1. Abstract

The ocean is a unique ecosystem that we cannot afford to lose. Yet every time people pollute the ocean, marine organisms are threatened and the damage could become permanent. Our team decided to focus on oil spills for our real-world problem. Spills are typically caused by ship equipment failure, human error, and natural disasters. Any of these accidents could potentially leak millions of gallons of oil into the ocean. Not only could the ocean ecosystem be destroyed, but it would take a large amount of time and money to clean them up. To help combat this problem, our team designed a unique remotely operated vehicle, or ROV, to clean up oil from our waterways.

This report details how we used the engineering design process for our SeaPerch challenge. After **identifying the mission** and **brainstorming solutions**, we **created ROV designs** in TinkerCAD, a computer-aided design software website. Our team scrutinized these designs to find flaws, and then we **redesigned our ROV** to improve its design. The results section shows how our team created a **testing plan** that would evaluate the efficiency of our ROV, even though we did not build the robot. We also attempted to foresee potential problems our ROV might encounter. The final section of this report includes **lessons learned**, **challenges,** and our **next step**.

We designed an ROV equipped with sponges specially designed to absorb oil from the water. Two of the sponges are attached to a conveyor belt. The conveyor belt moves the sponges in a circular motion to pick up the oil. The sponges will then be pressed against the sides of the ROV where the oil is squeezed out into the storage boxes on the ROV. When the storage boxes are full, the ROV will return to the ship or shore to empty the boxes. One of our concerns was the inefficiency of time required to clean up oil spills. Our goal is to clean up oil spills in the ocean by being time and cost efficient. That way, both marine life and human beings will not be harmed by the effects of oil spills.

2. Task Overview

Our ROVs main task is to remove oil from water. Oil can end up in the ocean when an accident occurs during transportation. Oil drilling can also lead to oil leaks and spills. Boats and ships generate oil pollutants in the water. The presence of this oil affects marine life and creates pollution. Oil spills are one of the biggest causes of oil in the waters, threatening the ecosystem.

We have designed an ROV to clean up spills using custom made Oleo Sponges created by the Argonne National Laboratory. The sponges are able to extract oil from water. The outer part of the sponge is made out of polyurethane foam, and the inside of the sponge is covered with **oleophilic molecules**. Oleophilic molecules are able to separate oil from numerous liquids.

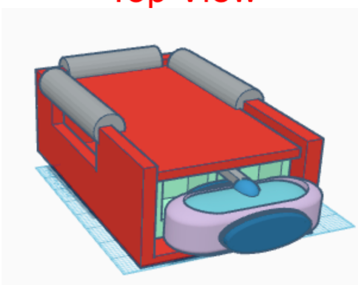
The Oleo Sponge will act as a filter to remove the oil from the water by soaking the oil up. These sponges are attached to the bottom of the ROV, and will constantly be moving through a conveyor belt conveyor. The sponge will first go into the water and collect oil, then proceed to go inside the robot where it will have the oil compressed out of it. The robot will store the oil collected in aluminum boxes that are located inside the ROV, which is also made out of aluminum. The process will repeat with each sponge until the storage boxes are completely filled with oil.

3. Design Approach

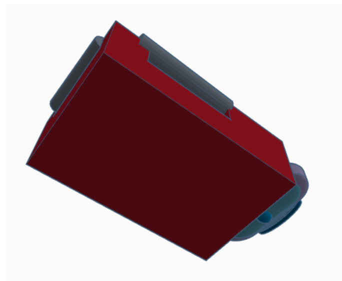
ROV Design Iterations

1st Iteration Design Flaws

Top View

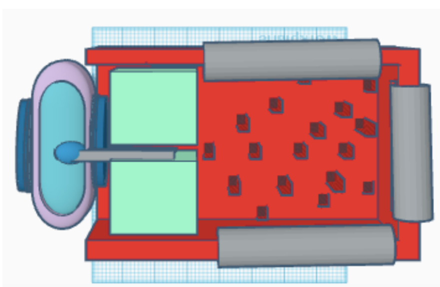


Bottom View



- There are no holes in the bottom of the ROV for water flow. The ROV will become slower because of the water piling up inside of it, creating **drag.**

