Deep Sea Dominators

Our Team

Madelyn

I like Seaperch because it involves math and I want to be a math teacher when I grow up.

Mila

I joined Seaperch because I want to be a Marine Biologist when I grown up, and learning about undewater ROVs can help me study Marine life.

Jake

I joined Seaperch because I like robotics and building things, but also because I like the competition.

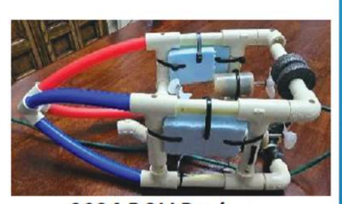
Thea

i joined Seaperch because I like learning about various STEM concepts, and I also love to design and build.

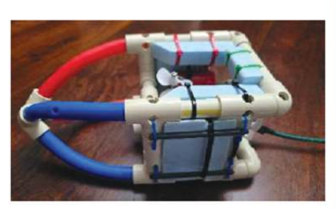
Design Process

Our Team used the Engineering Design Process to work through how the different aspects of the ROV design to complete the tasks.

- **ASK** – Identify the improvements to go through the courses without making major changes. How can we increase our speed and maneuverability (Subhodeep Ghosh, 2019)? How do we pick up items? Will our center of gravity (Hall, Nancy, 2024) change?
- **IMAGINE** – We looked at creating an ROV that is 20% smaller than our previous design. We wanted to change the arm to possibly two prongs to allow us to pick up objects better by scooping.
- **PLAN** – The designs were talked about on what could be done without having to move from the torpedo design (Conceptual Guide) while maintaining an open box frame (The Unique Challenges) we had the previous year.
- **CREATE** – The Team builds the ROV and then tests, makes the improvements when a new issue arises.
- **TEST** – We tested after each version is created to be able to make sure the ROV worked. We also tested the buoyancy (Buoyancy, n.d.) (Chart 1) and the speed of the ROV.
- **IMPROVE** – Considering the pros and cons, modifications are made.



2024 ROV Design



2025 ROV Design

	Design	Pros	Cons
Version 1	Frame Design	Much smaller	Buoyancy is not neutral.
	Arm Design weight – 57.1 g	Hook with barrier, is visible with tape and retracts	Hard to rotate. Can't pick up anything unless it has a hoop.
The Team measured out the CPVC and PEX pipe straight pieces to be 20% smaller, but the fittings are the same size. The insulation added started at 165^3cm. We started with the arm design from last year that only uses CPVC pipe.			
Version 2	Frame Design	Created stability for the motors.	Weighted and not surfacing as fast.
	Arm Design Weight – 76.8 g	Can pick up items without rope	Very heavy. When picking up 1 item, the other arm could get in the way and it is not balanced
The Team added insulation to the sides of the ROV based upon the buoyancy test conducted (Table 1). The insulation covers the sides of the open box frame, but most sides are still open. Carbon fiber rods were attached to the outside of the insulation to help create more stability for the motors and the insulation. For the arm, the team created a pitchfork design with two carbon fiber rods.			
Version 3	Frame Design	Air is released form the pipes faster, removed weight	The ROV continued to tilt port side. We had issues with buoyancy, causing us to have to adjust the insulation.
	Arm Design Weight 29.5 g	Lighter than pitchfork design with two rods.	Object would slide off. Weighed down the front due to the center of gravity being off when we picked up items.
Team created weight reduction (CDS, 2024) by adding more and larger holes while still keeping structural integrity (TWI, n.d.). Changed the arm to a singular carbon fiber rod.			
Version 4	Frame Design	Positive buoyancy	Tilts to the starboard side.
	Arm Design weight – 27.2 g	Lightest. Serrations to grip the rope. Objects slide on carbon fiber easily. Folds up from the back to keep the same center of gravity when picking up objects.	The serrations are father back and make it hard to get things to start. Objects still slide off sometimes.
The ROV still had negative buoyancy and so we added insulation around the top of the sides and back. The team adds an arm that has a single carbon fiber rod attached with hot glue. Grooves were filed in the carbon fiber rod so the hot glue would hold. The arm has serrations and attaches to the back of the ROV, while previous versions attached to the middle. Tested different color electrical tape used at the end of the arm to see what could be seen underwater the best.			

