The Finnovators

Newport High School Robotics, Newport, OR, USA

Staff

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Abstract: This company is composed of six students who aspire to become engineers. We are based out of the coastal town of Newport, Oregon where we all attend high school together. We built this Remotely Operated Vehicle (ROV) to operate underwater and complete specific missions for NASA's exploration of both Europa, a moon of Jupiter and the Gulf of Mexico. It is capable of moving in any direction, retrieving items off of a seafloor, broadcasting a live feed and taking snapshots of this feed, and measuring depth and water temperature. It has a working claw to pick up and carry objects which operates using a pneumatic system. The ROV withstands at least 5 meters of water depth and has a cubic design with sides that are about 31 centimeters long. It weighs 9 kilograms in the air and is neutrally buoyant in water. We built our ROV from scraps, with the motors, Arduino and pneumatic actuators as the most complex items we purchased. For some of our pieces such as the claw and the motor shrouds, we used Autodesk Inventor and designed the exact pieces that we needed and 3D printed them ourselves. Our ROV's claw has been designed to easily fit around objects that are both spherical and rectangular for versatility purposes. It can operate in salt, fresh, and chlorinated water, so it would be valuable to groups wishing to conduct underwater exploration.

Project Cost

Item (Quantity)	Cost (Dollars)	Status	Donator	Reasoning
Johnson 500 GPH bilge pump motor (4)	87.48	Purchased		Propulsion
PVC Frame (10'4")	11.25	Donated	NHS Robotics	Structure of ROV
PVC (Coupling and 3" Pipe for Pressure Housing)	10.00	Donated	Mentor	Pressure Housing
TTL Arduino Camera (2)	79.90	Purchased		Vision
MPX4250AP Depth Sensor	15.41	Purchased		Measure Depth
LM35 Temperature Sensor	0.79	Purchased		Measure Water Temperature
¼ inch acrylic disks	13.43	Purchased		Pressure Housing
⅜ inch acrylic disks	10.99	Purchased		Pressure Housing
Linear Actuator 043-DXP	62.30	Purchased		Claw Operation
Xbox 360 controller	29.99	Purchased		Driving of ROV
Arduino Uno	12.99	Purchased		Control System
Flotation (pool noodles)	4.00	Purchased		Buoyancy
Electronic Plate	2.00	Donated	NHS Robotics	Mounting electronics
Air hose (110 ft)	36.00	Donated	Mentor	Claw Operation

Power Filter	7.97	Donated	NHS Robotics	Smooths Power
Power Shutoff Switch	4.00	Donated	NHS Robotics	Emergency Power Off
Sabertooth Dual Motor Control (2)	59.99	Purchased		Control the motors
Acrylic Cement	6.58	Purchased		Pressure Housing
50 ft. Ethernet Wire	8.91	Re-Used	NHS Robotics	Data Communication
USB to Ethernet	14.99	Donated	NHS Robotics	Communicate with Arduino
3-D plastic (1 Reel)	44.99	Donated	Mentor	Print Custom Parts
Screws	3.00	Donated	NHS Robotics	Pressure Housing
Shrink Wrap	7.49	Purchased		Soldering Wires
Relay	6.79	Purchased		For Solenoid Valves
O-ring	1.00	Donated	Mentor	Pressure Housing
Backup Camera	12.99	Purchased		Rear Vision
Solenoid Valves (2)	149.20	Purchased		Pneumatics
Brass Check Valve	18.80	Purchased		Pneumatics
Pneumatic Fittings	39.02	Purchased		Pneumatics
7 Inch Monitor	32.99	Purchased		Display For Video
5V DC-DC Converter	14.22	Purchased		Power Reduction
Rotary Actuator	128.55	Purchased		Claw Rotation
PVC Union	44.00	Purchased		2nd Pressure housing
3 inch PVC Cap	4.79	Purchased		2nd Pressure housing
Total	986.80			

Estimated Budget

Item Category	Estimated Cost (Dollars)
Structure (PVC)	30
Cameras (3)	180
Motors and Control	150
Arduino	50
Electronic Housings	35
Claw	90
Wires/Tether	25
Temperature Probe	20
Depth Sensor	25
Pneumatics System	440
Control Panel	20
Total	1065

