Stansbury High School

Sea Storm Robotics

5/2019

Members:

Tina Grossman: Mentor
Tan Sungkhapong: CEO
Autumn Zierenberg: CFO
Ailsa Mensinger: Resource investigator
Bella Colovich: Head document editor/creator
Gavin Norman: Electrical engineer, pilot
Dyson Smith: Second electrical engineer
Kendrik Craig: Pilot, structural engineer
Emma Wilson: Safety manager, structural engineer
Hannah Bastow: Safety manager, assistant document editor

Abstract

Stallion Storm Robotics has developed a Remotely Operated Underwater Vehicle (ROV) that meets the requirements of the 2019 Mate ROV competition. The Sea Storm ROV is designed to perform in freshwater, yet it can also be modified to perform in saltwater. In addition to this, Sea Storm's ROV -- endearingly named Cheese Bag after the teams various initials- is specifically designed to be easily manipulated and modified to fit any consumers needs; Although it currently has been adapted to assist in scientific endeavors, replace various equipment, and lift wreckage. Cheese Bag is one of the more innovative ROVs out there, illustrating Stallion Storm Robotics' concept of "overcome and improvise".

Sea Storm has worked tirelessly to perfect their ROV into what it is today, putting in 472 hours of work into building since January of 2019. Because of this, Team participants are now well practiced in controlling Cheese Bag, and know the importance of completing all necessary safety tasks before hand to ensure bystander and team safety. The completed, medium-sized ROV has a simple yet intuitive design and functions with ease.

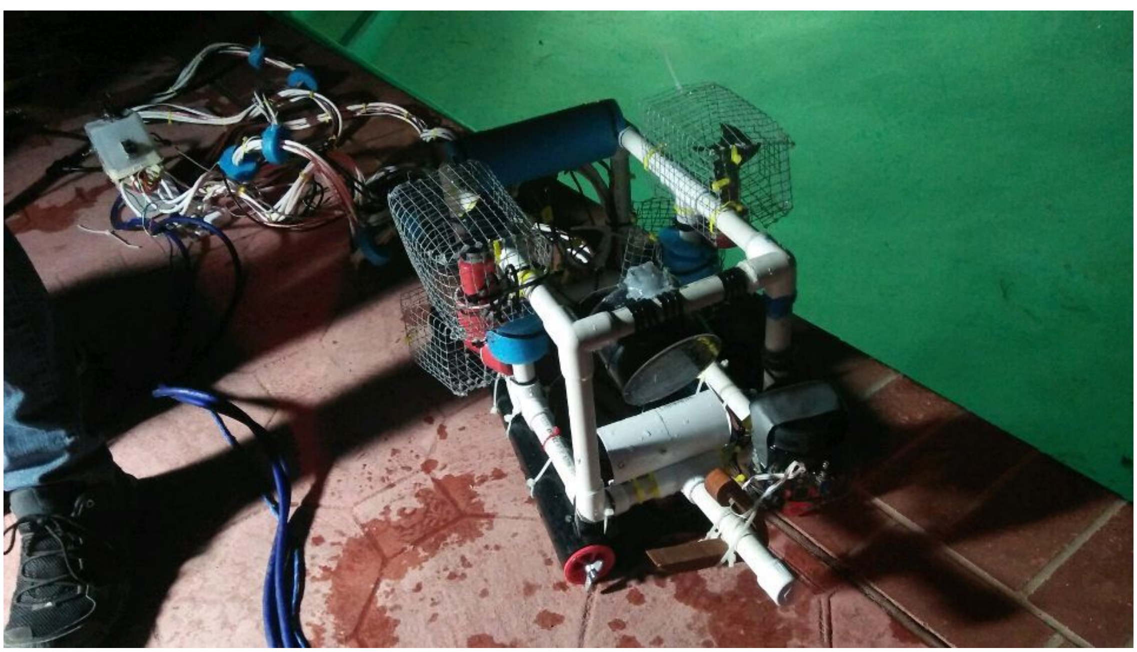
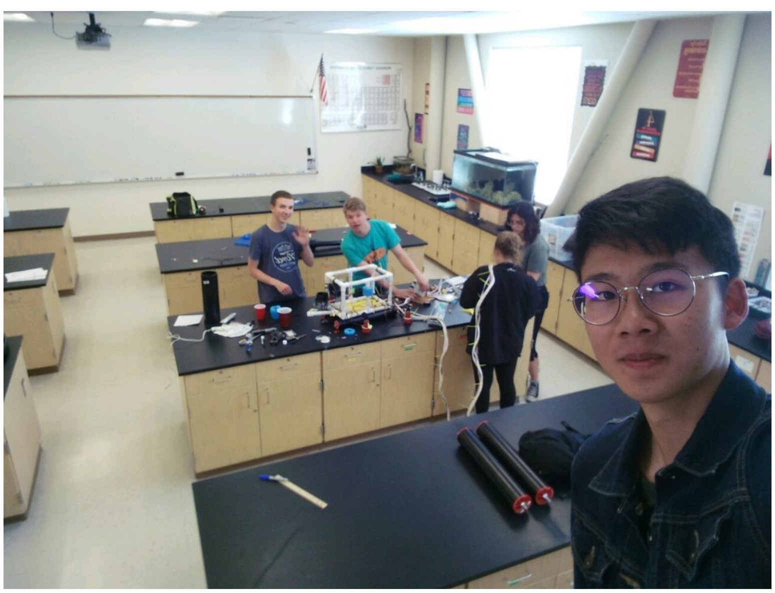


