Oceanus

(o-see-nee-is)

Technical Design Report
Underwater Robotics
2024-25

Unity Junior High School
Cicero District 99
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Team Members

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Abstract

The SeaPearch 2025 competition theme is coral restoration. Coral reefs are getting harmed by storms, predators, pollution, and diseases. We needed to design an ROV to complete the obstacle course and mission course. In the obstacle course, the ROV has to go through different angled hoops each 18in. wide. In the mission course, it will have to move objects around and hang coral. The real world connection is placing new coral and collecting samples to see what is harming coral reefs. We built our ROV using the engineering design process steps: ask, imagine, plan, create, test, and improve. We asked ourselves, how we could build an ROV to help restore coral and make it hydrodynamic and lightweight? We imagined different solutions, planned a design by making a scaled ROV drawing, and created ROV Medusa, a utility frame prototype with ½ inch PVC pipe and multiple holes drilled in different directions for more water flow. We tested our prototype in water to collect data about driving speed. Lastly, we used the data to improve our prototype by creating another ROV, Umiko. It has a smaller front surface area because the frame slants up in front, which makes it more hydrodynamic. Its small lightweight frame is still big enough for attachments. It also has a lightweight 4 inch long pegboard hook to make sure when picking up objects the hook won't weigh it down. Also, there is strain relief in the back to make sure the tether stays in one place and doesn't ruin the ROV's balance. We used pool noodle for buoyancy. We also tested propellers with different pitch, diameter, and number of blades to see which would make the ROV faster by making a thrust stand in a bucket of water. The best propeller was the SeaMATE propeller by 0.06N, but we went with the Seaperch propeller because SeaMATE would increase our budget. We chose our 2nd ROV, Umiko, for competition because it is faster than Medusa by 0.56 seconds. We learned many things, like how communication is important, throughout underwater robotics that we will carry with us throughout our lives. It also helped us think about other improvements to add to our ROVs in future years.

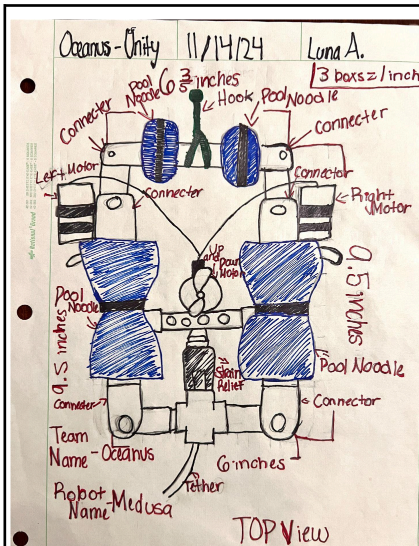
Task Overview

The 2025 SeaPerch Competition theme is coral restoration (Robonation, 2025), a plan that helps recover damaged or degraded coral reefs (Great Barrier Reef Foundation, 2023). Coral reefs are getting harmed by storms, predators, pollution, and the stony coral tissue loss disease (Dana Wusinich-Mendez, 2025). Ways to help coral are planting nursery-grown coral into reefs and ensuring that coral habitats have good quality water with right temperatures and nutrients (NOAA, 2019 and Robonation, 2025). An ROV can help by having equipment needed to collect samples. In the obstacle course, our ROV starts at the surface and wall, goes through five 18" hoops, placed in different angles, resurfaces, and comes back in reverse order. This task shows how ROVs maneuver swiftly around plants and animals in the ocean. The mission course will have a surface vessel PVC structure representing a boat that deploys the ROV as the starting and ending points. The ROV will need to remove marine life from the top of the hatch and place it on the front platform. Next, it will open the hatch and move coral samples to the coral tree. Then it will then collect a deep sea coral sample from the deep dive platform and marine species and sea sponge from the front platform and place them in the bio-bucket under the hatch on the back platform. Then it will collect two sensors from the surface vessel and place them in their sensing locations. Lastly, it will close the hatch. These tasks model how researchers maneuver through places to reach harmed coral, plant healthy coral from nurseries, remove harmful species, and collect data on water temperature (Robonation, 2025) and (Office of Habitat Conservation, 2021). To complete the obstacle and mission course our ROV has a small frame which makes it lightweight and easier to go through the hoops and pick up heaving objects. We also have a 4" hook placed in the front of the frame to be able to pick up the props and move them. There is flex seal so when picking up the props they don't fall off easily. Strain relief in the back which makes the tether balance, this makes the ROV balanced while driving.

