotics engineering (About Construction). Their knowledge of robotics, fluid dynamics, materials science, manufacturing processes, thermodynamics and heat transfer, and Environmental Science aid in their ability to perform in all these different categories of engineering (About Construction).

Mechanical engineers help to create new technologies that will aid in ocean observing systems. Along with many others, they are planning the research and operational components of these systems. With the completion of this grand task, the world's oceans will be linked and new knowledge about the oceans will be obtained. With this knowledge, we will be able to more accurately predict and prepare for changes that will impact the nation and the world. Hurricanes, Tsunamis, Storms, Droughts, Global Temperature change: All will be deciphered by the successful completion of these new observatory inventions (Engineering and Communication).

With these mechanical engineers' products, the world will be able to safeguard itself from the unpredictable conditions of earth. Their ability to design and create along with their background and skills, aid in their effort to defend the human race.

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Great Lakes Observing System- GLOS

By Anthony Ward

We decided to research GLOS because we are closely connected to what occurs at the Great Lakes. The Great Lakes are our ocean. The long-term goal of ocean observing is to improve understanding of ocean climate and ocean environment. GLOS is working to preserve this goal.

The Great Lakes Observing System (GLOS) is a non-profit corporation that provides a wide community access to present and past data on the hydrology, biology, chemistry, geology and cultural resources of the Great Lakes, its waterways, and the St. Lawrence River. GLOS is funded by the NOAA Coastal Services Center, which is an office within the National Oceanic and Atmospheric Administration. There are more than 300 users of the system ranging from environmentalists to scientists and teachers. The Great Lakes Commission is leading initial development of GLOS along with nongovernmental organizations.

GLOS uses many tools to perform their research. Some of these tools include buoy systems, satellite observations, ship observations, and aerial observations. All of these components will help GLOS ensure national security, improve predictions of climate change, and restore degrading coastal ecosystems.

Works Cited

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