Table of contents

Project management

Sea Storms CFO Autumn Zierenberg was appointed to be in charge of tasking out and following up with teammates as to ascertain whether or not certain tasks were completed. This included selecting dates and coordinating with the entirety of the Sea Storm team. This emphasis on timing ensured that we were prepared to achieve both goals we set for ourselves and necessary deadlines (I.e. when ROV test date was, safety inspections, and competition day). This organization prompted us to have enough time for trouble shooting and new additions.

When we ran into problems that seemed insurmountable we managed them by asking ourselves what could be done, and then after we had brain stormed for awhile chose the course of action that suited our needs best. Often times we would be stuck in a trial and error situation until we thought about it again and explained our Solutions to finer problems to the group, presenting the pros and cons to each. We would then use the same method of going with the one that best suited our needs.



No team is perfect in any setting and we are not exceptions. We often had minor disagreements that were solved through a lot of give and take in the design phase. These disagreements were best handled through taking the problem and looking at it in different perspectives then talking it out.

Our team chemistry was greatly improved by these methods and resulted in precision when handling problems and disagreements within the team.

Design Rationale

Thrusters: Our method of propulsion began with a thought of waterproof motors, and after research, we came across 12V DC bilge pumps. Normally used for bilging, they can be cut to reveal a waterproof spinning disk. Once measured we were able to print a 3D attachment that slides right on the bilge pump and has a propeller on the other end. With an amp draw of 5.6, and a lift capacity of about 5 N each, we give you our motors!

On the ROV, we have positioned 4 motors for optimal vehicle control. Positioned in the center, and one on each side, we have one set of motors pushing up and down to give us depth control. Next to the depth motors, we have forward and backward motors giving us the ability to move ahead or behind. Shrouded in a metal wire cage for safety, our motors are ready to move us to new places!

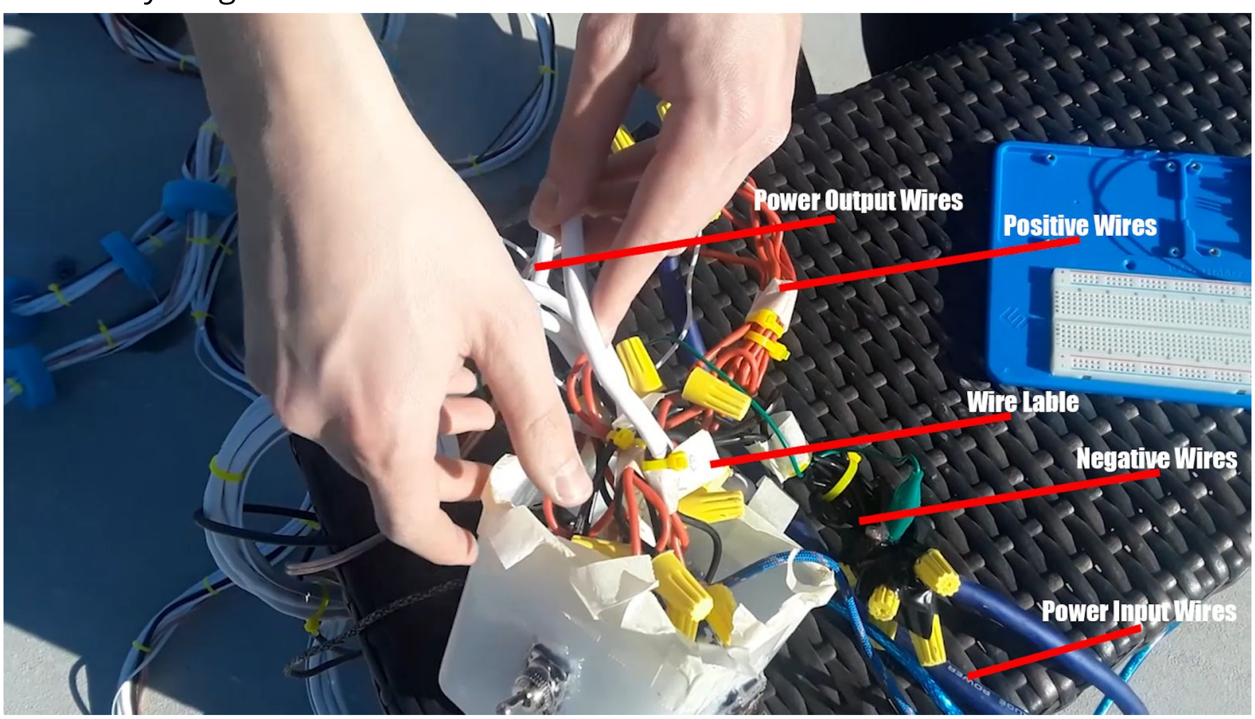
To control the motor, we have 20 feet of speaker wire (speaker wire because in one length, there are two wires) letting us run only one wire for each motor instead of two. That wire goes from each motor into our control box. The wire from each motor meets up with a 6 pin switch. When wired correctly, we can achieve a simple yet effective way to control the direction of the motors. Power and ground is applied to the middle section of the switch. At the ends of the switch, one wire pair is crossed, and then connected up with the other pair. The end result is a switch that when pushed one way causes the motors to spin one way, but when switched, the polarity of the motors are swapped and spins the other way!

