Abstract

During the SeaPerch season, our team had to brainstorm and make adjustments to our ROV due to the new 2021 Challenge and build off of last year's ROV. We wanted to keep our design as **small** and **lightweight** as possible so we can move **swiftly** and **smoothly** throughout the water. During the last Seaperch season, we made our ROV super **light** and **small** using CPVC pipes[5], which are **lighter** and **smaller** than regular PVC pipes. But this year, we wanted to go smaller and **faster**, so we chose to change our pipes to **3D printed** pipes. We kept the same shape and size as last year, but 3D printed our pipes so we could reduce a lot of our **mass**. We also 3D printed most of our connectors, in order to reduce our **mass** even more.

For the new 2021 SeaPerch challenge, we had to find a way to adapt to the new waterway cleanup. The first main thing we focused on was the trash on the surface of the water. We discussed and brainstormed, and decided on building a **mesh basket** that mounts on the top of our ROV, and mounts on our ROV with **carbon fiber** sticks. This won't really affect the **mass** of our ROV, since payload net and carbon fiber are very light. For the trash pickup that was submerged, we brainstormed and had 3 ideas. A motor clamp, a hydraulic clamp, or a simple hook. We all agreed to do the motor clamp, so we built it. But when we tested it, we realized the motors were not strong enough to hold the wiffle balls. So we went back to the drawing board, and designed the hook. The hook was really easy, because we just 3D printed 2 forks and attached them to the ROV. For the active mine, we cut a semicircle into the mesh net so we could lift the mine and keep it **balanced**.

Using the **Engineering Design Process**[2] we were able to find many opportunities that could change our design for the better. This would help us find problems that can be fixed later. We were able to find reliable options over time and excel to the fullest with what we can do.

Task Overview

The two tasks we will be doing are the obstacle course, and the challenge course, and finish it as **fast** as possible while getting the most points. Since we are trying to complete the obstacle course as fast as possible, we 3D printed attachments for our ROV to help it move faster. We added a motor cap which is a cone-shaped object put on the motor to allow for better **hydrodynamics**[1]. We also added the same cone-like shape design to the Float Caps (Figure 1.3).

For the challenge, there was a waterway cleanup, where there was floating and sinking trash which had to be moved by our ROV. This inspired us to add a net to capture trash above the surface and a hook to capture trash below the surface. To disarm the active mine, we added a cutout in the net that was shaped like the mine so we could grab the mine, turn it, and take it off. To pick up the wiffle balls, we are going to use a hook which we used for picking up the sunken trash. We will push the gate latch on the disposal vault with our ROV to open the gate and dispose of the trash and wiffle balls. In order to use the same ROV for both the obstacle course and the challenge, we would have to find a way to move or fold the net and hook. We would take the net and move it to the bottom of the ROV, that way there is nothing obstructing the top of the ROV. We would also make it possible to rotate our hook, that way it doesn't obstruct the front of the ROV (Figure 1.1).. These changes give us the best chance at beating both challenges.

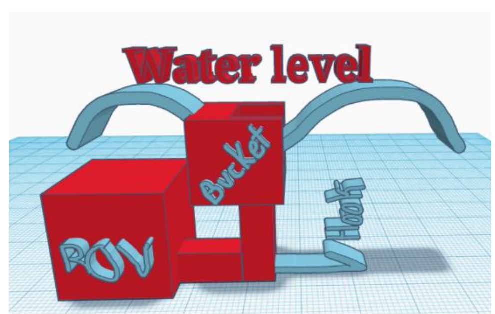

Figure 1.1
Basic design of our ROV with attachments

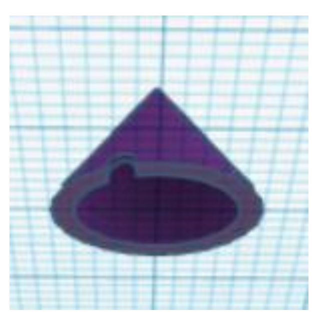

Figure 1.2 Figure 1.3
Hydrodynamic caps

Design Approach

Our design for this year is mainly based on our design last year, except we made improvements for this year's challenge and for our ROV to go **faster**. When creating our design and making improvements to it, we used the **engineering design process**[2] to come up with the best possible solution.
Our first **iteration**, our ROV from last year, was named Lio. Lio is a **small**, **lightweight**, and **fast** ROV that we used last year, and we were happy with the design. But we wanted it to be better, so we wanted to use this iteration to make our final design for this year, which we wanted it to be **lighter**, **faster**, and adapted to the challenge this year.