Arm – Version 1 | Arm – Version 2 | Arm – Version 3 | Arm – Version 4

Final Design:

We built an ROV that is different from the SeaPerch Kit. The final design is the same shape as our design from last year, but is 20% smaller. We got this by measuring last year's build and creating the equation: Length *0.8 = 80% of the original length of each section of pipe. We decided to make this change because the design we had last year worked well, as it got the team to internationals where they placed 5th overall but could be improved to create a better performance in the obstacle course. The ROV has a torpedo shaped front that helps with hydrodynamics and maneuvering through the obstacle course. To make the ROV even more lightweight we drilled multiple 3/8" holes in almost all the fittings. This removed .467g per hole in weight off the ROV design. We came to this by weighing a CPVC T without holes and a T with holes and getting the difference of 1.4g. We then divided that by the 3 holes in our T with holes. There are a total of twenty nine 3/8" holes on our ROV, removing an estimated 13.5g from the ROV weight.

We used blue insulation foam to create buoyancy. After a lot of testing, we had to put some in several places to create a balanced ROV that had the buoyancy we wanted. We angled the edges of the pieces on the sides so they wouldn't get pushed through and held them in place with two sections of carbon fiber rod each. This also helps stabilize the thrusters as it doesn't move or break when tightening the zip ties. We angled the front of the top pieces of foam to increase hydrodynamics.

The 4th and final arm design folds downwards from the back of the ROV and allows the rope to move back, then it is held by serrated edges created in the CPVC pipe. The serrated edges also add to the overall look of the ROV as it looks like teeth, so we named our ROV "Jaws". This arm design also helps to keep the ROV balanced by making sure that the objects we pick up are closer to the center of gravity. We used carbon fiber rod at the end because it is lighter, but also thin and strong. This way it can fit in smaller holes or fit easier in rope loops. Electrical tape at the end of the carbon fiber rod helps with visibility, and after testing different colors we decided on red and green.

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Real World Application

Coral Reefs are underwater areas that are made up of colonies of coral polyps that are held together by calcium carbonate. They are also known as rainforests of the sea and take over a thousand years to form. The first coral reefs formed on Earth 240 million years ago. That's before the dinosaurs were alive! The Great Barrier Reef is the largest reef system on Earth and can be seen from space. Coral have growth rings, just like trees!

How ROVs Can Help Coral Reefs:

ROVS play a very important role in the conservation and restoration efforts of coral reefs. They help scientists to observe and study corals without disturbing their ecosystem. They help with the study of marine biodiversity.
ROV's can help in preventing illegal coral mining, fishing and other activities that can harm the ocean
They help in transplanting coral fragments (pic on left) and assist with reef restoration projects.
ROV's like the Falcon and others can travel beyond what human divers can reach and help with Deepwater Coral Exploration. Some coral reefs are located at great depths in the ocean. Some of these parts are not easily accessible to humans. ROVS can explore all these areas and help us to gain more knowledge and even identify new species of corals.

The *Seaeye Falcon* was able to transect steep reef cliff faces and maintain stability in strong currents and swell surges. Nekton Maldives Mission © Nekton 2022

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Experimental Results

ROV Buoyancy Test

Table 1

	Insulation size	Buoyancy
Test 1	No foam – Butyl rubber tape sealed pipe	Negative – nose falls
Test 2	165^3cm added	Negative – nose falls
Test 3	152^3cm added	Positive
Test 4	16^3cm subtracted	Positive – floats slower
Test 5	16^3cm subtracted	Positive – floats up slowly
Test 6	38^3cm subtracted – Add zip ties	Positive – back sinks more
Test 7	Drill 29 holes - removing 13.23g	Positive at first – but water leaked past tape
Test 8	Removed Butyl tape sealed pipe – replaced with hot glue sealed pipe	Positive - but water leaked past glue, then negative and tilted
Test 9	Removed hot glue sealed pipe, replaced with open pipe	Positive
Test 10	30^3cm added, version 3 arm design	Positive, floats too quickly
Test 11	48^3cm subtracted, version 4 arm design	Slightly Positive, desired result

Buoyancy is always a challenge but in our case it was difficult as we had such a small ROV, we had to really think of different options. Areas to place insulation or pool noodles were limited.
For Tests 1-5 we conducted the test in a plastic container filled with water. For Tests 6-11 we tested in a community pool. This year we tried sealing the three sections of pipe on the top of the frame with butyl tape, then hot glue, to create buoyancy without the bulk of insulation foam, but water leaked past eventually, so it was not reliable. As you can see from Table 1, we had challenges in getting the ROV leveled. By adding and slightly closing off the sides with insulation foam we were able to overcome that challenge. Our ROV is still more positive in buoyancy, but this works as the vertical thruster is able to produce more power diving than surfacing.