The controller for the ROV is a medium sized Tupperware container in the shape of a cube. We flipped it on it's head and then cut holes for the switches. All the wires fit nicely inside the container, and once labeled with tape, the control box was done. On the top of the control box there are two switches placed side by side. These make it go forward and backward. Push forward on the right switch to make the right forward motor push forward, pull switch back to pull the motor backwards.

On the sides of the box are one switch each. These are for the up and down motors. Push the right switch up, and the right motor will pull up. Push switch down to go down, etc. Controls are very simple and feel very natural.

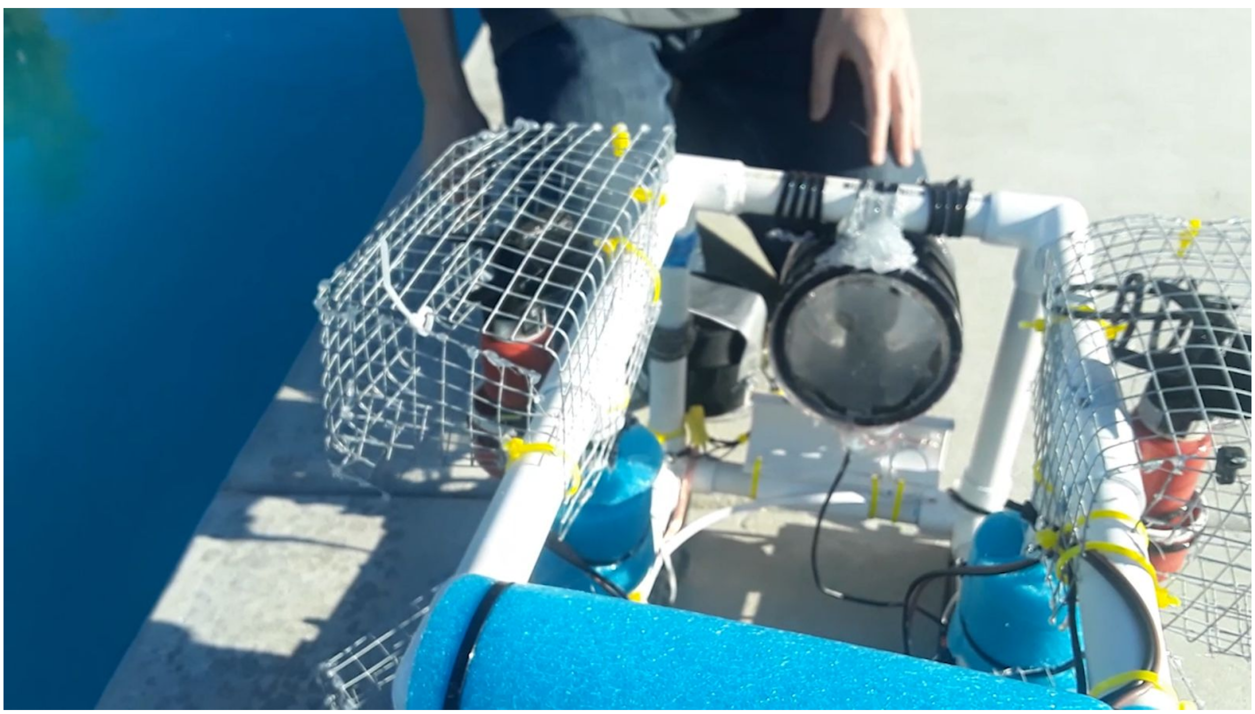
On the front there is another switch, a simple connect-the-circuit switch. Once turned on, electricity is sent to 3 linear actuators and pushes on a release plate, dumping the fish.