Design Approach

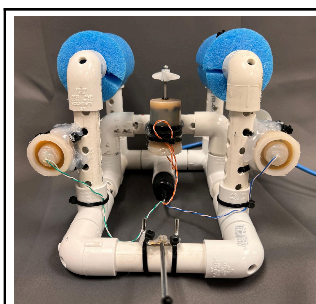
The importance of the engineering design process is to guide us in creating an ROV by helping us to solve problems, have more effective solutions, and expand our creativity (Teach Engineering, 2023.) The first step is to **ask** ourselves questions to understand the problem. The first question we asked ourselves was, how could we build an ROV that could help restore coral reefs? The second question that we asked was, how can we make our ROV hydrodynamic and lightweight? The second step is to **imagine** different solutions to solve the problem. Ideas we imagined were building a lightweight ROV for increased speed, drilling holes to create more water flow, making the ROV **hydrodynamic** with less surface area, having a lightweight hook, trying different propellers with larger pitch and diameter to increase speed, and achieving good **buoyancy** to make it easier to drive. While imaging, we thought about **constraints** and **criteria**. Constraints are limitations. The constraints that we had were a $25 budget for any added parts, having only 3 thrusters, the frame could only be made of PVC pipe, and the battery could not be larger than 6.5” x 3” x 4” and must be 12V DC with a maximum of 9 amp hour rating. Criteria are requirements. Our criteria were the ROV must fit through 18” diameter hoops, include waterproofed motors, wires need to be electricity insulated to prevent the flow of electricity in the water, ROV materials can not damage pool or water quality, and the ROV should be able to pick up objects.

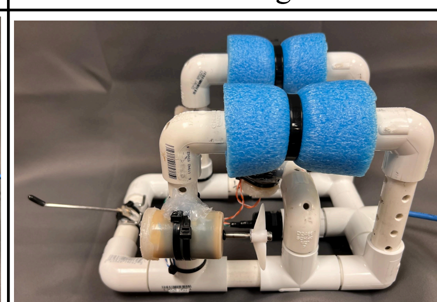
The third step is **plan** a **prototype** design by drawing the ROV (Science buddies, 2012). Our necessary design features were strain relief in the back so the ROV’s wires don’t get damaged and to make sure the tether stays in place to balance the ROV, a lightweight hook because in the mission course the ROV will have to pick up props in coral restoration tasks, multiple holes drilled into the PVC pipes to create water flow, and make the ROV lightweight so it can move faster in water. We looked at the Seaperch build manual to see different frame options. The V-Wing can have balance issues and drift if strain relief is not in the right place, but a pro can be it is hydrodynamic. The mini is lightweight, but too small with no space to add pool noodles because propellers would hit them. The utility ROV pros are that it has a good amount of space, is hydrodynamic, and has good balance. A con is it is on the bigger side, which makes it heavier (Robonation, 2021). The planning step involves creating a scaled drawing. ROV Medusa’s drawing is a top view of the ROV. The scale is three boxes per inch. In the drawing every important material is labeled and the measurements are calculated.



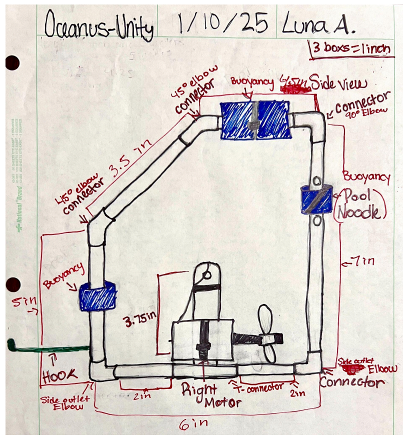
Medusa’s Design Plan

The fourth step is to **create**. In this step we constructed a prototype to figure out how to improve our design. Medusa has a utility frame made of ½ inch PVC. The frame measurements are 9.5in long, 6.5in tall, and 8.5in wide. Medusa weighs 983g. The left and right motors are placed on both sides of the frame, and the up and down motor is placed in the middle pipe facing the front side. When creating Medusa,we wanted the ROV to be lightweight so it can move faster in water. We drilled many holes in the frame all the same size but in different directions because more water can flow through, which helps it drive better. Medusa’s buoyancy is made of