Figure 1.1
Lio mesh basket

Because the challenge was different from last year, we had to come up with different ideas to succeed in the challenge. For the active mine, we thought that using a narrow stick would work, but we put the other challenges in mind. Because we still had to pick up the rings and move them to a different location, we thought of 3d printing[6] ourselves a narrow hook. But when we tested this in the pool, the mine turned easily, but it was impossible to lift. So we went back to brainstorming ideas and thought about using our ROV to push it up rather than pull it. For the garbage patch part of the challenge, we were going to mount a net of payload netting to the top of our ROV. Because it was very sturdy and at the top of our ROV, we thought that the net would be useful in picking up the mine along with moving the items. So we cut a small area for the cross to fit into the net and tried to pick up the cross. This time, we were able to turn the mine and move it off the pole. (figure 1.2)

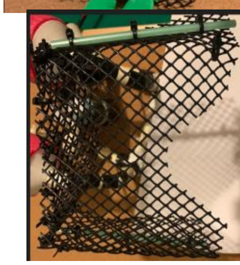

Figure 1.2
Cutout for the active mine

Also, we wanted to make our ROV **lighter** so that it could go faster in the water So we brainstormed a couple of options and narrowed it down to using **carbon fiber** pipes or using **3D printed**[6] pipes. Both of these materials are lighter than the CPVC pipes Lio used. When we tried the carbon fiber, we had to cut it to size so that it could fit the ROV. Cutting it with a pipe cutter was nearly impossible and was messy. Drilling holes through the pipe was also messy and difficult. We figured out that we had to use a specialized saw to cut the carbon fiber, but we didn't have access to that type of saw. But, cutting the 3D printed pipe wasn't as bad as the carbon fiber. It was smoother, cleaner, and easier. So we decided to use the 3D printed pipes because there was less troubleshooting. (figure 1.3)

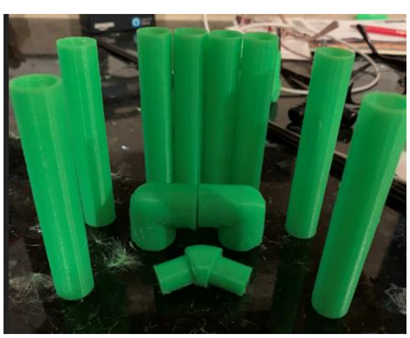

Figure 1.3
Our 3D printed parts

Figure 1.4
Lio frame

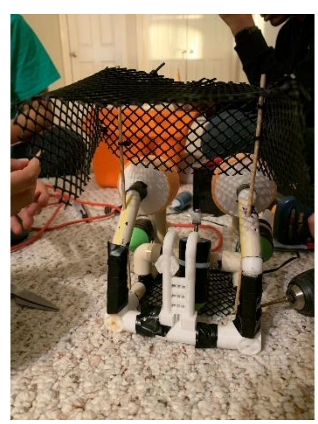

Figure 1.5
Basket on Lio

Design Approach – *(cont)*

Along with the pipes, we also didn't use the standard **CPVC** connectors. We changed our connectors because the CPVC[5] connectors had a lot of mass, and our goal was to reduce the **mass**. So we thought the best thing to do was **3D print**[6] our connectors. For the 90 degree elbows, we 3D printed our elbows to fit the outside of our 3D pipes, so that it could be a tight fit and our ROV won't fall apart. Our 3 way connector also has the same concept. But our 45 degree elbows went to the inside of the pipe, rather than the outside of the pipe. We had to measure the inside of the pipe and the outside of our elbow and make sure they were the same measurement so that they would have a tight fit. By taking all of our CPVC parts, and switching them to 3D printed parts, we reduced the **weight and mass** of our ROV so it could go **faster** in the water. (figure 1.1)