On the back of the control box is a line of parachute cord that is used for tether stress relief. It is about an inch shorter then the smallest wire and will go taught before anything else.



The only other wire system is the laser system. Running through 20 feet of ethernet cable, we can power our 3V 5ma red lasers. Positioned at exactly 5 cm apart and parallel, we are able to measure any object underwater from a distance. To adapt our voltage to run the lasers at 3 volts, instead of the provided 12, we used a fun little converting process. First, the 12 volts from the power supply is passed through a 12V car adapter and turned into 5 volts. The 5 volts is then used to power an Arduino Uno, which we can use to get 3.3 volts for the laser and 5 volts for the webcam. After a travel distance of 20 feet, the 3.3 volts for the laser becomes less then 3 so we can operate the lasers at 5ma. On a breadboard (solderless circuit board) we have it wired to plug into a button so we can control the lasers from the surface. Simple and works like a charm.

<u>Structure:</u> The structure of the robot is mostly inexpensive ¾ inch PVC pipe and corner pieces for the body shape, with some thicker 5 inch PVC as weights attached to the bottom and filled with rocks to keep it neutrally buoyant. The body of the ROV is built like the outline of a box, with a diameter of 71cm.



In the front, we have a larger, 8 inch diameter PVC pipe cut and sandwiched between clear plexiglass and sealed with waterproof silicone glue acting as our camera housing. This is attached to the top of the front of the ROV.

In the back top, we have a piece of polyethylene foam, sized so that it has the same positive buoyancy as the camera housing. This is essential, or else we wouldn't be able to stay level underwater.

Directly underneath the polyethylene foam is the anchor point of the ROV to the control box. Everything passes through this point, tether and parachute cord.

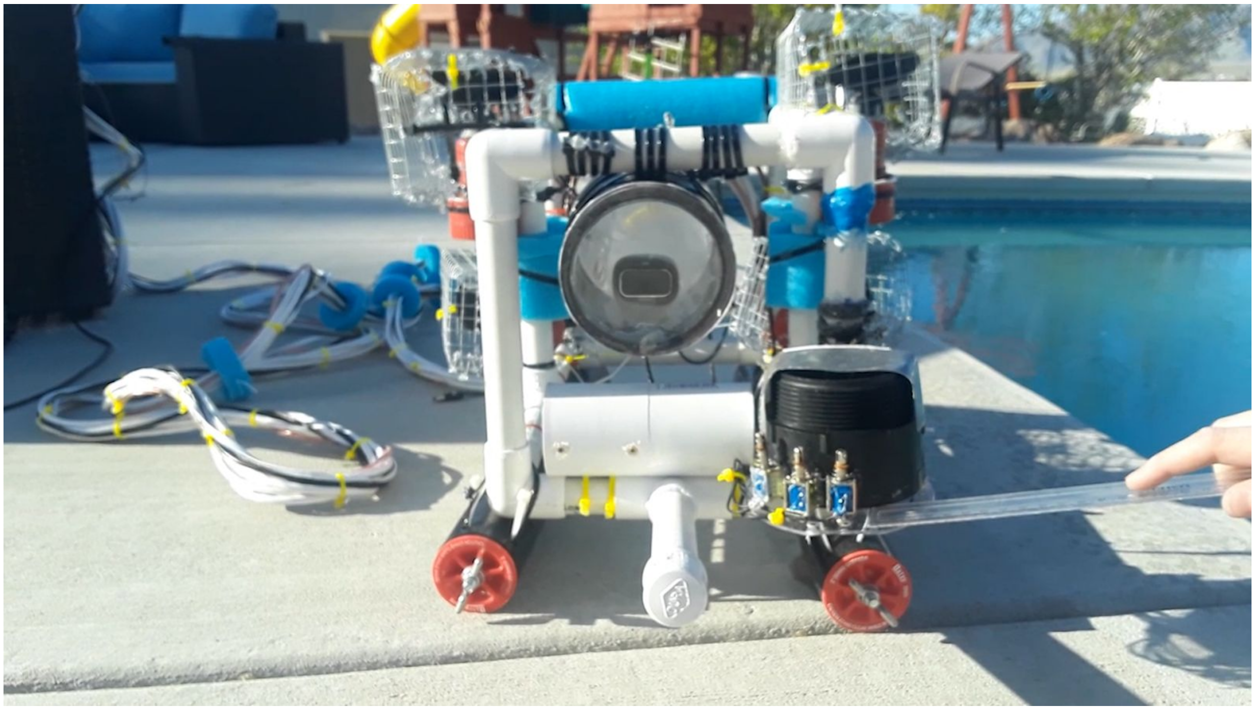
Protruding from the front of the ROV is our grab arm. Simply a straight ¾ inch PVC pipe that doesn't move, and slightly positioned up to better hold any object it picks up.