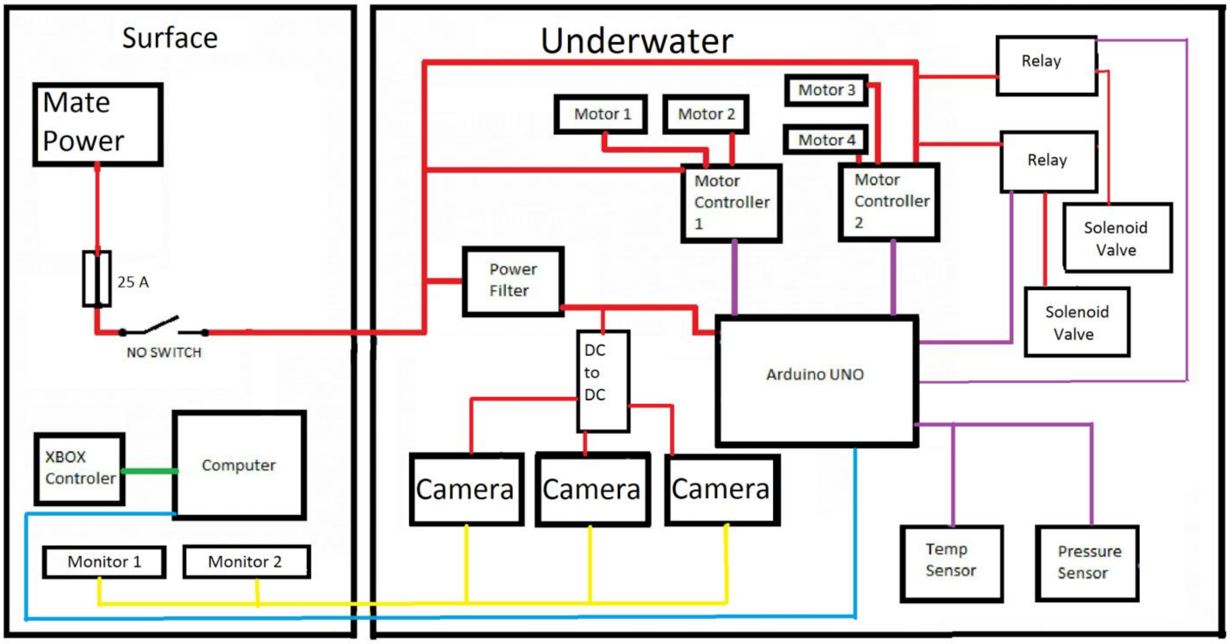
Travel Costs

Our team has a budget of $11,000 for travel, which covered plane tickets, hotel fees, and meal costs for all members of the team, chaperones, and two club officers. Each plane ticket is approximately $500 round trip.

Budget Planning

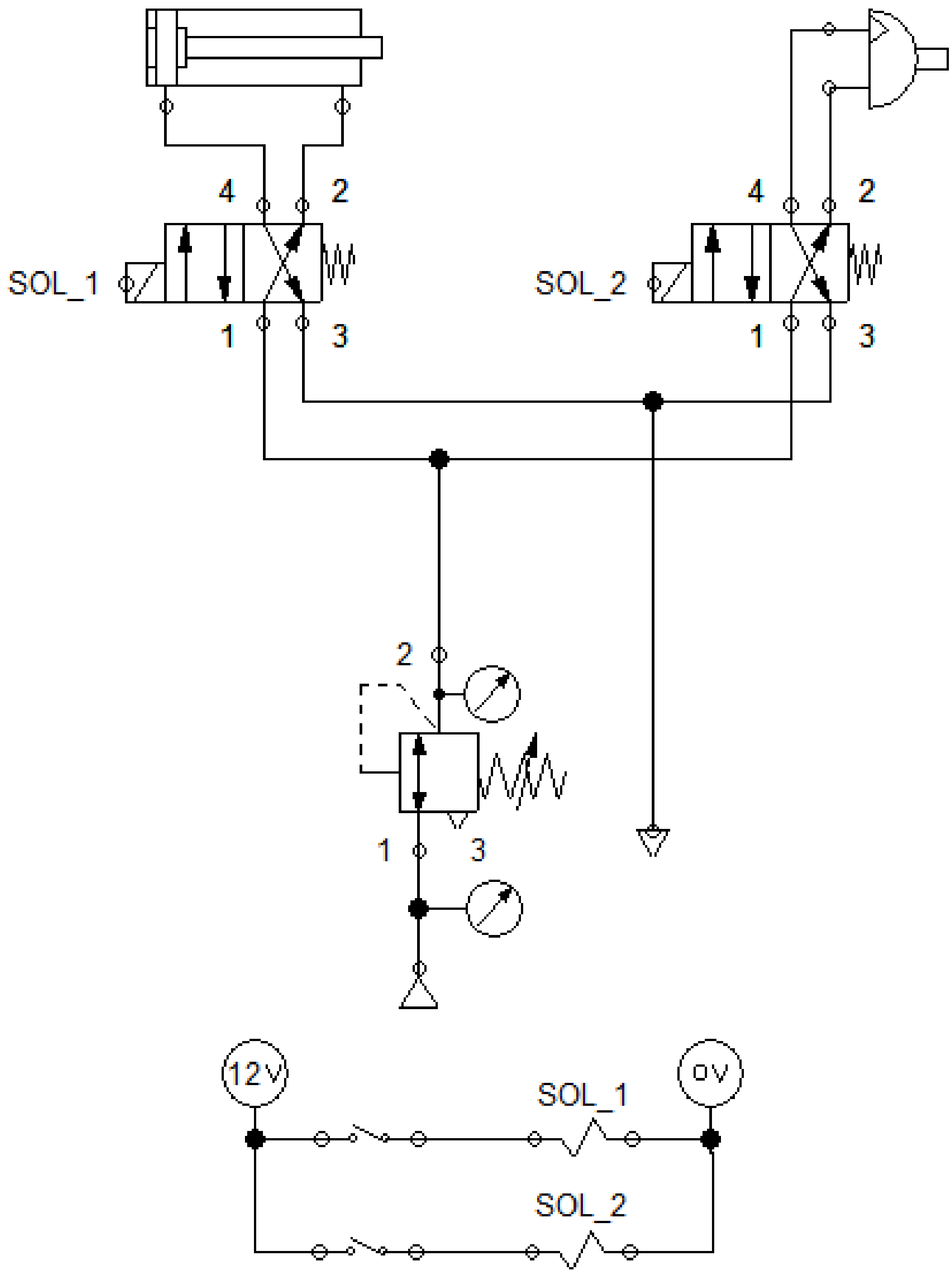
To stay within the budget and figure out exactly what items our team was going to need, we made an estimated budget list after researching potential items we would need. We kept our estimated budget broad so we would have room to buy items along the way that we hadn’t originally thought of, without throwing ourselves off budget.