Figure 1.1
3D 45 degree elbow

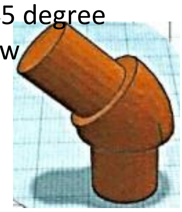

Figure 1.2
90 degree barbed elbow

Figure 1.3
3D 3-way connector

Another challenge we faced with the sunken waste at the bottom of the pool. The previous challenges weren't like this, so we had to brainstorm options to pick these up. We wanted to use a claw controlled by our controller, so that we could pick up the water bottles. The claws would be **3D printed**, and it would be spun by a motor, which would be inside of a 3D printed box. For the waterproofing of the motor, we chose between Plasti Dip[5], and MarineWeld[5] **epoxy**. We tried both of them, and they both worked great and served as a layer. But we chose the MarineWeld over the Plasti Dip because the Plasti Dip tends to peel off after a while, and also because the MarineWeld was harder and more protective. And since it was ready to go to the water, we took it to the pool. The claw was moving inside the water, although it got stuck every once and a while. But when we tried to pick up the water bottle, we could never do it. When we took it out of the water and tried to pick up the water bottle, it still didn't work. We concluded that the claw **wasn't strong enough** to hold the water bottle and that it wasn't going to work. So we took more time to brainstorm, and we thought of an idea that was simple and easy. We wanted to use just two carbon fiber sticks with forks attached to the ends of them, something like a hook, so that we could pick up the water bottles. When we built this and tested it in the water, we were successfully able to pick up the water bottle and move it. (figure 1.8)

Figure 1.4
Our clamp in the water

Figure 1.5
Our fork design

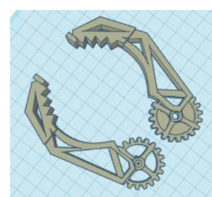

Figure 1.6
Our clamp design

Figure 1.11
Lio v2 underwater

Figure 1.7
Our 3D printed parts

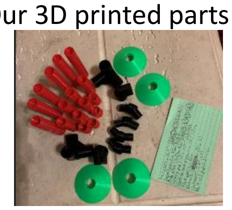

Figure 1.8
Fork hook

Figure 1.9
ROV with attachments

Our final design is named **Lio v2**, because it is an improved version of Lio. It is made of different materials, mainly **3D printed pipes**[6] and connectors, rather than **CPVC**[5]. Lio v2 is lighter than Lio and is adapted for the waterway cleanup challenge, but it kept the overall **shape** and **size** as Lio.

Experimental Results

On our long SeaPerch journey, we had to experiment with many different things. Some examples we tested were what to pick the sinking and floating litter up.

Task	Iteration 1	Iteration 2
Active Mine	Use a narrow hook to lift the mine	Put a cutout in the net and pick up the mine with it
Disposal Vault	Use the ROV to push the latch and unlock it	
Garbage Patch	Use a bucket to move the items from the patch	Use a net to move the items from the patch
Sunken Waste	We wanted to use a motorized claw to pick up the waste	We wanted to use forks to scoop up the sunken waste
Obstacle	Since we had to add additional attachments to support the challenge, we decided to reduce the ROV mass to keep the fast paced timings intact	

Figure 1.1
Difference in iterations

Task	Issues	How did we overcome the problem?
Active Mine	The mine wouldn't come off the pole with the narrow hook because it was getting tilted	We put a cutout and added two carbon fiber sticks to the net to lift up the mine with equal mass distribution.
Disposal Vault	We had trouble with vault door opening over the surface of the water.	We adjusted the height of the challenge course to stay low under water.
Garbage Patch	The straws were hard to catch and they kept sliding off	We started to hit the straw in the center so that it will be even
Sunken Waste	The claw couldn't pick anything up because it wasn't strong enough	We used forks and carbon fiber sticks to scoop the waste
Obstacle	Placing the attachments folded, for an obstacle run was a trouble.	We zip tied our net to the bottom and turned the hook to face upward

Figure 1.2
Problems and solutions

Figure 1.3
Goals and solutions

Task	Goal	Solution
Obstacle	To get the fastest time	Make our ROV small and light
Active Mine	Turn the mine and take it off	Use the net cut out to lift it off.
Disposal Vault	To open and close the vault	Use ROV to push the lock and forks to pick up the ball
Garbage Patch	To be able to collect the garbage and move	Use the net to collect it.
Sunken Waste	Pick it up and move them	Use the forks to pick them up

Reflection & Next Steps

During our Seaperch Journey, we learned a lot of things about science and how simple design changes can have a big effect on the handling of your ROV. The more **weight** on the ROV, the more **gravity** exerted on the ROV. Our team explored and experimented all three types of **buoyancy** methods (**positive buoyancy, neutral buoyancy, and negative buoyancy**)