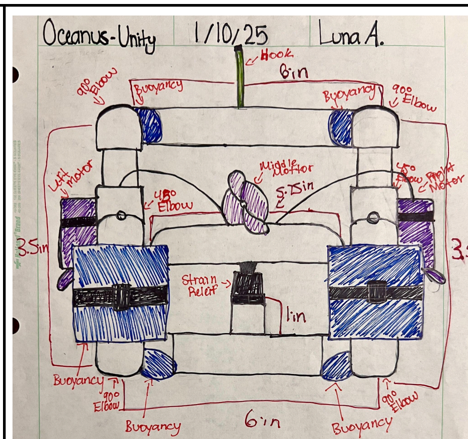

Medusa’s Front Profile


Medusa’s Side Profile

pool noodles which are placed on the top. The design pros were that Medusa is small so weighs less, is stable and reliable, and has strain relief which keeps the tether in one place making sure it doesn't affect the ROV's balance. The design deficiencies were that Medusa drifts to the side, is not very fast because of her larger surface, and has slightly negative buoyancy which isn't good because it will take a long time to perform tasks.

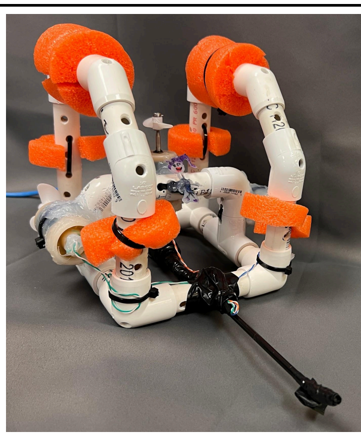


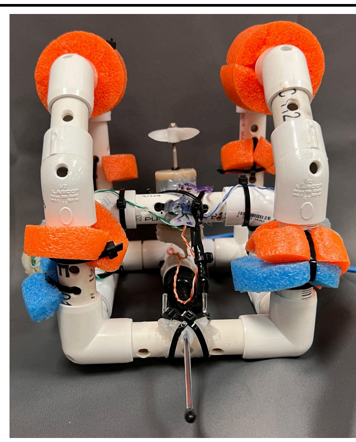
Umiko - Side View

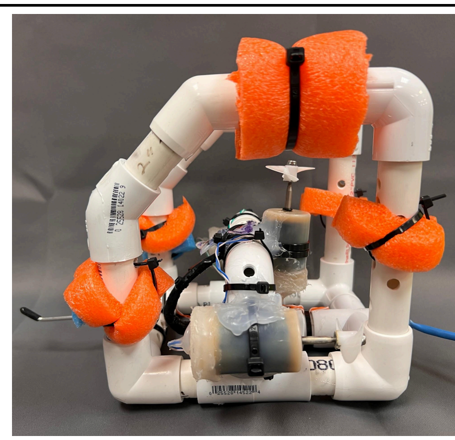


Umiko - Top View

The fifth step is **<u>test</u>**. We tested Medusa's buoyancy and driving speed. The 6th step of the engineering design process is to **<u>improve</u>**. In this step we designed another robot which was an improvement of our prototype. Umiko is our second **<u>iteration</u>** ROV. He is 7 inches tall, 8.5 inches wide with motors, 7 inches long, and weighs 994 grams. There's a slant on top of Umiko's frame, which makes him more hydrodynamic. He's also smaller than Medusa, which helps with going through the 18" hoops, and he's faster than Medusa, which is great for completing the mission and obstacle course. The right and left motors are placed on the middle part on both sides. The up and down motor is placed on the middle pipe at the center facing the back. The side motors help the ROV turn. When using both the ROV moves forward or backwards. The up and down motor moves the ROV up and down. We chose these motor placements because it makes our ROVs balanced, not heavier on one side and tilted. We waterproofed the motors to protect the electric part when underwater. Umiko had a 7 inch hook with tape on the end and strain relief on the back to help keep the tether in one place to keep the ROV balanced. However, there were some things that we needed to modify, such as how Umiko drifted to the right when we drove forward, took a while to go up, and sometimes sank. We decided to change the hook because when picking up objects we noticed the ROV tilted forward a lot. We modified Umiko to have a lighter 4-inch long, cylinder pegboard hook with a little curve at the end made of Alloy Steel and Zinc. We added Flex Seal on it so when picking up objects they don't fall off the hook so easily. This change improved our ROV's function by making it faster because there was less weight. We also had more space to go through hoops. We do not have a camera because our past members noticed that with waterproofing it got blurry and it also added weight.

