Marine and Naval Technological Advancements for Robotic AutonomY (MANTA RAY)
Ghost Unpiloted Performance Platform Submersible (GUPPS)

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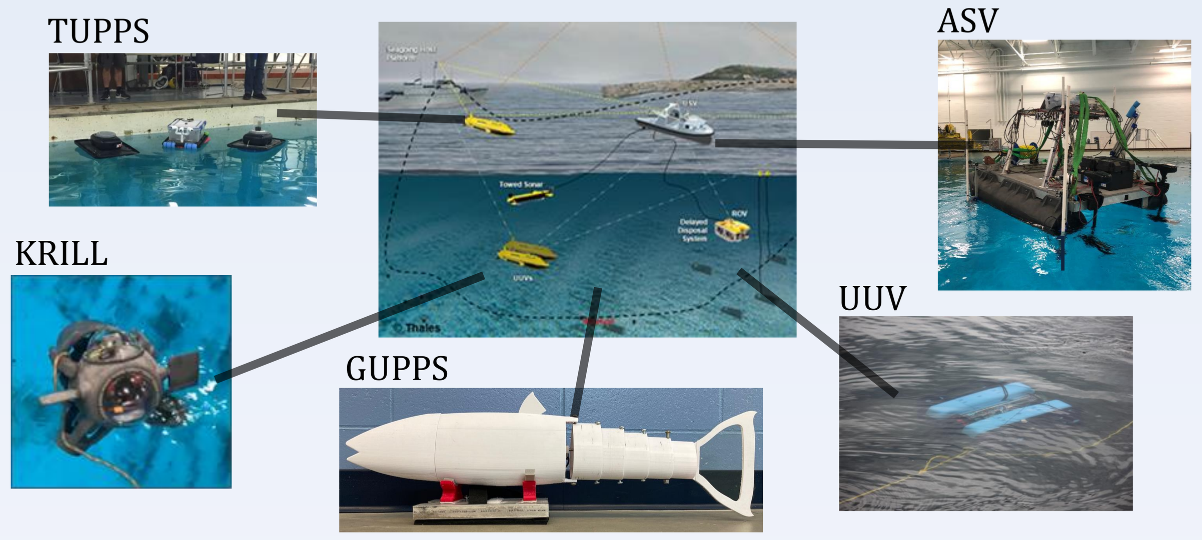
MANTA RAY Mission

Team MANTA RAY is an interdisciplinary project dedicated to creating, maintaining, and expanding a network of marine robots for seafloor mapping and underwater perception. The network began as just the autonomous surface vehicle (ASV) and unpiloted underwater vehicle (UUV) but has expanded to include a prototype of the ASV, known as TUPPS, and two kinds of remotely operated vehicles, known as Ghost Unpiloted Performance Platform Submersible (GUPPS) and KRILL. With these systems, students work to improve communication between vehicles, develop autonomous behaviors and algorithms, and upgrade existing mechanical systems to improve precision and performance.



GUPPS Mission

GUPPS is one of newest additions to the MANTA RAY fleet. The purpose of GUPPS is to unobtrusively investigate underwater areas of interest using a biomimetic robotic fish. Ultimately, GUPPS will be deployed in local AquaFort steelhead trout fisheries in Newcastle, NH. Last year, GUPPS team goal this was to finalize design specifications and bring it to life as a working model in air. The goal of this year's team is to enable the biomimetic fish to swim in a straight line at a constant depth of 1 m.

Buoyancy

Variable Buoyancy Control Chart
Measured component weights from center point to find center of mass and center of buoyancy. This was used to make a variable chart in excel.