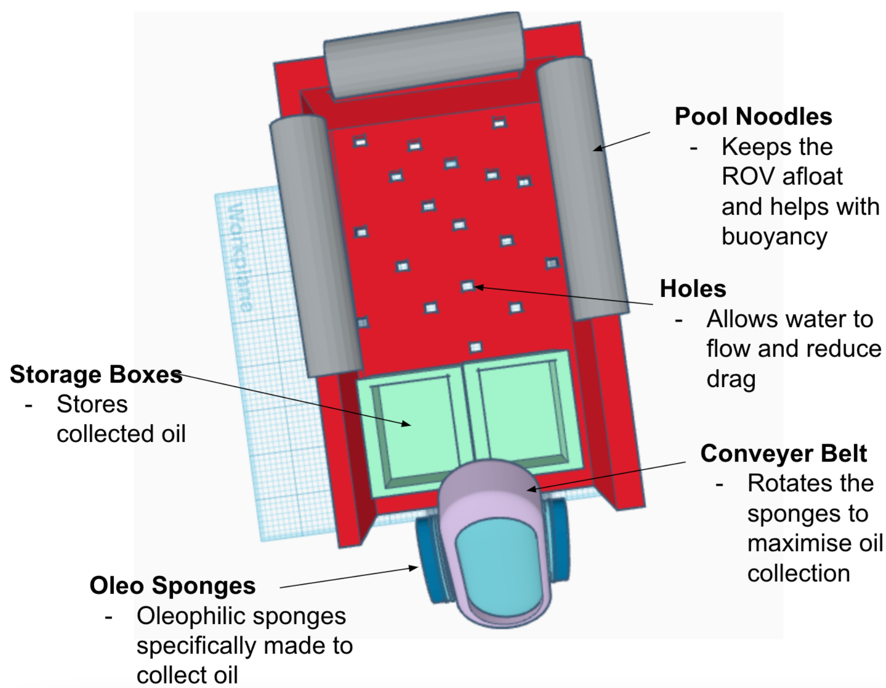
2nd Iteration Design Flaws



- The positioning of the conveyor belt causes the sponges to be entirely submerged. They only need to be partially submerged for the oil to be removed.
- The opening of the storage boxes face forward so all the oil falls out and water flows in.

Final ROV Design

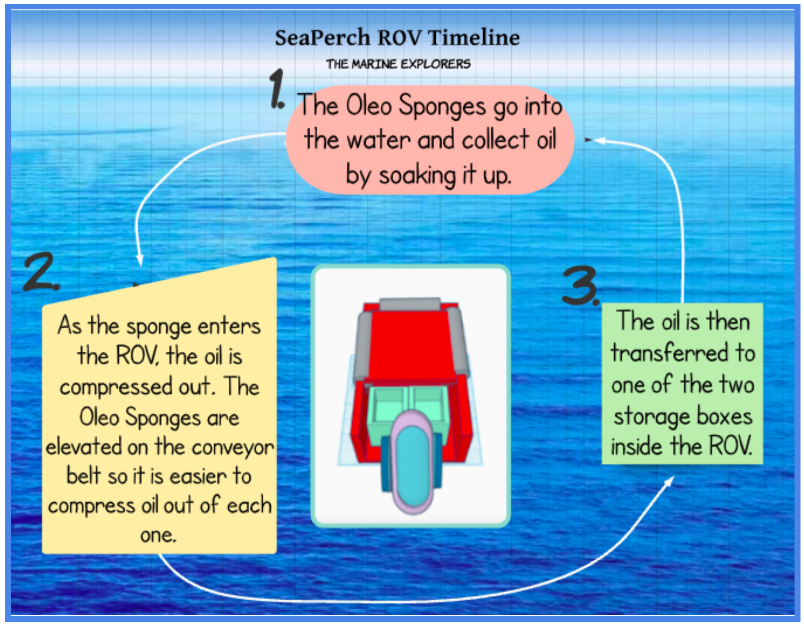
Created by our mechanical engineers on TinkerCAD.com



The construction and design process of our ROV contained a heavy amount of research and building upon others' ideas. First, the team members tried to research any type of special material that could absorb oil in salt water to combat the real-world problem. We came up with various ideas such as:

- Cotton
- types of polymers
- Sponges

However, we decided that cotton was too fragile to be used in oceans, and finding specific types of polymers was a struggle, so we settled on researching special-manufactured sponges that absorb oil.