Systems Interconnection Diagram (SID)

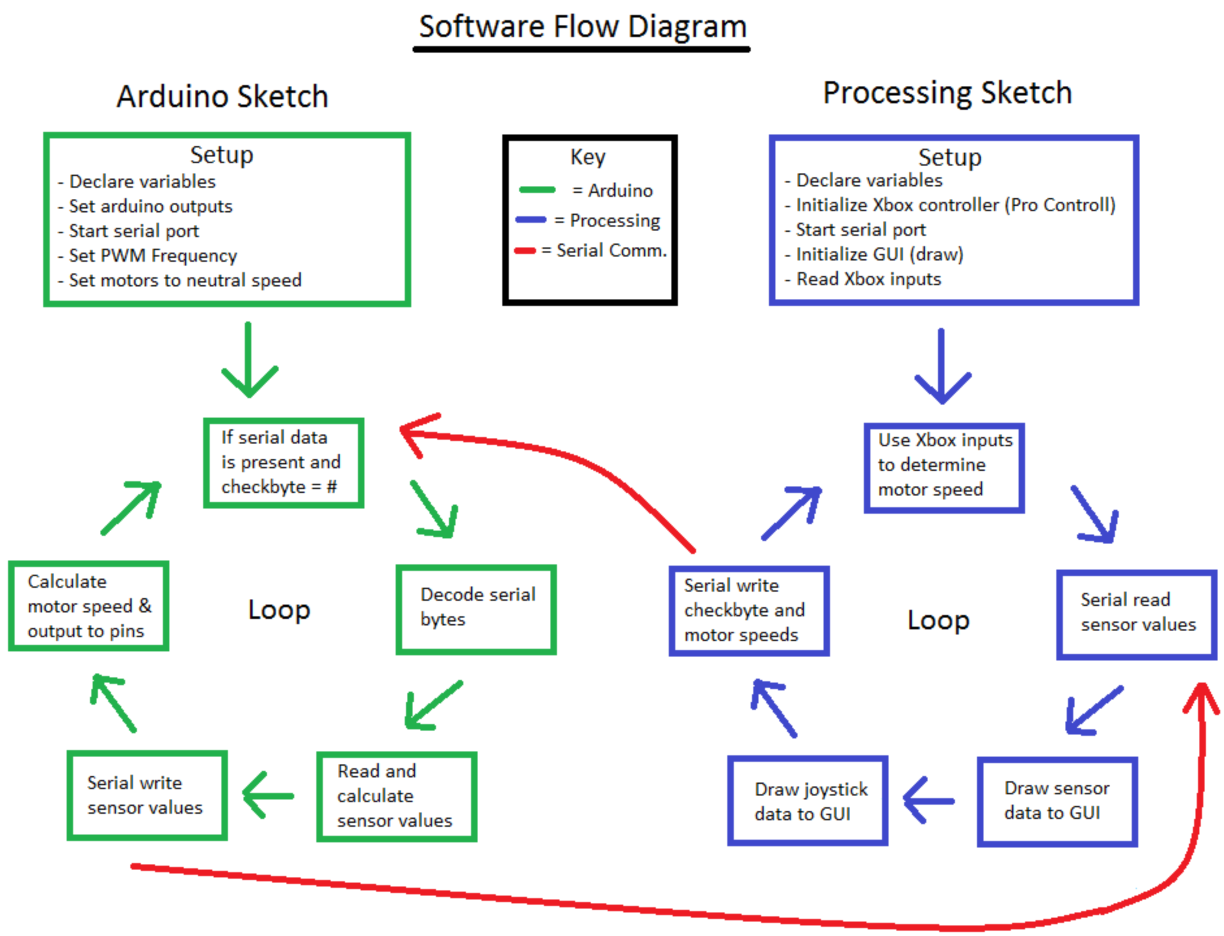


Electronic System of the ROV enabling movement

Fuse Calculation:
4(motors)*5 amps=20 amps
2(valves)*0.5 amps=1 amp
Electronics=2 amps
Total=23 amps
23 amps*150%=34.5 amps
Optimal fuse=35 amps
Largest fuse allowed=25 amps
Fuse used=25 amps



Pneumatics system enabling the claw function of the ROV



Design Rationale

Structure

Our ROV has been designed to be under 48cm so that it can easily be transported to Europa. We wanted to keep the structure relatively simple while still being easy to function, so we chose to use a cube design. We built our frame out of PVC because it is lightweight and inexpensive, and the frame measures 31x31x31cm. We used two cylindrical pressure housings to protect our pneumatics and electronic system, each being in their own housing. The pneumatics housing is built out of 3 inch PVC with a 3 inch PVC coupling, an O-ring, a 3D printed flange, screws, bolts, washers, 2 acrylic disks, and acrylic cement. The O-ring is used to prevent liquid from seeping into the pressure housing, and as the pressure increases, the rubber is pushed deeper into the cracks between the PVC and the acrylic. We screwed the acrylic to the flange to pre-seal the O-ring. On the opposite end of the housing, the acrylic disk is glued to the PVC with acrylic cement. The second housing uses a 3 inch PVC union, pipe, cap and a rail inside. The union has a piece of acrylic inside it that seals against the O-ring in order to keep water out, and it's easily removable, which along with the rail inside makes it quick and easy to get the electronics in and out. We calculated the depth that the housings could theoretically go to using a set of pressure vessel failure equations we found at rogercortesi.com.

The equations are: $\frac{t}{ID} = \frac{1}{2}\sqrt{\frac{3(3\times m+1)P}{8\times m\times \sigma_{yield}}}$ and $\frac{t}{ID} = \frac{1}{2} l - \sqrt{\frac{1-(2\times P)}{\sigma_{yield}}}$.