We as a team particularly enjoyed testing the ROV and finding out if a problem exists, how could we fix it? If we found a problem with the ROV during a pool practice, we would meet up to brainstorm an idea on how to fix it, such as when we had an idea to use a motorized clamp to pick up bottles on the floor of the pool. The motor was not strong enough and if we wanted a strong motor, we would be adding a lot of weight to our ROV. So the next day we brainstormed and put together our ideas for another design. Then we write down the **pros and cons** of that specific design. The design with the least cons and the most pros will be used and tested to make sure it works. This would usually be the steps we take when solving a problem using the **engineering design process.**

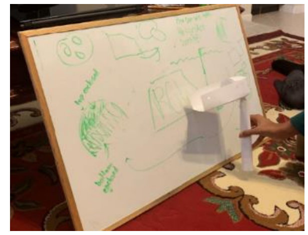

Figure 1.1
Whiteboard with ideas

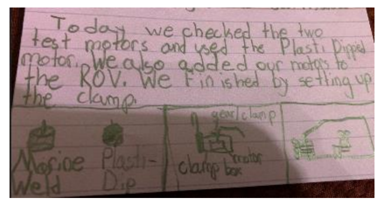

Figure 1.2
Index card with ideas

We will take away what we learned this year and try to implement better designs next year. Designs that are **faster**, more **lightweight**, more **hydrodynamic** and more efficient. With that new knowledge, we can use different materials that are more lightweight to improve the **speed** of the ROV.

We constantly discuss how we can improve our ROV's efficiency. If we do come up with an idea, we always discuss why we should use that idea instead of another idea or why we should use that idea instead of our current design. This allows us to know whether or not if the design is worth adding, because the design may make the ROV slower if not thought through properly. Overall during the Seaperch journey this year, we as a team learned a lot this year and we will use what we learned to make a better, and faster ROV.

Figure 1.3
The team brainstorming

Acknowledgements

The Liopleurodons team would like to thank SeaPerch, Robonation, AUVSI Foundation, Alvin ISD, District sponsors, parents for providing us the pool access and resources and our coach Ms. Krishna for giving us this opportunity for a wonderful underwater ROV experience.

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Budget

Item	Quantity	Cost
3D printed pipes	37 in (37 g)	$1.85
3D 3 way elbows	2 (13 g each)	$1.30
3D 45 degree elbows	4 (3 g each)	$0.60
3D float caps	4 (6 g each)	$1.20
Barbed elbow 90 degrees	2	$0.24
Carbon fiber sticks	4	$1.00
Barbed elbow tee	2	$0.24
Marine grease	3 spoons	$0.80
Total		**$7.23**

Figure 1.1
Budget for the ROV

The 3D printed parts were calculated through $0.05 per gram.

Figure 1.2
Lio Model and attachments for challenge

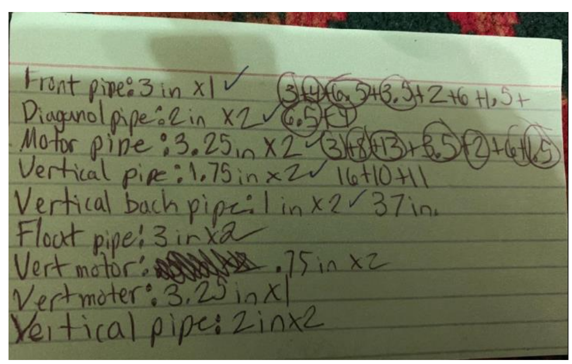

Figure 1.3
Pipe calculations/measurements

LIOPLEURODONS

AlvinISD, Pearland, Texas USA

STOCK CLASS (HIGH SCHOOL)

2-4 Years participating in SeaPerch

1-3 Times at the International SeaPerch Challenge

Our SeaPerch is unique because: (100 words MAX)

- It has a low mass
- It has a low volume
- It is fast and hydrodynamic
- It has many 3d printed parts

SeaPerch Design Overview: (100 words MAX)

Our rov is a small and lightweight robot that travels underwater at fast speeds. It is mostly 3d printed in order to reduce the mass of the rov. We also designed and 3d printed attachments to the rov to make it more hydrodynamic, such as our float caps, and our motor caps. We also have a lot of attachments for the 2021 seaperch challenge, like our mesh net, and our fork hook. We believe our rov is a great rov, that can overcome any and all challenges.

Our biggest takeaway this season is: (100 words MAX)

We learned many new things about SeaPerch that we didn't know before, like how a pandemic won't stop young engineers from building a robot and testing it.