As a failsafe to a failure in our laser system, we also have a 5 cm long piece of plastic that we can rubber band temporarily to the arm so we can measure by touching it to the object that we wish to measure.

Next to the arm is a cup made up of a large 8 inch pipe with a piece of plexiglass underneath. This is the fish dropper. It is held up by two small neodymium magnets, tied on with parachute cord, and pushed open by three linear actuators. Fish go in, cup floor closes and held shut by magnets, ROV goes over drop site, switch flipped, linear actuators open lid, fish fall out.

On the sides we have the propellers. Two on each side, and two types on each side. Right in the center of the side panels, we have them positioned so when it drives forward, it goes up ever so slightly, and when going up, ever so slightly forward. This allows for better maneuverability when trying to pick up an object. Each propeller is completely covered with a wire cage for protection.

Camera: The camera is a regular USB webcam (Xinidc Full HD Webcam 1080P, Web Camera with Microphone) from Amazon. To connect it from 20 feet underwater, we have a 30 foot USB repeater cable (UGREEN 30 Feet USB 2.0 Extension Cable Active) ordered from Amazon. To power it externally, we have a USB Hub (AmazonBasics 4 Port USB to USB 3.0 Hub with 5V/2.5A power adapter) Ordered from Amazon. We cut off the wall adapter end of the power cord of the Hub, and with a 5 volt connection from the Arduino Uno, we can plug the Hub into the Arduino, which is powered from the power source, giving us an externally powered USB webcam. The Hub is plugged into the computer, and through the Windows 10 Camera application, we can view from the webcam.



<u>Component Sourcing:</u> All the components listed below are bought new or donated because we had ideas on how to get the semi-raw materials to make all of our parts from. If we knew how to build something from the parts cheaper then if we were to buy it, then we did.

The PVC used to make the ROV body, the silicone glue, plexiglass, pipe-caps, in-line fuse holder, Oatey Blue Glue, superglue, fuses, and zip-ties were bought from our local Home Depot.

The bilge pumps, lift bag, linear actuators, white speaker wire (for bilge pumps), thick 4 gauge wire for power connection, anderson powerpoles, switches, ethernet cable, lasers, wire caps, USB Hub, repeater USB cable, and webcam were purchased from Amazon.

The hot glue and glue gun, neodymium magnets, Arduino Uno with wires and a button, electrical tape, and car USB adapter was donated by Gavin Norman, the alligator clips were donated by Ms. Taylor, the tupperware, and duck tape was donated by Autumn Zierenberg, parachute cord was donated by Kendrik Craig, saws for cutting, and a 3D printer for printing the propellers were donated by Mr. Huffman, scotch tape, lab space, and wire mesh for the propeller guards were donated by Ms. Grossman, the polyethylene foam was donated by Bella Colovich, and the pools to test and film are thanks to the Beazers, Betts, and The Stansbury Swimming Pool.

Project Timeline

10/26/18 - We are introduced to the competition for the very first time.

11/26/18- We commit to the competition and form two teams (ROV 1, ROV 2) .

11/30/18- three nameless participants refuse to pull their weight on ROV 1 and are cut from the team.

1/1/19 - Our budget opens.

1/23/19- ROV 1 participated in a coding workshop.

From 1/1/19 to 2/16/19 both teams are deciding on ROV specs, measurements so we can decide on what to get by mid February

2/16/19 - Our two teams go shopping at Home Depot for all the hardware.

2/23/19 - Our two teams ordered all our parts from Amazon.

2/25/19 - After a weekend of discussion, the two teams are combined together to complete the skill set needed to compete. We end up losing 4 participants from ROV 2.

2/27/19 - A mockup ROV frame is built -out of PVC- so a visual can be created and decisions on placement of equipment can be made.

3/6/19 - All ROV Equipment came from Amazon on time with the acception of the Lift Bag, which got delayed a week.

3/13/19 - Lift Bag Arrives.

3/15/19 - It is agreed that meetings will be held weekly until the video demonstration is complete.

3/18/19 - Lasers are being researched so they can be submitted by 4/1/19. The pre-final dimensions of the ROV body is cut to length.

3/20/19 - Bilge pumps are being cut so a propeller modification can be made.

3/22/19 - Lasers and glasses are found, and submissions for laser specs are ready to be made.

3/25/19 - Bilge pumps are measured and 3D designs are being made.

3/27/19 - A Propeller modification is printed, and doesn’t quite fit. It will be revised. Wiring is being finalized, and should start next week.