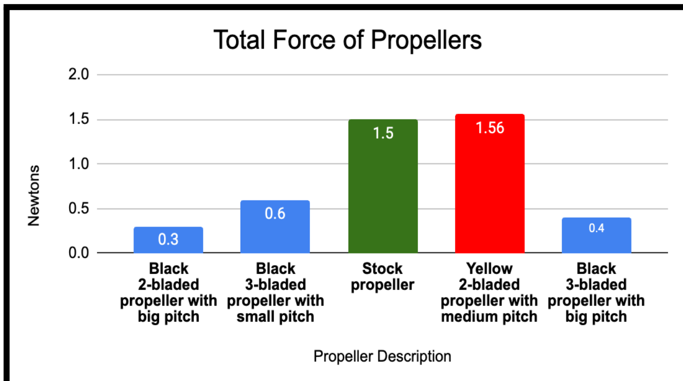

Umiko - Large Hook

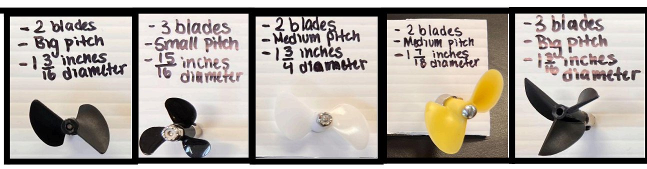

Umiko - Front, Small Hook


Umiko - Side view

Experimental Results

Buoyancy means the tendency of an object to float or rise when it is submerged in a liquid (Merriam-Webster, 2016). Pool noodles work as buoyancy material because they are filled with air pockets and don't absorb water weight. For Medusa's buoyancy we had to properly place the pool noodles and make sure we had good buoyancy by cutting it off little by little. For Umiko, we used the same method as Medusa to add pool noodles on the top. We noticed that Medusa went down too fast and tilted down in front because of the hook. When we added more pool noodles in front of Umiko, he tilted up. We added half a piece of pool noodle in the back, but then Umiko wouldn't go down, so we cut the top pool noodles. This made Umiko have slightly positive buoyancy. We did this because we didn't want the ROV to go up fast while driving, but needed it to go up while lifting props. We also took data on different propellers that could make the ROV faster. A larger diameter can make the propeller have more power. A big pitch allows the ROV to advance a greater distance each rotation. More blades creates more thrust. In the data table, the starting force is the amount of newtons the propeller started at, the ending force is the amount of newtons the propeller was at when it was moving, and the total force is the difference and actual force of the propeller. The two propellers that have the highest total force are the stock propeller and the yellow 2-bladed propeller. We chose the stock propeller because the 0.06 *difference* wouldn't really do much for speed, and putting the yellow propeller on the motor would be more difficult and increase the budget.

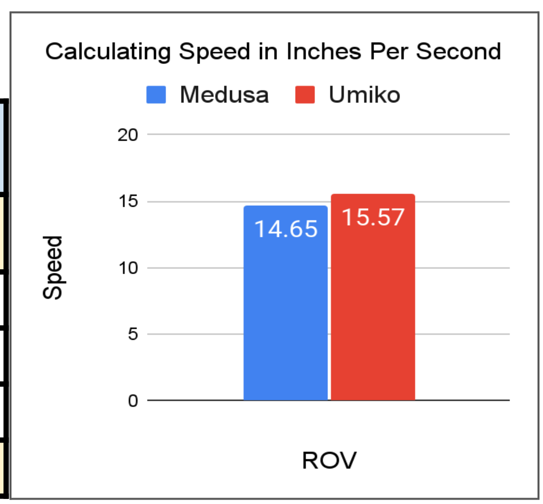




Force of Propellers (in Newtons)			
Propeller Description	Starting Force	Ending Force	Total Force
Black 2-bladed propeller with big pitch	0.8 N	1.1 N	0.3 N
Black 3-bladed propeller with small pitch	0.7 N	1.3 N	0.6 N
Stock propeller	0.7 N	2.2 N	1.5 N
Yellow 2-bladed propeller with medium pitch	0.7 N	2.26 N	1.56 N
Black 3-bladed propeller with big pitch	0.83 N	1.2 N	0.4 N

We also recorded data on how fast each ROV drives, up, down, forward, and backwards. We drove the ROVs forward and backwards 140 inches and up and down 75 inches to see which ROV was faster. Speed is how fast something is going. In this case, it's the ROVs. We calculated speed by dividing the distance the ROV moved with time it took to move that distance. The graph and data table shows the difference between Umiko and Medusa's speeds. You can see that the average time Umiko took to go forward is faster than Medusa by 0.56 seconds.

