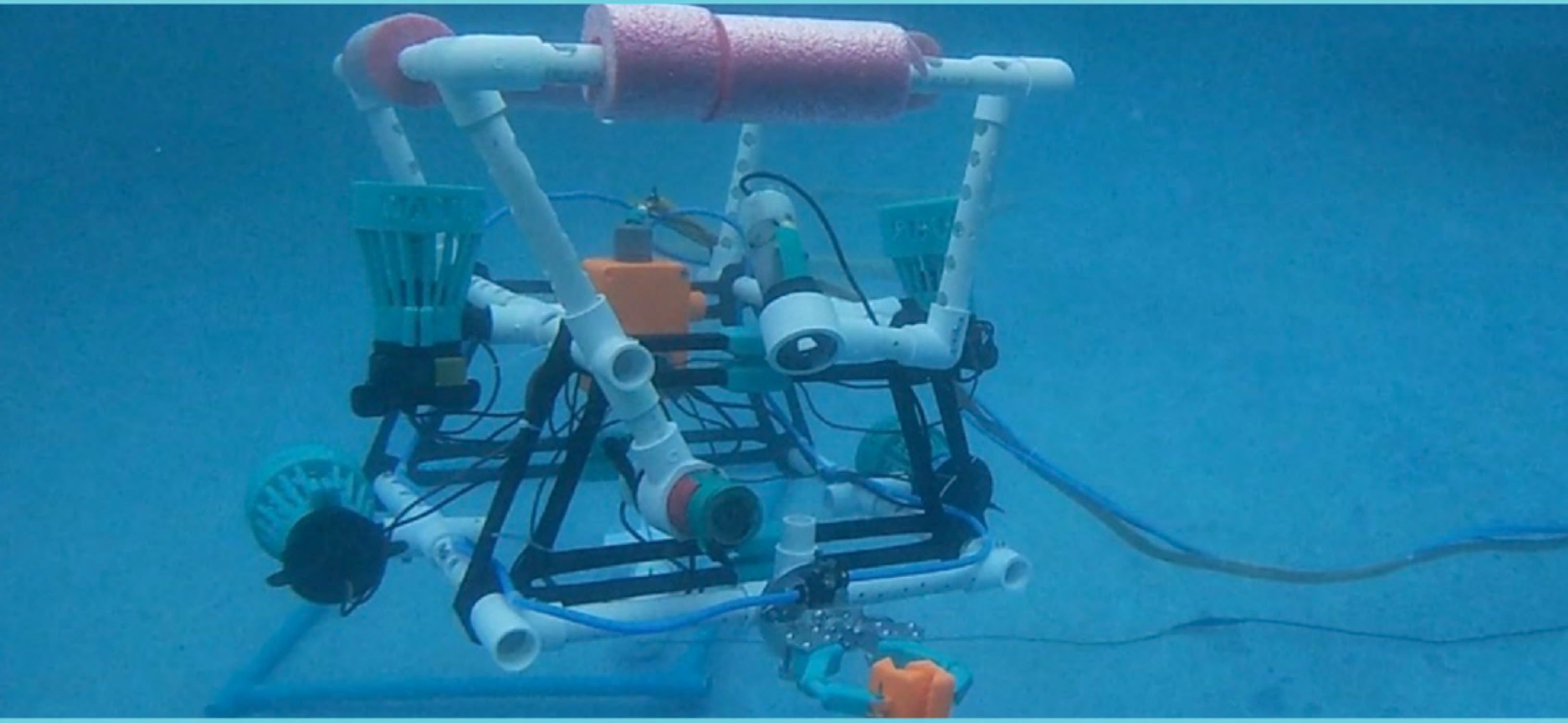
San Diego Miramar College, CA USA
Water Jets

TECHNICAL DOCUMENTATION for SLEEPY FISHY

2024



Company Member	Role(s)
Amaan Shaghel	CEO, Pilot
Kaylee Hou	COO, Electrical Lead
Akili Ploudre	Mechanical/Design Lead
Zach Joseph	Photogrammetry Lead, Co-Pilot
Joseph Rodriguez	Tools Lead, Electrical Team
Zayn Ashraf	Mechanical Team
Nina Sediki	Mechanical Team
Nadjila Sediki	Mechanical Team
Sebastian Morris	Electrical Team
Kshitij Pete	Mechanical Team
Antonio Pantaleon	Electrical Team
Aditi Verma	Brand Designer
Gina Bochicchio	Mentor

MATE ROV WORLD CHAMPIONSHIPS PIONEER

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ABSTRACT

This is the first year the San Diego Miramar College Water Jets are participating in the MATE ROV World Championship. Our underwater tethered ROV is controlled on land with joysticks and designed to transport and position objects and capture video footage. We named it: Sleepy Fishy.

Our ROV, tasked with deploying ocean observing assets for data collection, administering probiotics for diseased coral, and identifying healthy habitats for lake sturgeon, undeniably promotes our company's goal to further conservation efforts and scientific research.

Our small but mighty team, comprised of dedicated engineering students inspired by the intersection between marine life and robotics, spent countless hours in design, assembly, and testing to create our ROV.