3/29/19 - A second propeller is printed, and doesn’t fit. Looks like it could be a result of the way the printer prints. The design is completely re-done and will be finished when we come back for the week.

4/1/19 - The propeller works! We begin to wire and connect all motors.

4/3/19 - All motors are wired and the connections are hot glued and tested underwater for electrical issues.

4/5/19 - A camera housing is made using PVC and plexiglass. They are being siliconed in place, and since we are in the chemistry lab, we can use the fume hood to control the fumes.

4/8/19 - The camera housing is done and tested underwater at 25 ft and held. It is wired with the repeater cable and plugged into our external USB Hub and works!

4/10/19 - After some math, we realize that to balance the camera housing we need more positive buoyancy on the back of the ROV, so we calculate the amount of polyethylene foam needed to balance, and zip-tie it on. Also we add large black pipes to the bottom of the ROV to fill with rocks to keep it neutrally buoyant, as it is predicted to be very buoyant.

4/12/19 - We Oakey Blue glued the ROV frame in place and place it into the fume hood. The control box is also formed and wired. Looks like a control cube.

4/15/19 - We spend the next week placing the motors on the frame and positioning them so it goes slightly up when going forward, and slightly forward when going up. Buoyancy is also corrected with more rocks.

4/22/19 - We begin to build the props for demonstration, as we will be doing a video submission

4/26/19 - All props are done, except the cannons weight. We’ll figure it out next week.

4/29/19 - Tan used some calculus that he learned and figured out the volume of the cannon, and we rewrote my cannon program on the Nspire and found out it needed to weight about 2 kg to have a weight of 25N underwater. It actually worked!

5/1/19 - Today we spent 5 hours figuring out the fish drop mechanism, and it works! If you want to drop something heavier, you just need to add more magnets to the underside. We are also going to use a car battery to run the ROV since it is 12V. We are ready to test the final ROV.

5/4/19 - We are using the Beazers pool to test all our equipment and get ready to film next week. It went well, just needs a slight buoyancy change, and we are set.

5/6/19 - Buoyancy changes are made and final filming plans are set.

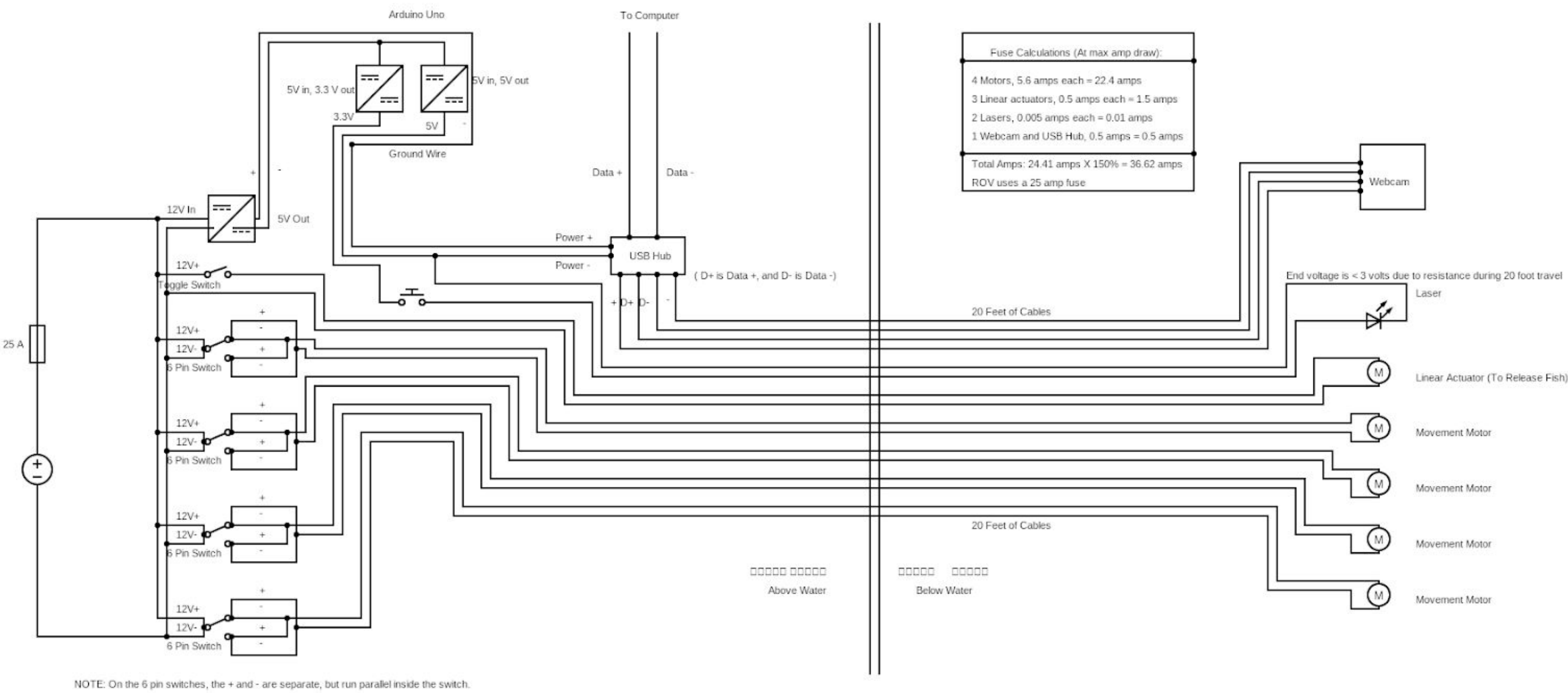
5/8/19 - We don't have time to film the 15 min underwater, but we film the ROV above the water, and the prop run through. We will film Friday, and until then, we can edit what we filmed today.