Oleo Sponges, made of polyurethane foam and wrapped with **oleophilic molecules** to take oil from water, are our prime material for absorbing oil. This sponge is able to absorb up to 90 times its weight in oil, making it efficient for the ROV to spend long periods of time in the ocean without constant returns to shore.

After finding out about Oleo Sponges that worked perfectly for our design, we decided we needed a way to maximize how much oil we could pick up. Instead of constantly needing new sponges everytime one was filled with oil, we decided to use storage boxes to squeeze the oil into. This way, we could remove the oil from the sponges and re-use them, allowing us to pick up much more oil before needing new sponges.

With the idea of storage boxes, we needed a way to transfer the oil into them, something we hadn't thought of before it came up. We soon came up with the idea of using compressors to squeeze out the oil. The compressors would squeeze the oil from the sponges at a fixed rate, into the storage box.

After our team researched many ways to pick up oil from the ocean using an Oleo Sponge, we thought of the idea to use a rotating mechanism similar to a conveyor belt. It is attached to the top of our ROV, and the Oleo Sponges are on the conveyor belt to repeat the process. The conveyor belt is slanted so the sponges can absorb oil from the water without any water getting into the storage boxes.

Placing the sponges directly into the conveyor belt wouldn't work due to the compressors not being able to wrap around the sponge and squeeze the oil out. We decided to slightly elevate the sponges on the conveyor belt so there was just enough space for the oil to be compressed properly. Our team also took **buoyancy** into consideration. We used three pool noodles attached to the top of the ROV so it wouldn't sink and be at the right depth to absorb oil.

4. Results

Due to COVID-19, our team, unfortunately, could neither build nor test our ROV design. However, we have a feasible testing plan if given access to resources and safe gathering of members. We would set up our test by putting oil in salt water at an approximate 1:2 ratio to replicate an oil spill in the ocean. Then, the ROV would be placed in the salt water to clean up its oil with its various functions. Also, we will put rubber animals to act as real marine life surrounding the oil spill to make the situation as realistic as possible. The subsequent changes after the testing will vary based on the ROV's performance in cleaning up the miniature oil spill. Problems could arise in the tests, allowing our team to slightly alter the ROV's design to enhance its performance.

A potential problem may be **drag** being created despite the rectangular holes in the bottom. This will definitely slow down the ROV due to the increasing weight of the water flowing in the area behind the storage boxes. To maximize the ROV's speed and **efficiency**, a possible solution to this setback would be to add more holes in the back and sides. This way, instead of trapping water, the ROV will have water flowing in and out, so the speed or weight of the robot will not be affected by the water.

Another problem the ROV might have is that it has to make numerous trips back to shore to remove the oil from the storage boxes. This may take too much time. To solve this problem, we decided to expand the storage boxes so that the ROV can last in the water for longer periods of time.

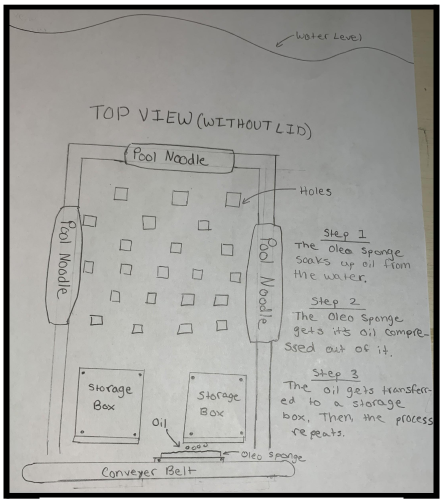
We also noticed, the sharp edges of our ROV might accidentally hit the "marine life" (rubber animals in the test) and injure them. By looking at the basic SeaPerch, the PVC pipes/edges are round, so if the ROV was to collide with marine life, neither parties would sustain much damage. Although the pilot of the ROV has a critical job of controlling the robot, wandering animals might swim through the ROV's path and cause an accident. As a result, rounding the corners of the entire ROV would protect marine life and the robot itself.