COMPANY STRUCTURE

Leadership Team

Amaan Shaghel
CEO, Pilot:

executive leadership decisions

pilot of Sleepy Fishy

Kaylee Hou
COO, Electrical Lead:

summarized progress and outlined future agendas

led electrical team

Akili Ploudre
Mechanical/ Design Lead

led 3D modeling and printing for our frame and motor shrouds/guards

Joseph Rodriguez
Tools Lead

lead solderer on control board and other electrical components

Zach Joseph
Photogrammetry Lead, Co-Pilot

led photogrammetry using RealityCapture, pneumatics controller

mechanical

The mechanical team is responsible for the design, construction, and maintenance of the physical components of our ROV. This includes creating the structural framework, ensuring stability and buoyancy of the ROV, and integrating mechanical systems such as hydraulic and pneumatics. They work on building props, assembling the ROV frame/tether cross, and troubleshooting any mechanical issue that may arise.

electrical

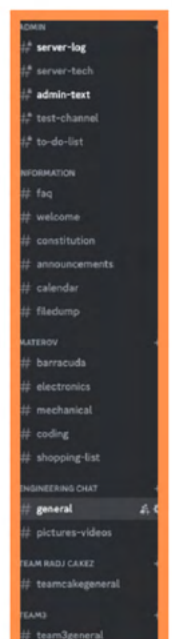
The electrical team is responsible for soldering, assembling, and maintaining any electrical systems for this project. This includes implementing the control board, tether wiring, and power distribution systems to ensure the ROV functions properly. They handle the integration of cameras and ensure reliable communication and control between the ROV and its operators. This team also troubleshoots any electrical issues, ensuring all systems operate safely and under various conditions.

PROJECT MANAGEMENT

The Water Jets company meets every Monday, Wednesday, and Friday for 6+ hours/week. In between, additional meetings are occasionally held to address urgent matters. Our company's primary source of communication outside of meeting times is on a Discord server. Here, we exchange ROV ideas and make collective decisions.

Because this was our first time competing, it was crucial that team members knew exactly where to find the resources and readings necessary for their tasks. To facilitate this, we created a website that contained any helpful links and information the team would need, ensuring easy access to essential materials and guidance. Additionally, after each meeting, Team Leads create announcements documenting everything accomplished, as well as address any tasks needing further attention in future meetings to stay organized and keep track of key deliverables.

The Water Jets are divided into two main teams: Electrical and Mechanical. Each team member is then delegated into a subteam, which consists of the Control board, hydraulics, pneumatics, camera/photogrammetry/CAD, frame/tether build, and prop build team. Members were assigned based on their technical skills and personal preference, and reported to their respective team leads with any ideas, issues, or questions.



BUILD SCHEDULE

September 2023: Recruitment and basic training. Held workshops on soldering, tool safety, and basic marine tech principles such as buoyancy, water pressure, remote sensing, and effective waterproofing.

October-November 2023: Split up company members into two teams: Electrical and Mechanical. These teams worked together to create a prototype ROV using available materials and components to test out the initial design concepts and functionality.

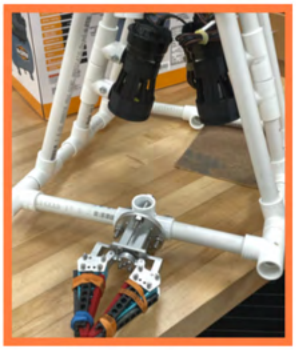
December 2023: We received our SeaMATE Barracuda ROV kit and entered the brainstorming/planning phase for our ROV features and designs.

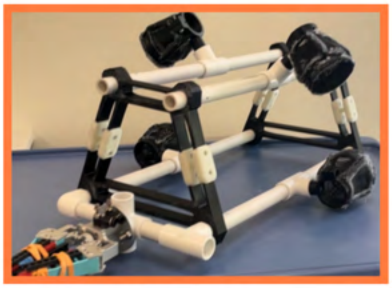
January-February 2024: Attended a two-day informational meeting in Long Beach to learn more about MATE ROV from experienced professionals. Our experience gave us the right direction to begin prioritizing and delegating tasks to subteams.

March 2024: Soldering and troubleshooting our control board, practicing photogrammetry/CAD, and 3D printing our first round of motor shrouds. First pool day: tested gripper underwater and adjusted frame and buoyancy.

April 2024: Finalized the control board and continued printing frame and motor shroud models. More pool testing!

May 2024: We finalized our ROV and our pilot practiced maneuvering Sleepy Fishy through the tasks!


March 13


April 24


May 10


May 13

SAFETY

safety rationale

Safety is the top priority for the Water Jets. Because our meetings took place in a classroom lab, we had access to an emergency eye wash station, first aid kits, safety goggles, fume hoods, and fire extinguishers in case of emergency.

Any task that required handling potentially hazardous tools was first approved by our Tools lead/other leadership and our mentor. Before using the tools on the ROV, we held workshops where company members could first practice on smaller-level projects to become accustomed to the tools. During the ROV build, team members worked in pairs so they could look out for one another.

Electrical Safety:
Any soldering was done with magnifying glasses, fume hoods, and the lab door propped open for ventilation.

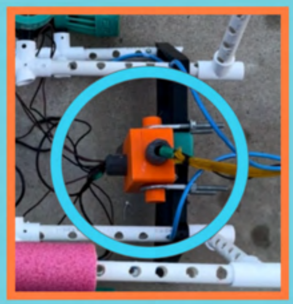
Mechanical Safety:
Any PVC cutting or drilling was done with safety goggles on and the piece secured in a vice with wood placed underneath.

Waterproofing Safety:
When using epoxy and acrylic, safety goggles and gloves were worn to protect against harmful substances.

safety features

Control System: The control board is equipped with fuses (15A from power supply to control board) to protect from overloads, ensuring the safe operation of the electrical system.

Tether Management: The tether includes a strain relief system to prevent cable stress and potential damage during deployment and retrieval. All solder connections inside are waterproofed with Seal and Solder connections, and electrical tape. All wires are covered with wire abrasion protection.