The first equation is used to calculate the required thickness to unsupported ID for an end cap where P is pressure, m is 1/v (one over the poisson's ratio) and sigma yield is the yield stress of the end cap material. The second equation is used to calculate the required thickness to cylinder OD for a cylinder where P is external pressure, v is the poisson's ratio, and E is the young's modulus of cylinder. We plugged in our variables and found that both our acrylic end cap and PVC cylinder could withstand a depth of 155 meters. This structure allows us to complete the challenges because the design is fairly open, allowing water to flow through the ROV and thus restricting the amount of water resistance we have while driving. The pressure housing also allows our ROV to go to the depth needed to complete our tasks.

Propulsion

Our vehicle has 4 thrusters, with two placed in opposite corners for vertical movement, and the other two placed on either side of the ROV, parallel to the pressure housing, for forward/backward movement. The motor wires are strung through the PVC that makes up the frame of the ROV to keep them organized and neatly contained. They contain enough power for us to successfully maneuver quickly throughout the course to complete tasks.

Sensors

This ROV is equipped with 3 TTL Arduino Cameras that have been waterproofed using epoxy. Our camera takes live video and it is capable of taking screenshots. This allows us to have vision from our ROV while driving it. There is a MPX4250AP depth sensor that is located on the end cap of the pressure housing which displays how many meters below the water surface the ROV is. We also must test the temperature of a stream of water, so we have a LM35 temperature sensor that is on the claw.

Claw

We used Autodesk Inventor to design our own unique claw and then 3D printed it. It is designed to pick up PVC and small objects, and it protrudes from the base of the ROV. It is capable of opening and closing, and it uses a linear and rotary actuator and pneumatics system to do so. The piston of the linear actuator is attached to a hinge point on the claw, and as the actuator piston retracts and extends, the claw opens and closes. There is an air compressor on land, and a pressure regulator between the actuator and compressor to reduce the pressure being fed to the vehicle. The claw is essential to complete most of the tasks because it can pick up and carry objects, such as samples of coral or oil.

Resources

Our project ended up being $80 under our estimated budget. It was inexpensive because we built nearly everything from scratch - the most complex items we bought being the motors, depth sensor, and Arduino. The total amount spent was $986.80

Originality

Our ROV was entirely designed by this team. We chose our motor placement for optimum maneuverability, and we placed 3 cameras in such a way that we could effectively see our claw, behind the ROV, and below our ROV. Nearly every component of our ROV was built from scratch, which makes it both unique and inexpensive. This also allowed us to try different techniques for certain components and use the one that we found most effective. The only downside to this hands-on approach is that it collectively took us approximately 1,006 combined hours to build.

Workmanship

The overall quality of the workmanship is remarkably high. All of our electrical system is neatly contained inside the pressure housing and tether. It is very easy to access the electrical components for maintenance. Inside of our pressure housing, our electronics are mounted on an aluminum plate. There is a 3D printed rail glued to the interior wall of the pressure housing that allows the electronic plate to easily slide in and out of the pressure housing. The vehicle is aesthetically pleasing while remaining practical because all wires are neatly stored, everything is clean and maintained, and the structures on our ROV are neat and simple in appearance.

Control System

We are using an Arduino and an Xbox 360 controller to direct our control system and motors. We chose an Arduino because we had some previous knowledge of how to program them and we didn't need all of the processing power a Raspberry Pi offers. As for the Xbox 360 controller, many of our members were very familiar with them and it has a lot of buttons/joysticks which gave us multiple options. We built a waterproof electronic housing to waterproof our control system, and all of our electronics are on board.

Ballast System

To keep our ROV level and upright, we ensured that our center of buoyancy was over our center of mass. The pressure housings are at the top of the ROV frame, which makes the center of buoyancy at the top of the vehicle. Our motors are contained in the lower portion of the ROV, which puts the center of mass under the center of buoyancy. We equally distributed the weight and buoyancy of our ROV to maximize its stability.

Features and Benefits

- Claw-picks up and carries objects
- Pressure Housing-electronics are all waterproofed; electronics can withstand more than 5 meters of pressure; all electronics are on board
- Motors-4 motors for stability, equal weight distribution, and maximum thrust
- Size-small ROV which enhances mobility and simplifies transportation
- Materials-ROV is made from scratch, which means that it is relatively inexpensive

Safety

Our team members always wore safety glasses while constructing and working on our ROV, for activities such as hammering, soldering, drilling, sanding and cutting can be very dangerous. In case of emergency, we had a first aid kit and fire extinguisher on hand at all times. We unplugged electrical appliances when not in use to avoid electrocution. We also tested our pressure housing to ensure that no water would get in and cause an electrical hazard. While designing our ROV, we designed a motor shrouding to cover our propellers. The claw and pneumatic system operates with a low PSI. The claw itself is plastic and has rounded edges to avoid snaring objects. We also used a fuse between our battery and the ROV to prevent too much current from entering the electrical system and heat shrink tubing to prevent wires from short-circuiting.

Safety Checklist

Pre-Power

- ❏ Safety glasses on
- ❏ Area clear/safe (remove tripping hazards, excess items, etc.)
- ❏ Ensure shut-off switch is off
- ❏ Tether prepared for launch
- ❏ Tether connected to ROV
- ❏ Tether connected to control panel
- ❏ Pressure housing sealed
- ❏ Thrusters free from obstructions
- ❏ Verify air supply is properly regulated
- ❏ Ensure air supply is connected to pneumatic system
- ❏ Power source connected to ROV

Power-Up

- ❏ Power on
- ❏ Start programs
- ❏ Ensure computer is running properly
- ❏ Monitor on
- ❏ Tether connected to laptop
- ❏ Verify video feeds
- ❏ Air compressor on

- ❏ Test thrusters with controller
- ❏ Test claw

Launch

- ❏ Place ROV in water

In Water

- ❏ Check for bubbles after submersion
- ❏ If bubbles are present
    - ❏ Remove ROV from water
    - ❏ Investigate source of bubbles
- ❏ Otherwise
    - ❏ Engage thrusters and begin mission