Furthermore, there was a safety concern about our conveyor system. The tether in the standard SeaPerch kit has four pairs of wires. To power our ROV, we only needed three pairs of wires for our three motors. This gave us an extra pair of wires which is what we would use to power our conveyor belt. However, there was no on/off switch for the conveyor belt. To solve this problem, we would wire a "**kill switch**" button to immediately be able to shut off our conveyor belt motor in case of an emergency.

Another way to improve our ROV is by adding more pool noodles. Our current design has three of them: one on the port side, one on the starboard side, and one on the back. However, there is more space on the sides of the robot to hold the pool noodles in place. We think that this idea is efficient because many parts of the ROV are made of heavy materials, the pool noodles will help balance this out and create **neutral buoyancy**, allowing the ROV to freely move through the water.

5. Reflection & Next Steps

We learned many lessons about teamwork and critical thinking through the engineering design process. Our team thoroughly enjoyed thinking of a novel ROV design that could contribute to waterway cleanup, specifically oil spills. We gained a lot of knowledge and experience from designing our ROV.



Original Drawing by Aanya, our CEO

First of all, our team learned that research and brainstorming are key to developing an original and working solution to a problem. We came up with many great ideas, and we couldn't have finished the design without every member contributing. For instance, when thinking about material to absorb the oil from the ocean, our team did a lot of research to come up with the perfect item. We thought of using items such as cotton and sponges to absorb the oil before deciding on the latter to use for the design. In addition, another problem we encountered was how to get the sponges to the storage box. We thought of many possible solutions before one of us brainstormed using a conveyor belt to put the sponges on. The team members then built upon that idea to produce our final product of elevating sponges on the conveyor.

Another challenging part of the project was sorting out our design ideas in TinkerCAD. We believed that we had gotten the basic idea of the ROV done. However, when we went to TinkerCAD to try and design it, things got harder than we thought they would. For example, we still think that the conveyor belt idea was good thinking to incorporate in our ROV, but we struggled with finding a way to design it on TinkerCAD. We also had trouble positioning other parts of the ROV, such as the storage boxes and pool noodles. Consequently, a hand-drawn design made by Aanya (see photo on left), which made drawing in the CAD program a lot easier. From then on, it was smooth sailing for the project, including working on the design and explaining the parts through the technical design report.

In conclusion, our team enjoyed working on this task and designing a hypothetical solution to the tragic problem of oil spills. We will use our newfound SeaPerch knowledge of brainstorming and designing to assist us in our future endeavors and experiences.

Our next step would be to actually *build* the ROV in-person. This would allow us to have the opportunity to **test and evaluate** its performance. Our school's SeaPerch program is for 7th and 8th graders. Since all of our team members are in 7th grade, we plan to participate in the SeaPerch competition next year. We look forward to building our design and seeing how well it would perform a real world mission. We hope to get the full SeaPerch experience without restrictions due to COVID-19. This is what we plan to do next year in the next Seaperch Competition.

6. Acknowledgements

Of course, our team could not have achieved our goals without the help of many others outside of our team. First and foremost, we would like to thank NAVAIR and SeaPerch for holding this competition and allowing students like us to continue our experience in robotic designing and engineering despite possible roadblocks due to the ongoing pandemic. We have enjoyed the experience a lot and appreciate the opportunity given to us to expand our knowledge and understanding of engineering and science through the SeaPerch program.

We would also like to thank Mount Laurel Schools–specifically, Harrington Middle School– for hosting a SeaPerch team, once again giving Mount Laurel students an opportunity to learn through their own school and take pride in their district. The hard work and dedication through other HMS SeaBots members and coaches is admirable and something to look up to.