Thruster Protection: The thrusters are fitted with IP-20 standard 3D-printed shrouds/guards to prevent injury and damage.

Pneumatic System: The pneumatic system features a shut-off valve and regulator and all pneumatic elements including the valve, air line, air hose fittings, and gripper are rated for a minimum pressure of two and a half (2.5) times the maximum supply pressure (40 psi)

Frame Design: The ROV's frame is designed with no sharp edges or protrusions to reduce the risk of injury during handling and operation.

SAFETY PROCEDURE

Set up:

- [ ] Fill up air compressor and regulate to 40 psi
- [ ] Unroll the tether and eliminate any knots
- [ ] Plug tether strain into control box
- [ ] Prevent company members from stepping on tether by alerting them of deployment
- [ ] Double check no parts have come loose from the ROV and all connections are secure
- [ ] Recovery equipment handy (pole, net)

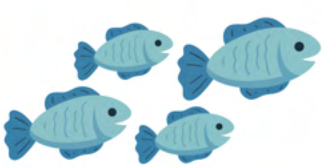
All electric components/topside technology is far away from the water

On deck:

- [ ] Connect control box to power supply
- [ ] Turn on 12 V power supply
- [ ] Call out "power on!" when turning on control box switch
- [ ] Test thrusters and pneumatic claw
- [ ] Test both camera views on monitor and computer
- [ ] Before placing ROV in the water, announce "Fishy in the water!"
- [ ] Visually check for air bubbles
- [ ] Deck crew members call out "ready"
- [ ] Pilot calls "3, 2, 1, start" when he begins moving

Post run:

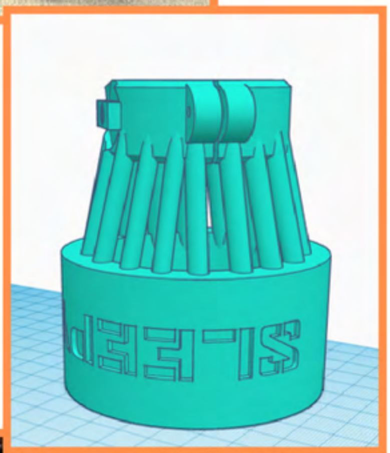
- [ ] Announce "Fishy out of water!" when taking out ROV
- [ ] Call out "power off!" when turning off control box switch
- [ ] Turn off 12V power supply
- [ ] Safely unplug and disconnect tether from control box
- [ ] Roll up tether neatly in hose reel
- [ ] Place topside tether and camera wires into sealed waterproof bag
- [ ] Set ROV somewhere safe to dry
- [ ] Clean up work area of all materials, props, supplies, or trash



FISHY OUT OF WATER!

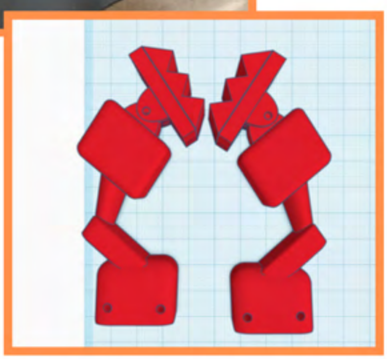
DESIGN RATIONALE

The design goals for Sleepy Fishy (SF) prioritized cost-efficiency and adaptability to benefit our company the most in the future. We wanted SF to be as fast as possible, have modularity, and creatively find ways to change the PVC-inspired design into ABS using 3-D printing.



We started our frame design using the given vectored frame design from SeaMATE that's made out of ½ inch PVC pipes and various PVC pipe fittings. Using this design we started to draft and create different designs using TinkerCAD. These designs would later be 3-D printed, tested, and adjusted to the company's needs. We were given access to an AnyCubic Kobra and Dremel 3D45 printers which both can print ABS. We then began to change the PVC with ABS by starting with the main frame.

After many prototypes that were designed and printed, we decided on our final frame design SF Model Theta. We create our frame to have durability while being modular. The holes were to provide less weight and maximum water flow through the frame to decrease drag. The Frame is split into two halves and connected with a connector that's also ABS. The corners used for the PVC are a 3D print design that was used to hold ½ PVC pipe for making cuts (). This gives our frame strength allowing us to tighten the PVC in place to the main frame.



Between the two mainframes are horizontal ½ inch Schedule 40 PVC pipes that are drilled with ½ inch holes on both sides. We used ½ inch 3 and 4-way PVC fittings to connect our pneumatic claw, camera, and motors to the frame. We researched and found a customizable ½ inch PVC pipe fitting which allowed us to replace the PVC with ABS. This maintains the modularity ability of our design and allows for use to have customizable angles to be later used for adjusting motor placement and the buoyancy attachment.

DESIGN RATIONALE

We organized all of our planning for our design into 3 phases. Phase 1 had two teams: Topside and Poolside teams. The topside team's responsibilities were our control box, camera, and pneumatics. The poolside team was responsible for the frame, motors, strain relief, and buoyancy. Phase 1A had each team read through the Barracuda General Guide and the documentation that was relevant to their task. In Phase 1B teams would start the designing and assembly of each of the components.

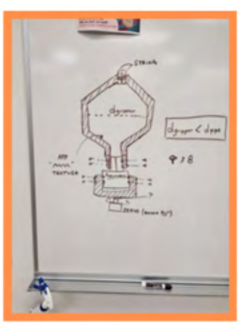
At the end of Phase 1B, we transitioned into Phase 2 which had each of the team's components come together to have a single ROV and begin building props to practice within the pool at a later date. In this phase testing and troubleshooting out of water was done with the motors, controller, cameras, and pneumatic gripper.