ROV Retrieval

- ❏ Surface ROV
- ❏ Remove ROV from water

Power-Down

- ❏ Turn off main power
- ❏ Turn off air compressor
- ❏ Turn off monitor
- ❏ Unplug tether from all connection points

Project Testing

Throughout the design and building of our ROV a lot of testing was done. The first thing that we tested was our original pressure housing design. We first did a simple test of the pressure housing by holding it down inside a small pool that was about 1 meter deep, there were no leaks. We then did a more reliable test by adding weight to the pressure housing, tying a rope to it, and dropping it into our local bay. The pressure housing went down approximately 6 meters and we left it for about 5 minutes to ensure there were no leaks. After we retrieved it we inspected the inside and found that it was dry. This was a very important test, as the pressure housing is a key component in the success of our ROV.

Another important component in our original design was the camera. This got tested multiple times in a variety of ways. The first thing we did was connect the camera to an Arduino for power, and then connected the soldered video lines to a TV to ensure that it would work for our needs. After we successfully tested the camera we continued on with our project. Once the electronics board was complete, we tested the camera by connecting it to the monitor we would be using for our competition. This also worked just fine, which was good news.

To get communication between our laptop and the Arduino inside the ROV we needed a USB line in our tether. Originally we wanted to use an Ethernet cable that we would cut the ends off of and solder the USB wires to this for the signal. After a long solder session, we tested our new custom cable and found that it was not able to get communication between our laptop and the Arduino. We figured out that the signal must have been decaying over the long cable, and eventually came up with a solution to the problem. We purchased a USB to Ethernet converter for one end of the cable and an Ethernet to USB converter for the other end, for Ethernet signals can travel much farther along Ethernet wire than USB signals can. We tested this cable the same way and had success.

Our electronics board was something that we tested extensively. The original board included the Arduino, two motor controllers, a circuit board, a power filter, and a camera. A big part of our testing process was the circuit board that was connected to the Arduino and the motor controllers. We started off designing this on a breadboard using jumper wires. Throughout this design process we continued to have issues with our motor controllers causing our motors to oscillate very quickly. We tested the issue multiple ways including a voltage meter and oscilloscope. Eventually we determined that the PWM outputs on the Arduino were set at 30Hz when the motor controllers required 1000Hz. After this issue was fixed we had a functional board. Next, we tested the power filter circuit. We determined that there was no power getting through the circuit, this meant that none of the main power coming from our tether was reaching our electronics. After some testing and troubleshooting, we found out that the power filter was connected backwards, the input wire was connected to the output of the power filter, and vice versa. Once this was fixed the power filter was working properly. Now we had a fully functional electronics board.

The next part of our testing was in our local pool. Here we did our first main test of all the ROV’s systems. In the pool multiple components were tested, starting with the motor directions. We connected the tether to all the necessary surface controls and then put the ROV in the water to test the motor directions. In the water we found that there was not much thrust coming from the motors in any direction. Eventually we realized this was because they were working against each other (later after the pool test we were able to fix the motor direction by swapping the polarity of the wires). Another thing that we tested in the pool was the camera. It worked very well - it had good picture and was not dark. We also tested the buoyancy of the ROV in the pool, after some trial and error we were able to get the ROV neutrally buoyant in the water using pool noodles. The next thing that was tested was the pneumatic claw. This was done by simply lining up with an object in the water and grabbing it. The pneumatics system worked very well with both the grabbing and rotating of objects. That being said, there was however a leak in one of our actuators that needed to be fixed. While we were in the pool we needed to get a power draw measurement in amps. This was done by activating all of the motors at the same time so that the most power would be used. Once we had our power draw reading we were mostly finished in the pool. One thing that we noticed while there, however, was that our tether was quite stiff and was preventing the ROV from moving freely. To solve this issue, we removed the sheath from our tether so that there would be more flexible (we used electrical tape in place of the sheath). Our first pool test was finished.

After our regional competition we realized that a lot of work needed to be done to prepare for the trip to NASA. We altered the design of our ROV significantly. We decided to add a second pressure housing, more cameras, onboard pneumatic valves, as well as alter our motor placement. All of this required more testing.

For our redesigned ROV we wanted to put the pneumatic valves on board, this would reduce the amount of tubes needed for air in our tether, thus making it more flexible. Our pressure housing was full with the electronics board and everything on it, so we needed another pressure housing. Our team ordered a waterproof dive box that would be large enough to fit the items in. We tested the depth of this waterproof box by placing it inside of a pressure cooker, and then we filled the pressure cooker with water up until 10 psi, this would be sufficient pressure to ensure no leaks would occur at the competition. After the test was complete, we removed the box, and turns out, it had leaked. To solve this issue, we decided to make another PVC pressure housing very similar to the original one we had. Once we had built this new pressure housing we tested it in the pressure cooker to 15 psi, there were no leaks, which was good news for our ROV.

Another addition we wanted to make to our ROV was to add more cameras. During the regional competition we found that it would be beneficial to have multiple cameras, one especially facing the rear of the ROV. We purchased two new cameras, one of which was another TTL camera, and one was a backup camera for a car. These both needed to be waterproofed due to the fact that they would be mounted outside of the pressure housings. We waterproofed these cameras using epoxy as suggested by a MATE instructional video. We tested these cameras after they had been waterproofed and it was a success, we now had 3 cameras for our ROV.