Speaking of the HMS SeaBots, our success in achieving our goals could not have taken place without the help and advice of the SeaBots coaches, Ms. Barrett and Ms. Ashman. They have answered our questions, provided advice, and helped us understand underwater robotics. When our team was facing challenges, Ms. Barrett and Ms. Ashman were there to assist us with anything we needed and provided us with helpful feedback to improve our understanding of underwater robotics.

In addition, the parents of the team members are also people to thank because we would not have been able to be part of the HMS SeaBots, let alone the competition, without them. Their unconditional support has driven us to accomplish the goal and keep going despite the challenges along the way.

To collaborate with each other, our team used a WhatsApp group chat and met with private meetings via Zoom. GSuite applications were also used.

We would also like to thank Argonne National Laboratory for providing the team with additional information regarding the Oleo Sponges used in our design.

These people and groups have been an essential part of our team's accomplishments in the SeaPerch program , so it is only right that we acknowledge their dedication to our team.

7. References

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8. Budget

Materials and Purpose	**How was the component used?**	**Quantity**	**Total Cost**	**Vendor Link**
Laundry Tub Faucet Block	Squeezes oil out of the sponges	2	$7.16	link
Oleo Sponges	Absorbs oil from the ocean	2	$11.94	N/A (Email from Argonne National Laboratory)
Plastic Sheets	Material for ROV Structure and storage boxes	15	$0.15	https://www.alibaba.com/product-detail/Free-sample-cheap-corflute-5mm-Corrugated_62259382091.html
TOTAL COST			$19.25	

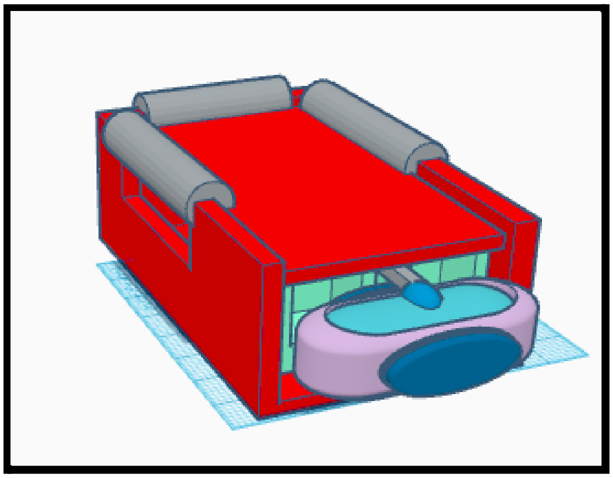
Detailed budget: SeaPerch Team 4 Budget

Fact Sheet

The HMS SeaBots - Marine Explorers

Harrington Middle School, Mount Laurel, NJ USA

0 - Years participating in SeaPerch
0 - Times at the International SeaPerch Challenge



Our SeaPerch is unique because: (100 word max)

Our SeaPerch is unique because it has many different features that contribute to its ability to remove oil from the ocean. It has a mechanism similar to a conveyor belt attached to it, and uses oleo sponges as the most important part of the design. Oleo sponges specifically collect oil, and they are time-efficient and don't create a lot of waste. Our SeaPerch is also made of a variety of materials in different shapes and sizes, such as aluminum and pool noodles.

Middle School

SeaPerch Design Overview: (100 word max.)

Our design is made to collect harmful oils from the sea, many caused by oil spills. It has a feature inspired by a conveyor belt that rotates with oleo sponges on it, which soak up oil from the sea. The sponges then go inside the ROV and the oil is compressed out of them. Lastly, the oil is transferred to one of the storage boxes located inside the robot, and this process repeats itself.

Our biggest takeaway this season is: (100 word max.)

Our biggest takeaway from this season was the overall experience of designing an ROV for the first time. It was interesting to collaborate with a team and come up with ideas to save our ocean and ideas to design a robot that could complete this task. It was challenging at times, but we all learned a lot from the experience of designing this ROV together.