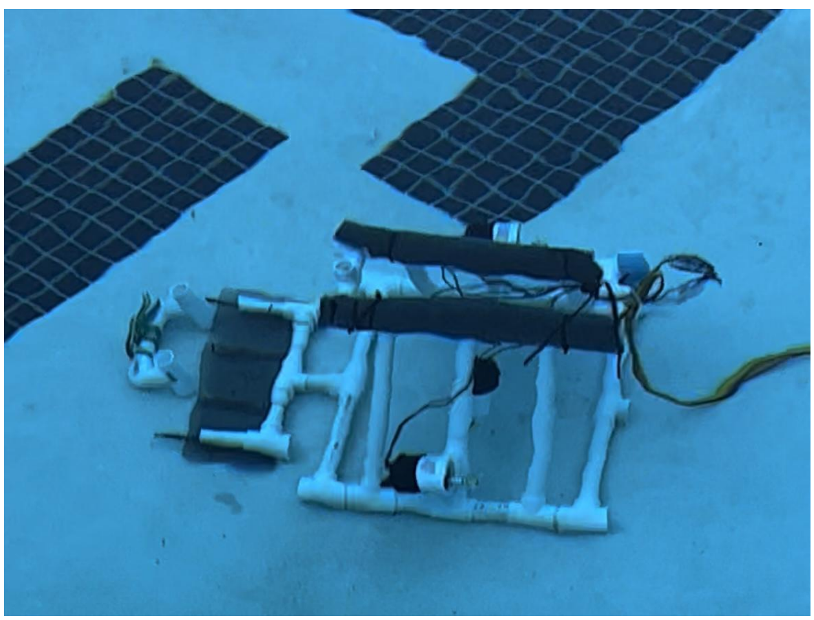
Pasadena City College
Pioneer Class
PCC Care Bears



Abstract

This report documents the finalized design for the underwater remotely operated vehicle (ROV). The purpose of the ROV is to service Marine life and help preserve Ocean health. PipeDream is Pasadena City College's first ROV. This document was created in the Spring of 2022 for the 20th MATE ROV World Championship Competition. This report outlines the mechanical configuration and design, software and hardware architectures, power, planning and a number of design process issues.

Acknowledgements

The Technical Documentation was written by the following people:

- Frank Alas - CEO, Lead Engineer, Testing & Operations
- Mariana Aldama - CFO, Lead Engineer, Systems Engineering & Design Integration

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Design Process

Building Pasadena's first remotely operated vehicle (ROV) began 9 months ago, with new members for the school's first time. The frame design, originally labeled as the vectored TriggerFish ROV Frame, was an inspiration used from the MATE ROV Powerpoint slides provided by marinetech.org.

Design Specifications and Constraints

This section will cover the details regarding the system and task specifications for the ROV. As well as limitations and constraints based on the MATE ROV competition rubric.

System specifications include:

- Must be able to fit in a 1 meter by 1 meter hole in the "ice."
- Must weigh less than 35 kg (or 77 pounds).
- Vehicle must overcome 3 obstacles such as placing a fish into a bucket, replacing seagrass, and unhook the ghost nest.
- Materials compatibility requirements must be met to be used underwater.
- Do not exert a lot of force onto the ROV as there are limitations on the material.

2.1 Facility Constraints

Facility limitations include pool access to test drive the ROV. Were limited to one day per week. Testing was difficult to do as a result.

2.2 Environmental and Safety Issues

The following is a list of safety issues and requirements for personnel or equipment operating near the ROV, Pipedream, meant to highlight relevant items needed to handle with extra care.

- Power Supply set to one phase to not burn out the fuses on the analog control board.
- ROV must be turned on underwater to prevent the motors from burning out.
- A check-list guide we follow before placing the ROV into the water.

3. Design Overview

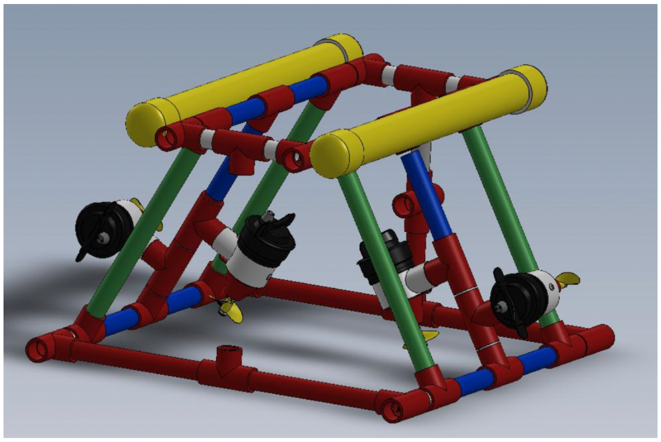


Figure 1: MATE ROV Powerpoint, Chapter 1, Slide 20. www.marinetech.org.
TriggerFish ROV Frame (isometric view)