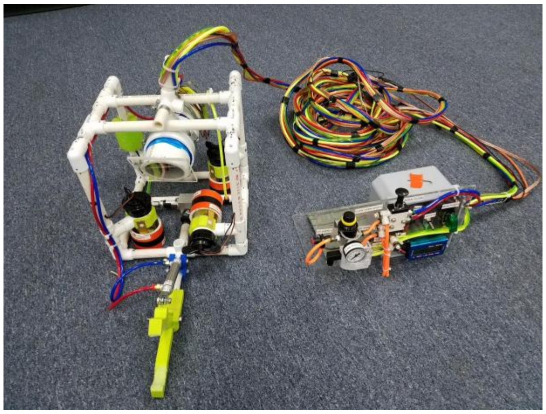
We also noticed during the regional competition that we did not have very much thrust coming from our ROV, we originally thought that this was due to the motors being only 500 GPH, so we decided to order new 1250 GPH bilge pump motors that would significantly improve the thrust of our ROV. These needed to be tested to ensure that they would in fact improve the propulsion power. The bilge pump motors stated that they would only draw 3 amps, however when we tested these new motors in water we found that the resistance caused them to use much more power (around 8 amps). This was a major issue because our motor controllers are only able to output 5 amps per motor, as well as the fact that we are limited to only 25 amps in the Ranger class. After some troubleshooting we realized that our original ROV was only drawing 8 amps which was odd considering the 500 GPH motors pulled around 5 amps each under load. We eventually determined that the motors were not running at full power due to a lack of voltage coming from our main power line. After some more testing we realized that the power line was losing about 4.5 volts over the 50-foot line. This was quite surprising because we assumed that a 12 AWG copper wire would be sufficient over 50 feet. After some more troubleshooting we determined that the wire was not actually copper, it was copper clad, which meant that we were losing power due to the resistance of the aluminum core. Once we ordered new 10 AWG copper wire we were only losing about 1.5 volts along the 50-foot cable. This was good news for it means that our motors are now much more powerful than they were before, thus giving more thrust in the water.

Another thing we tested on our newly designed ROV was the new pneumatics system that had been integrated into the new pressure housing. Once everything had been wired to the solenoid valves and all the pneumatic lines had been connected we tested the claw operation. It worked successfully on both the rotational aspect as well as the grabbing aspect. This was good because it allowed our tether to only have two pneumatic lines rather than 4 larger ones. This increased the flexibility of the tether significantly which improved mobility of the ROV. After testing the claw pneumatics system on land, we did a test in our small pool to ensure there were no leaks. The claw performed just as well underwater which meant we now had a working on board pneumatic system.

Now that we had a functional ROV, we needed to test and calibrate our sensors. There were multiple stages of temperature sensor testing. We started off by creating a simple circuit on a breadboard as well as a simplified Arduino sketch that would give us the needed information to test the temperature sensor. Once this was setup we began calibrating. To do this we had a working thermometer that we would use as a reference to what our temperature sensor should be. After some trial and error, we had calibrated our temperature sensor. The next thing that needed to be calibrated was our depth sensor. We did this in a similar way by creating a simple circuit and Arduino sketch. In order to calibrate the sensor, however, it needed to be inside the pressure housing so that it would be waterproof. Eventually we took the two sensors, mounted them on our ROV and did a dry test. The sensors worked, however the depth sensor was still uncalibrated. We then took the ROV to our small test pool where we calibrated the depth sensor. To calibrate this, we started with the ROV at the surface of the water and took a reading, then we went down to the bottom of the small pool and recorded that measurement. Using these two numbers we were able to calculate what the depth sensor should be displaying, and fixed our program accordingly. We then returned to the small test pool and ensured that our readings were accurate. At the surface of the water our depth sensor displayed a measurement of 0 meters, and at the bottom of the test pool is had a reading of a little less than a meter which is what we wanted. Now that the depth sensor was working we tested the temperature sensor in the water, it gave us an accurate reading as well which was good news, and it meant that our ROV’s sensors were now ready and functioning properly.

At this point our entire ROV was ready for a final pool test. We went to our local pool once more where we tested the ROV’s systems. The pressure housings were not leaking, the pneumatic claw was functioning properly, all of the cameras were displaying a video feed, and the sensors were giving us appropriate readings. We then fixed the buoyancy of the newly redesigned ROV using a similar method with pool noodles. After our ROV was neutrally buoyant we were ready for a practice run. All of the motors were working properly and in the correct directions so we descended down to the bottom of the pool, once here we stayed for a couple of minutes then returned to the surface to ensure that there were no leaks. Everything looked great. This was a huge success for the team for it meant all the testing we had done paid off and every aspect of the ROV worked properly.