Driver and Tetherer Tests

Chart 1

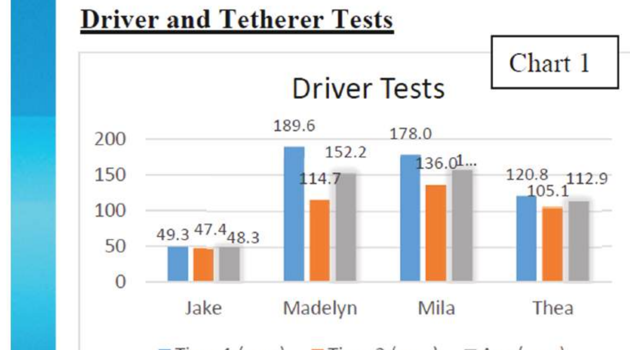
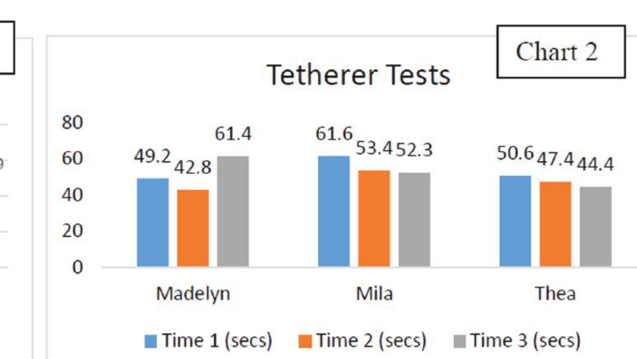


Chart 2



The ROV is only as good as a great team to drive and tether. We tested our four team members to drive (Chart 1). Not only did Jake have better times, he also was the most consistent in his time. Jake is determined to be our driver for the competition. The tetherer tests (Chart 2) show that Madelyn was able to produce the best result but Thea's times were a bit more consistent. They will take turns at the competition to tether.

Lessons Learned

Our Team's ROV was very successful with the obstacle course in the regional competition. Our time of 47.19 seconds was the fastest overall, including the high school teams. We spent a lot of time discussing and working on designs for the arm, and we are happy with the final result, but there is always room for improvement. We look forward to seeing how well it performs at the international competition. There was a last minute change at the regional competition mission course, so we had to quickly modify an arm design we used last year since the task was very different. This taught us that sometimes a team needs to adapt quickly to changing design requirements.

Lessons Learned:

- How to work as a team – Having 4 people on a team means that there are a lot of different personalities. We wanted to allow people to work in areas that were their strengths but also making sure that the whole team had knowledge and experience of the different processes.
- Learned new skills – One of our teammates was new, so the rest of us were able to help her build on her skills, while refreshing our own.
- New terminology – Every year we participate in SeaPerch we can increase our knowledge with new terminology. We learned about serrations, and how these can be small or large based upon our need. It is also important to us to be able to apply our new terms in other ways versus just in SeaPerch. We may not be using the word as much but noticing everyday items that apply, like a steak knife having serrations.
- New material – Last year we used new materials like PEX pipe and CPVC pipe. This year we used carbon fiber rods. This was used for our arm and to help create stability for our thrusters and insulation.
- New calculations – As most of us enjoy mathematics, we enjoyed coming up with the different calculations to determine how to make our ROV smaller. We were able to estimate how much lighter our ROV is with the added holes.

Things we enjoyed and those that challenged us:

- Thea – I really enjoy soldering and stripping wires. I found the pipe cutting to be hard as I don't have the strength to push the pipe cutter down.
- Madelyn – I really enjoy the pipe cutting. The soldering is a challenge as I have burned my finger in the past.
- Jake – I enjoy the soldering. I don't like the water proofing as it is messy.
- Mila – I enjoy the water proofing because I get to get my hands dirty. Cutting pipes with the pipe cutters is my least favorite.

Next Steps:

The plan is to continue being a team next year and working to push ourselves to do even better. As a team we would like to make the following changes if possible: 1) Creating more grip on the arm so that we can pick up or move objects better. 2) Experimenting with adding lights. The lights could give us better visibility of the ROV as they move through the obstacle course. This would be beneficial when the pool has a lot of ripples due to movement or wind. 3) If the lights don't work out then maybe change the colors of the PEX pipe from blue to yellow. Yellow has been tested to show up better in blue/green water than the blue we are currently using. 4) The question of whether we could make it even smaller has come up. How much smaller could we make it? Would this cause issues with the motor placement?