Once we were ready to go in the water, we transitioned into our final phase, Phase 3. In this phase, we started our in-water troubleshooting such as buoyancy, motor placement, motor directions on the controller, and camera placement. At the end of this phase is when troubleshooting has completed we are ready to film our qualifying video and practice a month before our competition date.

Phase 1
- Topside Team: Control Box, Cameras, Pneumatics
- Poolside Team: Frame, Motors, Strain relief, buoyancy

Phase 2
- Combine the teams' components, props

Phase 3
- Testing, troubleshooting, buoyancy video submission

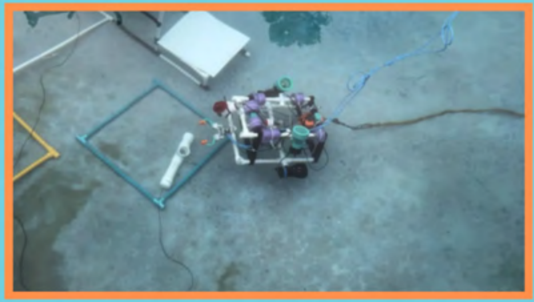


Hand Sketch → CAD Design → Share designs with company → 3D Print Prototypes 3D Prints

SYSTEMS APPROACH

Vehicle Structure

Following our goal of speed, we found ways to trim weight and help us gain more speed. There were a few shapes for the frame we brainstormed, designed, and tried but decided to go with a trapezoid shape which would give us less ABS used when compared to a rectangle-shaped frame. This decreases the size and the weight which will make SF move faster in water.



Our limit for our ROV was it had to be able to fit through a 1-meter square and be less than 25kg. We wanted SF to be much less than this and our goal was to get down to 2kg if possible. If we stayed at this weight limit we would surely be in the clear to not be over 1 meter in size.

Vehicle Systems

The main components of SF are two video cameras, a pneumatic claw, and a temperature probe. Many tasks that SF will have to complete require us to first be able to see what SF is seeing underwater. We used two cameras and waterproofing that were purchased from SeaMATE and housed in an acrylic tube. Camera #1 is positioned to assist the pilots with navigation and using the pneumatic claw to pick up items. The second camera is used for photogrammetry as its placement allows for the pilot to circle the structure and take a video to become a 3D model.

Picking up items and bringing them to the surface is a lot of what SF tasks will require to be completed. We decided on pneumatics for our method of payload and designed a custom gripper and claw to help complete tasks efficiently and quickly. We named our gripper “Franky Arms II” and gave us the ability to grab or hook many items underwater.
Lastly, we installed SF with a temperature probe which allows us to take the temperature of the water at different depths and locations underwater.

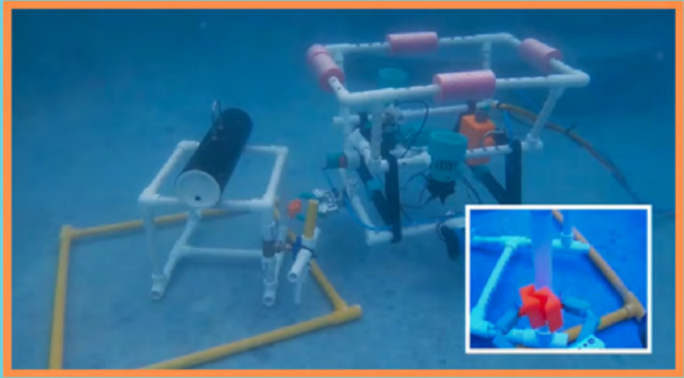
Each of these systems is required to complete all tasks. The first task requires us to pull out two objects to free a float to be brought back to the poolside. The camera allows us to see the use of our gripper to pull out and release the float to the surface. To retrieve the float the front camera can locate the float and guide it back to the side.

The second task for SF is to lay a cable attached to a SMART repeater then place it down and attach the AUX cable to it. The cameras assisted with the view of where the cable needs to be laid and where the SMART repeater is placed on the ground. Our gripper and claw assisted with the holding and placement of the SMART repeater and the AUX port cable into the repeater. We also added a temperature probe to measure the temperature of the water around the smart repeater and compare the two for calibration.

SYSTEMS APPROACH

Vehicle Systems Continued

The third task involved using one of our cameras to capture a video which is then used in a photogrammetry software to make a 3D image of the Coral reef we are focusing on. Placing the irrigation system and coral pieces requires the gripper and camera to pick up and place items in the required place.



The evolution of our claw came from our practice in water. We drafted ideas after the first claw and found a more efficient and secure design to pick up or hook items to our gripper.

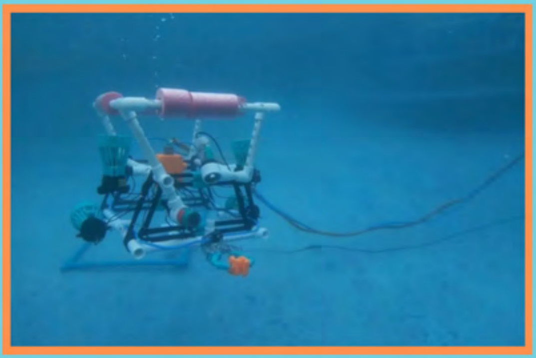
Control/Electrical Systems

The electrical components used for our ROV came from the SeaMATE Barracuda ROV kit. These topside electronics receive power from our 30A Powerwerx power supply via power pole connectors. Our control system in the brain of our ROV, it controls the function of and provides power to Sleepy Fishy. It also receives camera feed and sends it to our monitor for the pilot, and to a computer for photogrammetry/CAD.