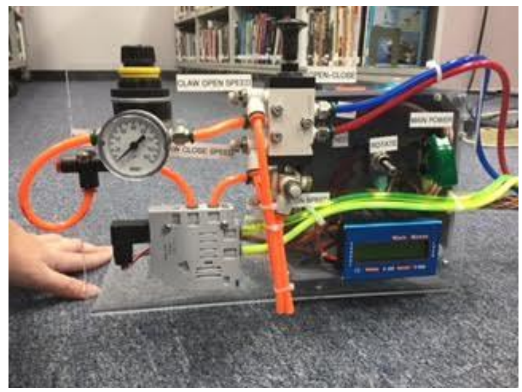
Photos



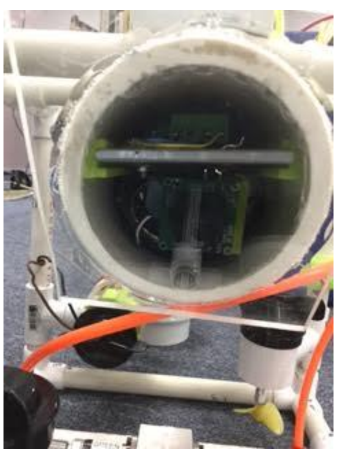
ROV design at regional competition

Brown and Russell build pressure housing

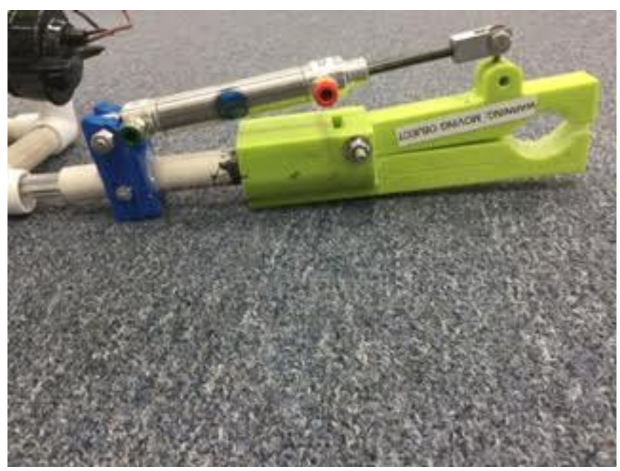
Testing pressure housing



Control panel



Inside pressure housing

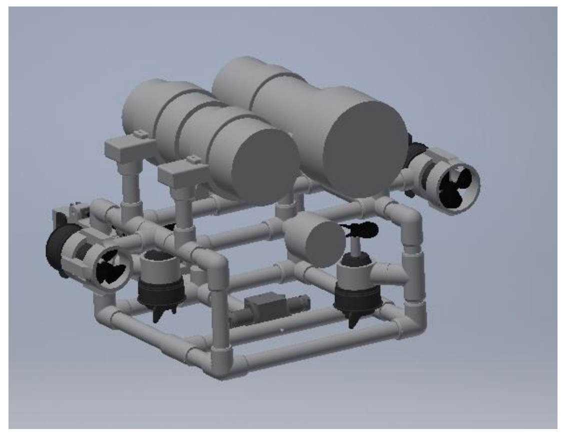


Claw mechanism


Rash builds PVC structure


Motor and shrouding


Front view of ROV


Back view of ROV

All photo credit goes to Natalie DeWitt and River Rundell, mechanical sketch done by Jostan Brown.

Theme

This year's competition focused on the exploration of space and the ocean. The technologies developed for space can also be used in the ocean because both areas need to have equipment that possess certain qualities. First of all, the environments in both locations are very different from Earth's surface. The electronics need to be contained in a pressure housing that is bolted shut to protect against the hostile environment. In the ocean, there is more pressure than on land, so the pressure housing keeps the electronics from being crushed. In space, there is less pressure than on Earth, so the pressure housing must prevent the electronics from being pulled apart by the lack of pressure. This competition allowed teams to discover how to successfully create a pressure housing for their ROV as well as the importance of size among ROVs and the space that electronics occupy. These are all significant because scientific organizations such as the EPA, NASA, or NOAA often need to build ROVs that meet many of these requirements. This competition has allowed students to explore real-world problems and discover how to design to meet demands. According to Sharon Nieukirk, a local marine biologist who has worked for NOAA for 19 years, "Meeting requirements is critical. If your ROV doesn't meet certain criteria such as having a waterproof system, it doesn't matter how well everything works - you won't collect the data that you need. We often have very expensive missions, so you need to maximize your chances of success. We get our criteria by learning from other teams' failures to build on what they have done and avoid making the same mistakes. You don't want do the same mission 9 weeks in a row - it's too expensive and takes too long. You want your first mission to be a success."

Project Management

Our team began meeting four months before the regional competition to plan the ROV. We spent an entire month making sketches and discussing potential ideas for all of the components of the ROV. We all became familiar with the manual and the tasks we needed to perform, and we created an estimated budget to see how much money we would need to spend. We created a Google calendar to share all of our other activities and to have a visual planner that showed everybody when and where we would be holding meetings. Our team also created a Facebook and Skype group message. These were valuable for times when we were individually working at home and had questions for our group. After our planning stage, we ordered all of the parts we needed and began construction. Our construction phase consisted of a solid 3 months of work, with many failed tests (see Project Testing) that helped us improve our ROV. Our team met at least once a week in the first two months of building, and anywhere from 2-6 days a week from then until the international competition. We kept our meetings occurring regularly to ensure that all team members remained active and engaged in the building process, and we all worked together to ensure that everything was constructed in the best way possible.

Individual Roles

Gatlin Andrews
Position: CEO
Grade: 11
Age: 17
In pursuit of: Degree in Computer Science

Ryan Russell
Position: Systems Engineering
Grade: 11
Age: 17
In pursuit of: Degree in Engineering at OSU

Jostan Brown
Position: Operations
Grade: 11
Age: 17
In pursuit of: Degree in Aeronautical Engineering

Natalie DeWitt
Position: Marketing
Grade: 11
Age: 16
In pursuit of: Degree in Mathematics

Alex Rash
Position: Design Integration
Grade: 11
Age: 16
In pursuit of: Degree in Computer Science

River Rundell
Position: Government and Regulatory Affairs
Grade: 10
Age: 16
In pursuit of: Degree in Publishing in relation to Engineering

Gatlin Andrews contributed to the project by programming the ROV control and sensor system. He also spent a lot of time working on the electronics board, which included soldering and circuit design. Gatlin was also responsible for creating the SID and software flow chart. Ryan Russell worked on anything that had to do with engineering. He helped design our pressure housing and 3D printed the rails inside the pressure housing. Jostan Brown designed the claw and put together the pneumatics system which controlled the claw. He also made the motor shrouding and other 3D printed parts, helped with the structural design of the ROV and created the mechanical sketch of the ROV. Natalie DeWitt mainly worked on the marketing aspect of this project. She managed the technical documentation and the poster formation, as well as managing due dates and setting up documents that were worked on and shared by the team. Alex Rash worked on the ROV structure, designed the ROV's PVC frame, and wired the motors. He worked on the pneumatic SID and the pneumatic control system. River Rundell worked on creating and applying the marketing plan. He designed the business cards and brochures. He also designed a plan to sell the ROV to businesses or scientists.