5/10/19 - Slight change in plans, we are going to use the Betts pool today to film, so we film! It went well, it does exactly what it was designed to do.

5/12/19 - Film is submitted. We did really well, and now all we can do is hope.

System interconnection design

Electrical: There is NO programming at all to make this ROV go! All the electrical for the ROV is from switch to motor electrics, and see below to the electrical SID.



Fuse calculations:

4 Motors, 5.6 amps each = 22.4 amps.

3 Linear actuators, 0.5 amps each = 1.5 amps.

2 Lasers, 0.005 amps each = 0.01 amps.

1 Webcam and USB Hub, 0.5 amps = 0.5 amps.

Total Amps: 24.41 amps X 150% = 36.62 amps.

ROV uses a 25 amps fuse.

Pneumatics/Hydraulics: Guess what? There are **none**!

Software: To create the electrical SID we used https://www.circuit-diagram.org/ , to make our documents we used Google Drive, to make our videos and create pictures we used Adobe Premiere Pro, Adobe After Effects, Adobe Illustrator, and Adobe Photoshop, and to make the propellers we used Windows 10 3D Builder.

Surface Operator Interface: Our ROV is controlled completely by analog switches and has no code to control the motors.

Safety

Safety overview:

The Sea Storm ROV was designed to prevent sharp edges-through an adhesive so we were able to ensure that when operating in the pool there wasn't anything that could damage the pool, persons, and any of the props that were being worked with. The Thruster covers were designed to allow water flow but also to shield the rotating propellers, if anything got caught in the propellers they would either be damaged by the bilge pump, or would break the propeller blade. When building the ROV we decided that it was best to create a safe environment to operate sharp tools while ensuring team safety. Another safety feature we added on, was gathering together wires with and Zip-tying them together. After we cut off the excess plastic we were able to use the adhesive to make the edges safe. The most important thing our team agrees on the fact that control is what you make it to be, therefore we engineer control by having close toed shoes and long hair put up into a bun or ponytail.

Safety checklist:

Task	Hazard	Implementation
1. Review electrical schematic and be sure all electrical connections are properly placed and sealed.	a) Electricity b) The accidental placement of feet on wires	• Remove any confusion on how the electrical system works • Where it is positioned

Sea Storm

2. Set up ROV and test moving parts	a) Hair/clothes may get caught in moving parts. b) Bodily harm from accidents on site.	● Proper attire is worn/long hair tied back ● Closed-toed shoes, safety glasses are worn
3. Ensure all ROV parts are secured and properly wired	a) Cause bodily harm on job site. b) Can pollute work site with fallen debris	● Perform a thorough check of the ROV to fix those parts that could potentially be liabilities.
4. Ensure that ROV has no sharp edges	a) Can cause harm to operators b) Can cause harm to onsite personnel	● ROV is thoroughly checked over for sharp edges before product demonstration begins ● Sharp edges are fixed with a safe adhesive.
5. Check that the tether is secured and a 25 amp fuse is in place.	a) Loss of tether or ROV b) Electrical shortage or withdrawal	● ROV's tether is thoroughly looked over to ensure no rips and that a 25 amp fuse is in play
6. Test all thrusters	a) Can cause injury to the inspector, and other personnel within the immediate vicinity.	● Inspector must be knowledgeable to the placing of moving parts and be able to communicate with operator of ROV.
7. Ensure that attachments are secure, and show no signs of corrosion or damage	a) Can cause electrical problems b) Can be of harm to operators	● Reattach unsecure parts of necessary ● Delegate only 1-2 team members to inspect and reattach

Critical Analysis/Reflection

<u>Testing and Troubleshooting:</u>

When we first began to assemble the ROV, we made sure to check the sizing so we didn't go over the boundaries and lose points. During the process of building, we tested the camera multiple times(finding that it got damaged once then got stuck on an overexposed setting for lighting), connecting it to a laptop. We also modified the bilge pumps and tested them to ensure they would perform flawlessly. To address the camera situation we ended up switching the broken camera out for our backup one and then since it was over exposed we used a human shade tool for when it's bright outside (sunglasses) to “overcome and improvise”.