Time in Seconds for our ROVs to Drive Forward 140 Inches		
Trial	Medusa	Umiko
1	8.99 s	8.55 s
2	10.25 s	8.46 s
3	9.4 s	9.96 s
Average	*9.55 s*	*8.99 s*



Reflection

The engineering design process, or EDP, is used to create and build different things. Each step lets the engineers think about the problem they are trying to solve and how they are going to solve it. The EDP is iterative, meaning some steps will be repeated. Failure is expected, yet it's a good kind of failure. The EDP creates a "learn from failure" mindset that allows the engineers to see what's wrong with their prototype and fix it. Analyzing the prototype makes engineers find what the problem is and find a solution to it. Throughout our EDP we learned that communication is key to thinking of ideas. By communicating everybody's ideas we created a solution that works for all of us and improved our prototypes. Through trial and error moments, we collaborated to find solutions to our problems.

At our first meeting our team **asked questions** about what ROV features would be essential to tackle the problem of restoring coral tissue. We brainstormed together that we needed a ROV that could restore coral tissue, and we needed a robot that was quick but precise because we needed to complete tasks without damaging the coral or sea life.

Our team **imagined** a speedy ROV navigating the SeaPerch course. We brainstormed different ways to make our ROV fast and looked for things to add that would make it faster, but also not bring it down when in the water. We first researched how to make our ROV quicker by looking into how buoyancy works. We settled on an idea to make a thrust stand and test the force of different propellers. All through this planning process, we analyzed prototypes of past teams as inspiration for small design changes. When we were ready to start **creating** our first prototype, we used our research and **plans** to begin. As a team we discussed our strengths, looking to see who was the best in doing certain things. For example, Amber and Citlali were the best at cutting PVC pipes and so cut them for our final ROV. Luna was best at drilling holes, and drill the holes on our final ROV. Kaleb was best at soldering. His job was to solder the final control box for our ROV. We all took part in assembling the frame and placing motors on it to be sure we all agreed we were creating the product we had envisioned.

The **test** trials in the pools indicated that Medusa was quick and could drive well. We liked how she drove underwater, but we weren't satisfied. We wanted a faster ROV. We learned from Medusa and used that knowledge to **improve** our second ROV, Umiko. When we finished building Umiko, we tested his speed the same way we did with Medusa to see which ROV is fastest while doing the different types of courses. This helped us decide the improvements we needed to make and what ROV to use for competition, which ultimately was Umiko. We noticed as we drove Umiko that we needed to fix buoyancy by cutting it little by little until we had the right amount. When testing Umiko we noticed that the first hook weighed him down, and tilted forward, especially when picking up props. When practicing in the pool, we realized that if we changed the first hook on Umiko to a lighter one, it would be much easier to drive. We were happy with the result but since we changed the hook, our buoyancy had to be fixed. We made some final ROV buoyancy improvements at competition because we knew, through trials, that if we did not make that change, Umiko would be unable to pick up props properly.

If we were to redesign Umiko, we would modify it to have less surface area, make our ROV's front slant at a lower angle, and make it lighter weight, all because it would be faster. Our team was testing out different types of propellers, so our idea is to test more types of motor propellers because there still might be a type of propeller that is faster, cheaper, lightweight, and better because from the propellers we tried out none of them were fast enough. One propeller was faster than the stock propellers, but the issue was that it was heavier and its cost was higher, but the speed difference was not much. After learning throughout the robotic season, we can use the skills that we learned by building a new ROV in the future knowing most of what could make the ROV faster. Also if one of our team members decides to go to college about engineering they can use the skills they learned to improve themselves.

Acknowledgements

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Appendix A - Budget

Vendor	Component	Quantity	How was the component used?	Cost per item
Home Depot	O-rings	3	It was placed on the propeller shaft to help seal the waterproofing on the motor.	$0.77
Amazon	Strain relief	1	Placed in the back of the ROV to balance tether and help with less tension.	$0.88
Amazon	4 in. pegboard Hook	1	Item is used to lift up objects and to deliver them into desired places.	$0.32
Home Depot	Epoxy	2ml	It was used to hold the motor and propeller shaft together.	$.66
			Total Cost	**$2.63**