Challenges

The biggest challenge that our team faced was finding time to all work together. Between sports, jobs, homework, musical lessons, and transportation problems, our team struggled to find time to all work together. However, we all modified our busy schedules to allow us time to collaborate as a team. Each of us additionally put considerable amounts of time individually into certain aspects of our ROV, which made our team meetings more productive. We all learned that when everybody makes little sacrifices, we all can all come together and work successfully.

Additionally, for a while we struggled with pressure housing leakage. As all of our electronics were on board inside of the pressure housing, this was not a small issue. Continuously, water would inexplicably seep in, which both frustrated and concerned us. By developing a meticulous way of tightening every screw on the bulkhead individually in a specific order, attaching the end cap to the body of the pressure housing, we were able to ensure that the fit of the end cap against the O-ring was completely watertight. Beyond these we faced and overcame many other challenges that are detailed in the "Project Testing" section.

Lessons Learned

When we formed our robotics team, none of us had ever done underwater robotics before. Everybody was interested in different aspects, but we all united under a common goal. By helping each other and through long frustrating hours, we all learned what it means to be in robotics and how vital trial and error really is. Most members came out of this project with the ability to use AutoCAD quickly and efficiently, as well as how to program, 3D print objects, and successfully wire a ROV. It has also gotten all of us more excited about future careers in engineering.

Future Improvements
In the future, we would make a calendar with a schedule dictating our own deadlines. We would make sure that we had ourselves on a timeline that allowed us to finish a month before the competition to allow the driver(s) to become extremely comfortable with the ROV controls. We would also learn how to program and use AutoCAD thoroughly before beginning to design the ROV to make the process easier. Additionally, we would all do background research so that we could feel as though we have a complete understanding of robotics basics at the start of this project.

Reflections:
For this, we all decided to write our own reflections because we each had a unique experience.

<u>River</u>: At first I didn't think I would like designing and building an ROV but I found I enjoyed it more than ever. Each step was interactive and it was even better because I made new friends along the way. I got to design the presentation, take pictures of the team's process, and give my own input on how we should build or change our ROV. I felt like a really had a voice in everything we did even if I wasn't very tech savvy. From building this ROV I have seriously considered an engineering job specifically working on robots and I wouldn't have it any other way.

<u>Natalie</u>: The Newport High School Robotics Team was my first exposure to hands on engineering. I have learned so much about mechanics and how much work actually goes into designing an ROV, and it has peaked my interest in pursuing an engineering career. I have learned the basics of AutoCAD and I successfully designed and 3D printed some of the parts for our ROV. I also helped to design our structure and used math from previous math courses to determine the different sizes of ROV parts. I was exposed to the world of engineering in a very positive way, and I am now more excited than ever.

<u>Ryan</u>:
Hi, I am Ryan. I am a junior at Newport High School. A friend of my family, Alex, told me about the robotics club at my high school, it sounded fun and I have always been interested in engineering, so I joined. The club has taught me so much about the mechanics of ROVs and how they work. Wiring everything was the hardest part, but it was cool to have great mentors that helped me learn how to wire the electrical systems of the ROV. I also learned how to use AutoCAD and 3D print objects. My plan is to go to OSU and study in their engineering program. I was a major part of building the pressure housing. Once we finished the pressure housing a couple of us went to a dock and tested the pressure housing to make sure it would not leak. It was a success. It was the start of something great!

Gatlin:

Joining the robotics team at Newport High School has been a very positive experience. I have always had a passion for computers, technology, and electronics. I am very glad I decided to join the robotics team; it has enlightened me in more ways than one. Before joining this club, I had an idea that I wanted to go into a computer science field after high school, and after working hands on and actually working on a project now I am sure this will be a good future for me. Throughout the time that we worked on our ROV I learned a lot about the way underwater vehicles work, as well as how much effort it takes to make one fully functional. Another thing that was very beneficial to me was learning how to solder, there had been many times that this skill would have been useful to know. As we were building and planning our ROV we ran across many issues, which allowed us to develop problem solving skills that will be very important later in life. I am very glad I joined the robotics team, I created friends, learned new skills, and had lots of fun along the way.

Jostan

I'm very glad I joined the Robotics team this year. I've always been passionate about electronics, engineering and just making things in general, and I've had the opportunity through robotics to do just that. I have faced many difficult situations and have had fun finding new and creative ways of overcoming them. In the past when I have designed and built things it was often by myself, or with one other person. But with robotics I've had the opportunity to work with a team, which has added a fun dynamic to building that I haven't had before. It's much more fun to work with friends than it is to work alone. Also, I've learned many new things and had the ability to practice and use many of these skills on a practical level. Some of these skills being the ability to use Autodesk Inventor and a 3D printer, to solder, to program, and to wire electronics. All in all, it's been a very positive influence on me and has helped me solidify my desire for a future degree in engineering.

Alex:

I have always thought it would be cool to be an engineer and robotics has given me a chance to be just that. During my time with the team I have had a lot of fun creating the structure for the ROV and working on its wiring. I also learned a few things such as what center of mass and center of buoyancy are and how they're important when designing a submersible. Additionally I have gained a lot of soldering experience, and learned how to use hot glue when heat shrinking wires. I think that the thing I enjoyed the most was creating a PVC structure and positioning motors on the structure. The whole process was like solving a big puzzle, and though it was at times frustrating it was a lot of fun.

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