After the completion of the ROV, we brought it to a pool to test. From the remote control, we tested each bilge pump separately and the release mechanism for the trout fry. After testing out of the water, we put the ROV in the pool and fixed the problems mentioned in the next section. After, the ROV was able to function well underwater, we did the tasks extensively before we recorded ourselves.

Challenges:

One of our first problems that arose was the buildup of the Rov. Since we are at a lower education it was difficult for most of us to understand how to create an ROV. Luckily we were able to assemble a team and come up with the design and how the ROV would operate.

Another trial we had was shipment of parts. We started out as two teams and merged into one, however both teams ordered the parts needed through Amazon which caused some problems. We placed the order through the school so when the parts were cancelled, the email was sent to the high school's finance office instead of our instructor, Ms. Grossman. Fortunately, Ms. Grossman contacted Amazon and was able to figure everything out.

We designed propellers to go onto the bilge pumps so there was something to push against the water. The propellers were 3D printed to fit the bilge pumps, but the first attempt was too small. There were two more attempts at making the propellers fit and at last we were able to make the propellers fit onto the bilge pumps by making the connection based on a triangular area instead of having it exactly fit onto the pump.

Once the ROV was fully built, we had issues with the buoyancy. At first it was too buoyant and wouldn't go under the water, then the camera base was filled with air and made the front float more than the back, affecting our plan to perform the tasks. At last, we found the right buoyancy that kept it level underwater.

Lessons Learned:

We can all agree that we have learned a lot from this project. Not only have we learned about the properties and functions of an ROV, but we now know a lot about how to work as a team. We all went through the stress over deadlines, the confusion on what to do, and the frustrations of not being able to accomplish what we needed to. It was hard on all of us, but we are glad we had struggles.

It is known that the journey is better than the reward. Of course we are glad that we reached our goal, but without the trials it wouldn't of been worth it. We freaked, we moaned, and we all wanted to get the project off our shoulders, however we pushed through. We all persevered and helped each other out through the hard times. We were always there for each other and will continue to be there until the end. We all made sacrifices that affected us in our own ways. We are glad we took on the challenge and were able to succeed what we wanted to.

Budget

School:	Stansbury High School		From:	1/1/19
Instructor:	Ms. Grossman		To:	5/15/19
Income Source:				Amount:
Stansbury High Science Department				500.00$
Tooele Science				5000.00$
Expenses:				
Category:	Type:	Description:	Projected Cost:	Budget Value:
Hardware	Purchased	PVC, adhesives	100.00$	100.00$
Electronics	Purchased	Speaker wire, switches, motors	300.00$	300.00$
Travel	Purchased	(3) round-trip to Kingsport TN	1000.00$	1000.00$
General	Purchased	Marketing, Transportation	100.00$	100.00$
Pool	Donated	Pool	0.00$	-
Projected Cost:			1400.00$	
Budget Coverage:			1400.00$	
Fundraising Needed:			0.00$	

Project Cost

School:		Stansbury High		From:		1/1/19	
Instructor:		Ms. Grossman		To:		5/15/19	
Funds:							
Date:	Type:	Category	Expense	Description	Source Notes	Amount	Running Balance
2/16/19	Purchased	Hardware	(See Component Sourcing, Home Depot)	PVC, adhesives	Body of ROV and some	72.54$	72.54$
2/23/19	Purchased	Electronics	(See Component Sourcing, Amazon)	Speaker wire, switches, motors	Controls and all needed electrics for ROV	302.79$	375.33$
NA	None yet	Travel	NA	(3) round-trip to Kingsport TN	To get to the International	None Yet	375.33$
NA	None Yet	General	NA	Marketing, Transportation	Display board, etc.	None Yet	375.33$
4/6/19	Donated	Pool	Pool	Pool	Test equipment and ROV	0.00$	375.33$

Total Raised:					5500.00$		
Total Spent:					375.33$		
Final Balance:					5124.67$		

References and Acknowledgements

References:

http://homebuiltrovs.com/seafoxretrofit.html

https://www.instructables.com/id/Underwater-ROV/

https://www.marinetech.org/

Acknowledgements:

And a big thank you to our supporters!!!

- Tina Grossman
- Stansbury high school
- Parents of team members
- Derek Perry
- Beazers, Betts, and Stansbury Park Pool for letting us use their Pools