This topside station utilized by the pilot to operate Sleepy Fishy is designed for rapid deployment and easy setup. Our control board is bolted into our pelican box to prevent any external damage and our monitor is securely mounted to the inside of the top lid with adhesive backing. Any camera or monitor wiring runs through an opening on the back of the control box to avoid interference with the rest of the control board.

Our tether consists of a waterproof box and lid that was 3D-printed with orange ABS. The box has a hole on top for a ¾-inch strain relief and the lid has a hold on the bottom for another ¾-inch strain relief.

SYSTEMS APPROACH



Propulsion

Our motors were used from the (SeaMATE) kit which contained four Johnson 500 GPH bilge pumps. We printed prototypes of different shrouds and guards for our motors found online but decided to make our own so that it met IP-20 standards and allowed for maximum water flow. Our final design was printed with ABS and named "Fins Version 4". We designed our guards and shrouds to be able to slide over the body of the bilge pump and be tightened in place with a nut and bolt. The shroud covered the propeller 5mm both ways. The guard was a honeycomb pattern that is less than 12.5mm in size to maintain IP-20 standards.

Our SF was designed to have vectored motor placement using a total of 4 motors for movement. The vectored motor placement was chosen because it is easier to change directions and its harder to be moved by current. We place our motors in the middle of SF and connect them to an ABS fitting that's attached to the frame.

Buoyancy & Ballast

Sleepy Fishy's buoyancy system is simple, modular, and easily adjustable for when we start testing at the pool to find its natural buoyancy. Our first system used a (measurement) pipe insulation that wrapped around a PVC rectangle with ABS joints attached to the top of the frame. We selected this insulation based on its density and ability to float on water. When we added this foam to our ROV it gave it a larger buoyant force which counteracts the weight from the ROV until we reached the point where if submersed fully in water there would be no movement up or down.

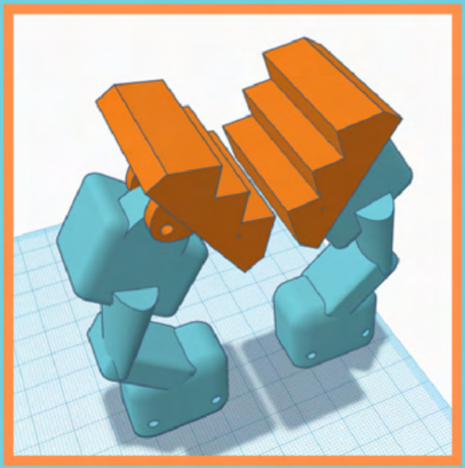
We then discovered that our foam used would not be able to work under the conditions and would in fact lose ~1/2 of its buoyancy at 14 feet. We changed to a denser foam that's normally used for wall insulation. This would give us natural buoyancy and deeper depths and enable us to complete tasks.

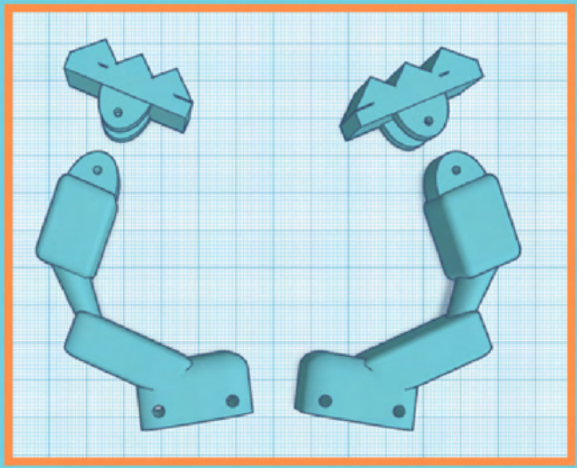
SYSTEMS APPROACH

Payload & Tools

We decided to place one camera facing the front with the gripper in view. This allowed our pilot to navigate and place the gripper in range to open or close and have the ability to hold items in the water. Our other camera was placed at the right side of SF and was used to record video that was recorded on to an external laptop and used in a photogrammetry program for 3d image rendering.

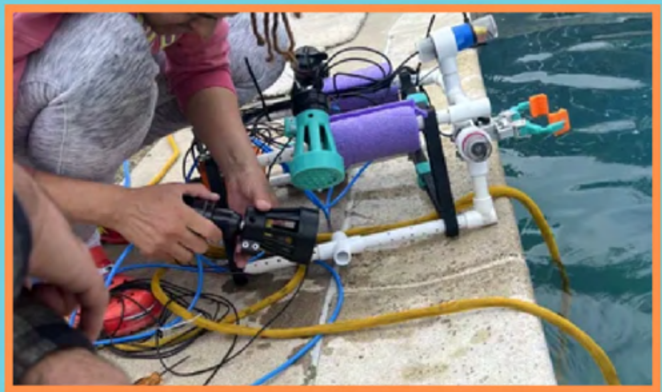
We decided to use pneumatic power as our power delivery system to use with a gripper. Our gripper was purchased online from Aliexpress and is rated to 135psi.