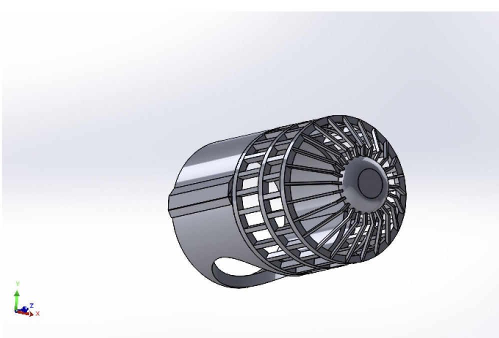
The design for PipeDream revolves around a trapezoid shape. The framework of the ROV has a 45-degree vector design. To ensure that the force of the motors can lift the weight of the ROV in the water, the motors were strategically placed. There are four motors: two motors to Surge (forward/reverse) and Yaw (turn), and two motors to Heave (up/down) and Sway (crab), which are vectoredly positioned. We learned that the net forces of the vector-positioned motors cancel out when the motors run in opposite directions causing the horizontal vector components to add together and shift the ROV towards any x-axis direction using the motor to Surge. The frame was made out of ¾ - inch polyvinyl chloride (PVC) pipes to meet the weight requirement yielding the maximum points, along with having easy mobility in the water. Instead of using buoyancy foam, poodle noodles were incorporated with zip-ties as a result of back shipping.

An arm scooper was incorporated to the bottom right side view as a substitution for an electrical robotic arm to ensure tasks were achieved. The prototype was made out of thin steel wire and held by hot glue, which was then replaced with a 3D solidworks model composed out of acrylonitrile butadiene styrene filament for UV resistances, light material, and tough loads.

The control system that was used was the Barracuda controller, which is composed of two printed circuit boards and has two joysticks. Each joystick has a 10k ohm potentiometer that gives a variable voltage to the integrated circuit on the Sabertooth motor controller. This signals the H-bridge, which controls motor speed and direction to the motors on Pipedream. The designers of the Barracuda board incorporated 4 LEDs assigned to each motor to indicate to the user the direction of each motor: the LED’s color range of either red (reverse) to green (forward). The left joystick moves two motors, forwards, backwards, and turns the ROV side-to-side. The right joystick moves two motors in the vertical direction, up and down, which includes strafing or crabbing motion.

The Barracuda controller kit came with a camera filter board to enable camera and monitor inputs.The Barracuda controller has additional features that were not used.
The tether used to connect the ROV to the control board has two wires for each motor, totaling to 8 wires.

3.1 Safety measurements
The tether has a strain-relief to prevent any damage from occurring. Wires, thrusters, and cameras were waterproofed. Fuses were found throughout the controller board and on the power supply cord. Safety guards were designed for the propellers on Solidworks to meet the MATE ROV Competition safety and regulations standards. The assembled view is composed of three part files as shown in the exploded view on Figure 1.3. A snap and fit design was integrated to tightly lock all three parts together while being on the thrusters, propellers, and PVC pipes.



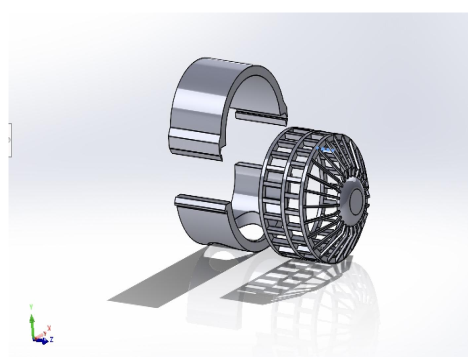


Figure 1.2: Propellor safety guard solidworks design (isometric view) Figure 1.3: Propellor safety guard solidworks design (exploded view)

Cost

1x Barracuda ROV with Thrusters and Tether for $1,200.00 each
2x Wire Soldering Lab Kit - One for $5.00 each
2x Pufferfish Practice Board - 1 for $6.50 each
1x Powerwerx 12V DC Power Supply w Powerpole outlet + GFCI for $160.00 each
1x Powerwerx TRIcrimp Powerpole Connector for $39.00 each
1x Underwater Robotics: Science, Design, and Fabrication (Revised Edition) - One Copy for $120.00 each
1x pool foam for $2.00
2x PVC pipe ¾ - inch by 10 feet for $7.00 each
2x 20-pack ¾ - inch Tees for $11.00 each
1x Zip Tie Pack for $2.00 each
1x Triggerfish / Barracuda Video System Kit for $210.00

Total Cost (after taxes): $1,778.50

Critical analysis of testing and troubleshooting

We encountered a few issues throughout the building process of our control box and our framework. Initially, the team intended on using a gaming controller to move the rover underwater. The initial thought process was that a controller would allow us to move the ROV easier due to the nature of the positioning of the analog sticks; for example, what we can control with two hands on the control box would only require two thumbs on a controller. Due to the complexity of the coding required, as well as the time constraints, we returned our focus to using the analog sticks. Here we encountered another set back. Our y-axis joystick was not getting the sufficient voltage which we would need in order to move from the bottom of the pool to the surface. A solution came from using a spare joystick and resoldering it.

A very crucial set back was that, due to covid restrictions, access to the pool at Pasadena City College was limited. Testing in the water did not become available until around April of 2022. Troubleshooting movement in the water would have to wait until we were given clearance.

References

MATE Underwater Robotics. “ROVs 101 - An introduction to ROV structure & the basics behind designing and building your very own underwater vehicle.” *www.marinetech.org*.

MATE Underwater Robotics. “Constructing the Barracuda Control Box in Analog Mode” *www.educate.materovcompetition.org*

SeaMATE BARRACUDA. “Instructions for the SeaMATE Barracuda ROV Kit” *www.marinetech.org*.