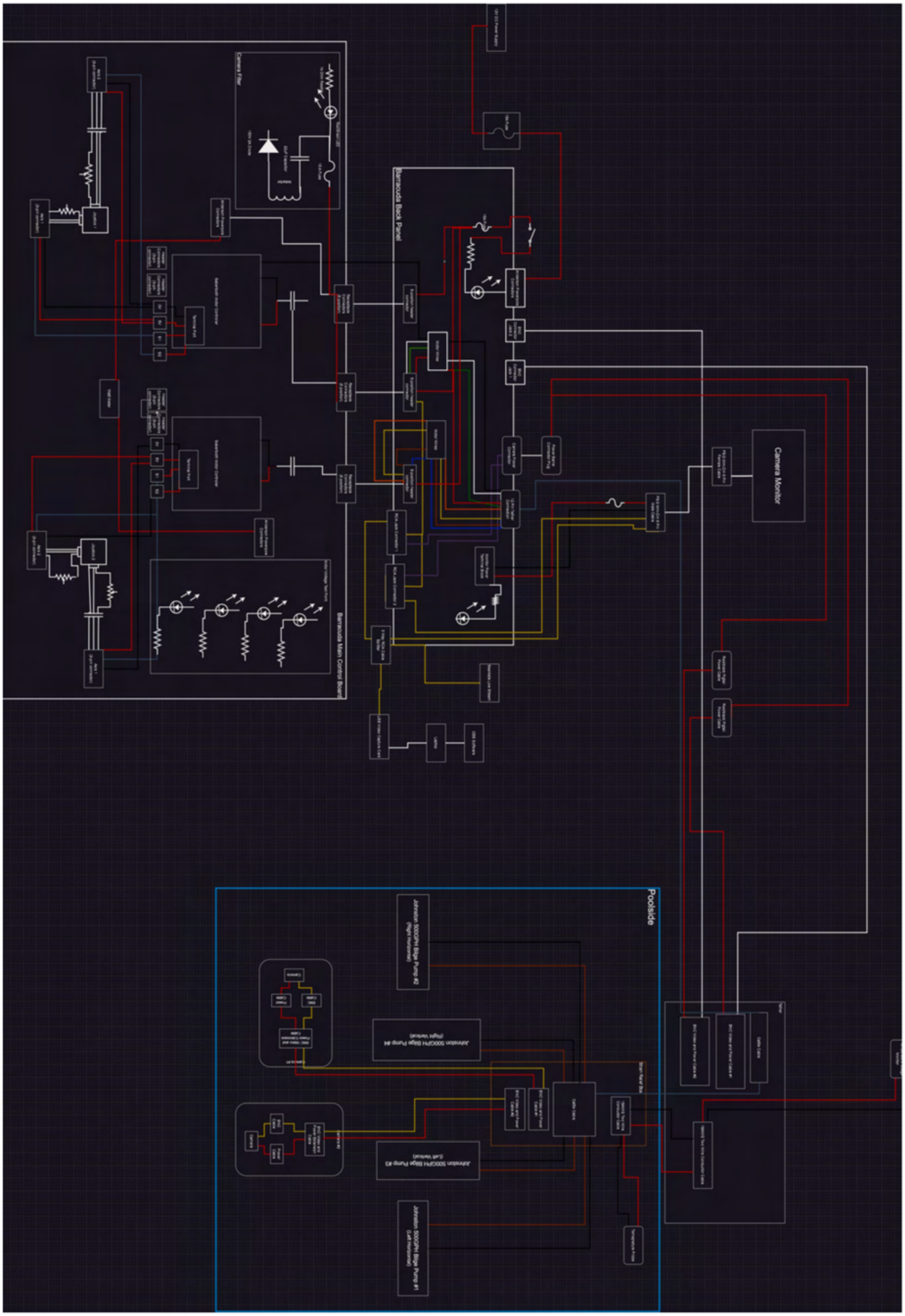




Build vs Buy/ New vs Used

As this was the Water Jets' first year competing in the MATE ROV competition and the second time that our community college has ever competed in a robotics competition, there were not a lot of resources that the team could have used. Through the NSF Special Project Grant, the team was provided with a full Barracuda ROV kit. The team tried to cut down on costs by trying to make as much in-house with 3D printing, the thruster shrouds, strain relief box, and other components were made this way. The decision to buy extra components for insurance in case the existing ones broke was a hard decision for the team but was necessary as one broken control board component would mean the team had no way of fixing it. Additionally, procuring these parts now meant that future generations of Water Jets wouldn't have to spend as much money, with this trail-blazing attitude the team sought to build the most efficient first-generation ROV they could.



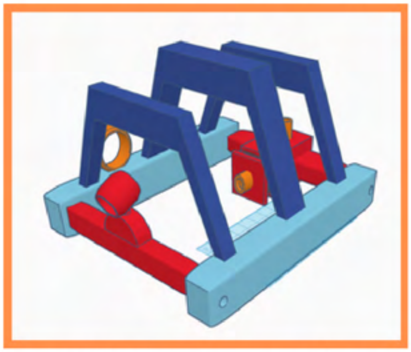

Camera Filter
Barracuda Back Panel
Barracuda Main Control Board
Camera Monitor
Poolside
Johnston 5000GPH Bilge Pump #1
Johnston 5000GPH Bilge Pump #2
Johnston 5000GPH Bilge Pump #3
Johnston 5000GPH Bilge Pump #4

CRITICAL ANALYSIS P.1

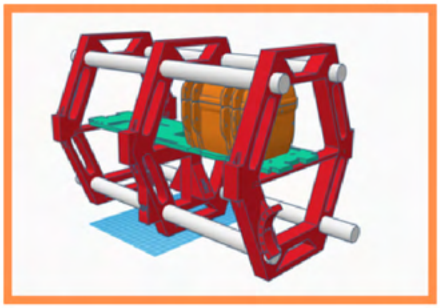
Alpha Iteration - 1st Design/Prototype

Beta Iteration - More Structure/Experiment

Gamma Iteration - Modularity and Strain



Delta Iteration - Increasing Modularity

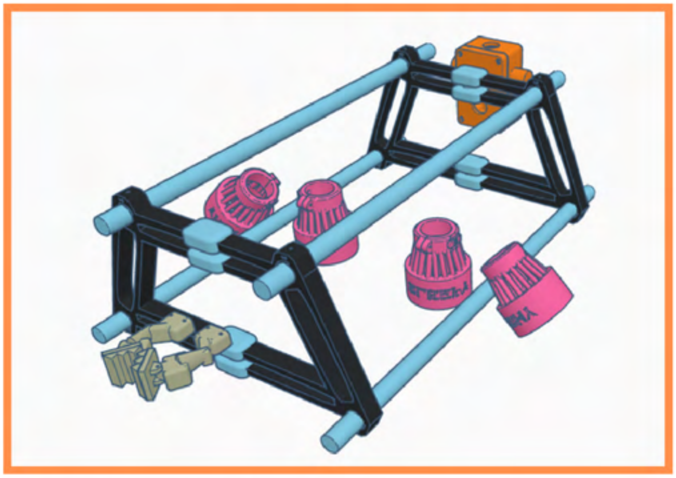


Epsilon Iteration - Cutting Weight

After completing our preliminary designs in TinkerCAD, each group began testing with cost-efficient methods to resolve issues. We made sure to leverage our limited resources and fill any gaps in understanding because we had no technical professionals assisting us. Each team rotated the use of tubs checking for water-proofing, general stability, and fulfilling our design requirements for each part of the frame.

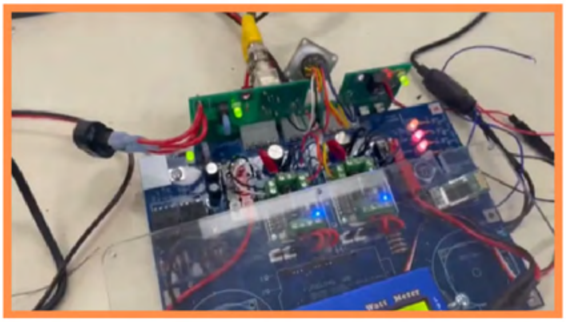
Because of the modularity we designed into our PVC/3d printed frame, we were easily able to address issues with minimal cost such waterflow and weight by drilling holes in the PVC and replacing individual pieces rather than overhauling the design. In designing the 3d printed chassis of SF, we were not able to print the beams all in one as the printing bed was smaller than the length of our frame. To compensate, we split the beams and inserted a cross-section to add stability, which we were later able to change out for a wider frame to create more room for modifications. Overall, we iterated through six different frames, adjusting each time to fit our design goals and harmonizing with our observations in testing.

Zeda - FInal Draft



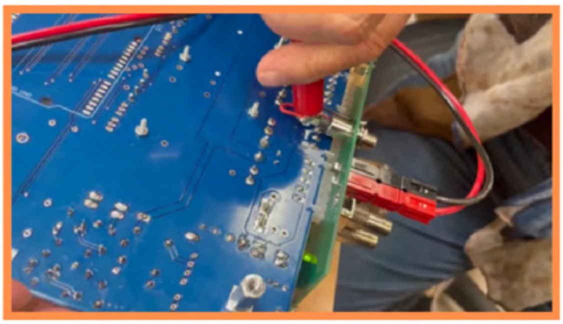
CRITICAL ANALYSIS P.2

Controls/Circuit Board

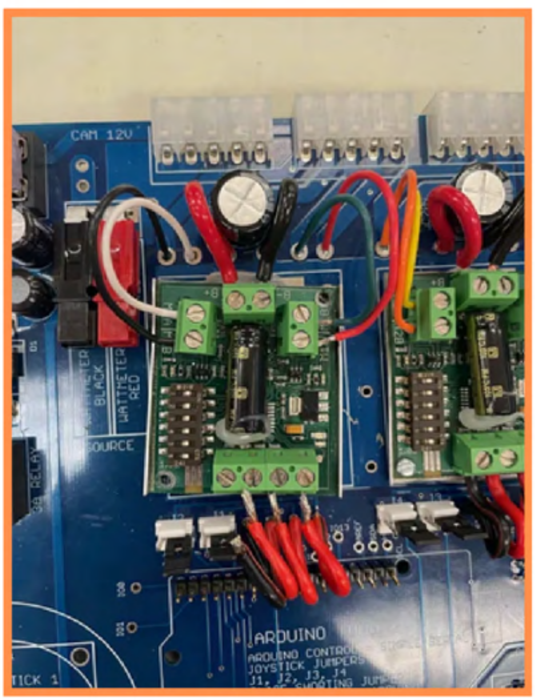


Whenever we faced an obstacle in our Barracuda control box construction such as not getting power or LED lights, we followed these troubleshooting steps.

First, we conduct resistance, voltage, and continuity tests with a multimeter and follow the traces on the backplane and control board. If there were any red flags in our tests, we resoldered the necessary electrical components.



Next, we go through the Barracuda Electrical Board Troubleshooting Guide and complete the steps relevant to our problem.



If the previous steps don't work, our final step is reaching out to more experienced experts for advice and guidance.

For example, one problem we encountered was getting a red, overcurrent light on our Sabertooth motor controllers. We first went through the control board traces with multimeter tests to narrow in on our issue. Because we were getting all the correct test values from the troubleshooting guides, we realized we had to go one step further and reach out to more experienced professionals. Finally, after realizing that some of our soldering joints were weak, we resoldered every component around the motor controllers, and we were no longer had the overcurrent issue.

ACCOUNTING

Budget

The way club funding at San Diego Miramar College is that each club gets an allowance of $150 each semester and can then request more by presenting an itemized budget to the Associated Student Government and having it voted on. As a result, our budgeting style was very adaptive as it had to constantly accommodate new unplanned expenses based on what was needed at that time.

Cost

The table below is a retrospective look at the year in terms of the cost of this project. It will help the next year of the Water Jets with how much they will need in terms of budget requests.

Income	**Type**		
Source			Amount
San Diego Miramar ASG			$2,308.03
Expenses			
Category	**Type**	**Description**	**Cost**
Frame	Purchased	ABS rolls	$217.40
Electronics	Purchased	Motor Controllers, Replacement Kit	$1,044.46
Pneumatics	Purchased	50 ft Pneumatic Tubing, Solenoid, Compressor	$214.40
Prop Building	Purchased	Everything needed to build the props for the competition	$410.20
Misc.	Purchased	Storage, Fluid Power Quiz	$135.10
Various Seals	Purchased	JB Epoxy, Acrylic Solvent, Watercolor stain Sealant	$63.09
			Total
			$2,084.65

I. Order of Business (5 min)
   A. Call to order: 1:00 PM
   B. Roll Call
      1. Advisor: Gina Present
      2. President: Amaan Present
      3. Vice President: Kaylee Present
      4. Officers:
         a) Chris Present
         b) Aditi Present
         c) Nina Present
         d) Nadjila Present
         e) Zach Present
         f) Kshitij Present
      5. ASG Representatives:
         a) Zayn Present
   C. Amendments to Agenda: None
   D. Approval of Minutes: Approved
   E. Recognition of Visitors : None
   F. Public Comment: None
II. Special Orders (min) : None
III. Presentations (min) : None
IV. Unfinished Business (100min)
   1. Project Development
      a. Pneumatics: Fluid power quiz and continue making the SID
         Electrical: Start to solder on replacement parts as well as testing with motors
         Mechanical: Work on weighing the props so they don't float in the water.
V. New Business (10 min)
   A. Budget Proposal

Item	Description	Price with Tax and Shipping
New Cameras	Needed new cameras as the old ones weren't waterproofed enough	$27.56
Waterproofing Kit for Cameras	Needed to make the backup cameras waterproofed and go underwater	$32.78
RCA Cable Extenders (50FT) x 2	Needed to go through tether up to topside	$28.02
ABS Filament x 3	Needed to 3D print things	$103.44
Sabertooth Motor Controllers	New motor controllers, the	€167,02 ($177.98)
x 2	old ones went bad	
RCA Splitter 3 to 9	Needed to take camera output to Mate, computer, and LCD Monitor	$10.73
Thermal Paste x 2	To help with cooling	$8.61 x 2 (17.22)
3 Ohm Resistors (2 Pack)	Testing Sabertooths	$10.66
Thermometers	Needed for a task underwater	$17.96
RCA Signal Switcher Box	Needed to switch between two input signals	$21.52
Pressure Release Safety Valve	Needed to pass safety regulations	$7.97
Female to Female brass ½ inch coupling	Needed to pass safety regulations	$9.34
Brass Tee ½ inch	Needed to pass safety regulations	$4.83
Rustoleum Spray Paint x 2	Needed to spray rebar so it doesn't rust	$13.96
Rebar ½ Inch	Weigh down props in water	$2.65
Rebar ⅝ Inch	Weigh down props in water	$22.89
Gorilla Glue Epoxy	Glue Shroud guard on	$8.06
18 awg Electrical Wire	Extra control board wire	$8.49
26 Gauge Electrical Wire	Extra control board wire	$9.47
Cable Mesh Sleeve	New bigger sleeve so it is able to fit in pneumatic tubing as well	$31.24
27 Gallon Bins x 3	Needed to store everything	$35.49
Total		$602.26

   B. Budget Approval
   1. Advisor: Gina Approved
   2. President: Amaan Approved
   3. Vice President: Kaylee Approved
   4. Officers:
      a. Chris Approved
      b. Aditi Approved
      c. Nina Approved
      d. Nadjila Approved
      e. Zach Approved
      f. Kshitij Approved
   5. ASG Representatives:
      a. Zayn Approved
   6. Club Members: Unanimous Approval
VI. Adjournment: 3:00 PM

An example of the minutes of a meeting where a budget request was passed. This would then head to the Associated Student Government to be presented by the CEO and voted on

ACKNOWLEDGEMENTS

The team would also like to thank Scott Fraser from Long Beach City College who helped us when we reached dead ends in our troubleshooting processes. He was also a source of inspiration when he met our CEO and COO, giving them advice that helped us develop Sleepy Fishy

Another person who helped the team was Matt Gardner from MATE ROV and the whole team is very thankful for that. Matt helped us nearly every step of the way whether it was troubleshooting the barracuda kit or asking about competition rules he was always there to help us.

Finally, the team would like to express their deepest gratitude to our advisor, Gina Bochicchio, whose invaluable guidance and support have been instrumental in the success of Sleepy Fishy.

Your compassionate and patient mentorship, coupled with the numerous hours that you have put into this project is what made all of this possible. You have been more than just a mentor; you have been a source of encouragement and wisdom, always ready to offer constructive feedback and practical solutions. Your dedication to nurturing the team's growth and your unwavering belief in the team have been truly motivating.

Thank you, Gina Bochicchio, for your unwavering support, insightful advice, and lessons learned throughout this project. This achievement would not have been possible without your extraordinary mentorship.

REFERENCES

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