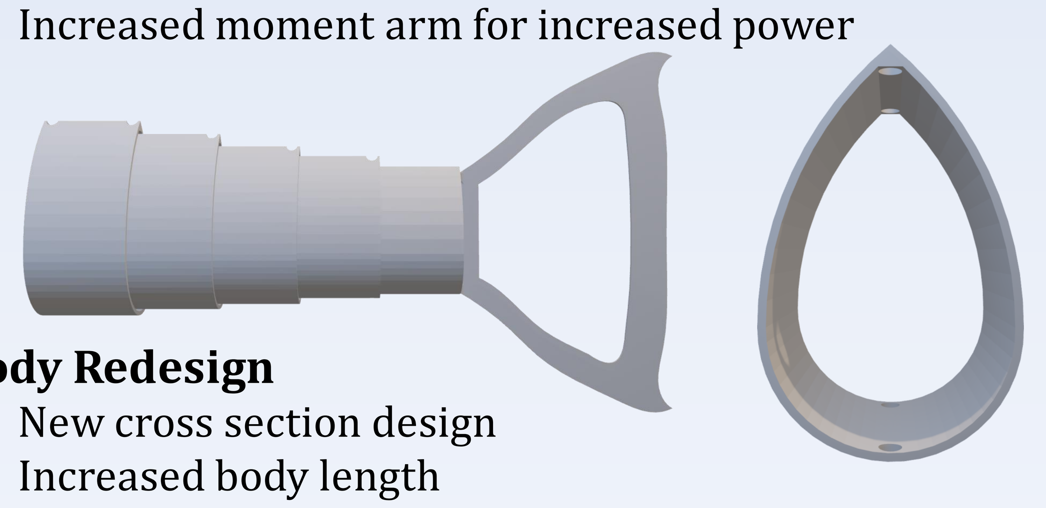
Buoyancy Control Unit/ Retrieval
An air bladder controlled with an Arduino uses two 6V-solenoids to control airflow from a CO_2 cartridge source via air valve. For testing purposes, a retrieval system allows for rapid inflation of the air bladder to bring GUPPS back to the surface.

Two Propulsion Methods Designed in Parallel

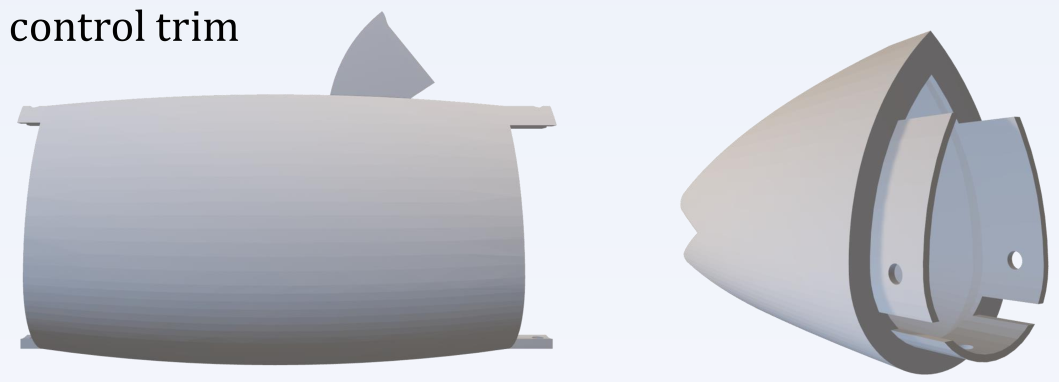
To achieve the GUPPS mission, two propulsion methods were pursued in parallel. One design utilizes the motion of the tail to displace water for forward motion and turning is controlled by the angle of the tail motion. The other uses a propeller for forward motion and the tail acts as a rudder.

Tail Propulsion

Tail Redesign
- Increase tail surface area
- Determined suitable connection method between tail pieces
- Repositioned servo driving point
- Increased moment arm for increased power



Body Redesign
- New cross section design
- Increased body length
- Integrated servo mounting location
- Cavities added for ballast and foam placement to control trim



Dry-Box Upgrade
- 2.5" PVC pipe
- Permanently fixed acrylic endcap
- Waterproofed gasket to connect electronics to servo
- Rubber stopper plug for electronics access

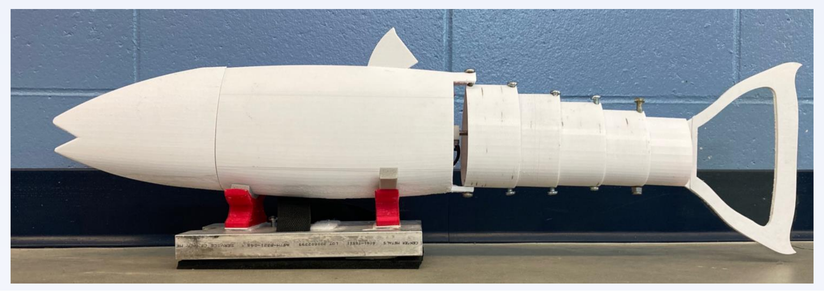
Electronics
- Arduino UNO microcontroller
- 7.4V Li-Po battery
- 80kg IP68 Waterproof Servo

Specifications

Dimensions
- 32" x 5" x 8.5"

Weight
- 3.5 lbs.

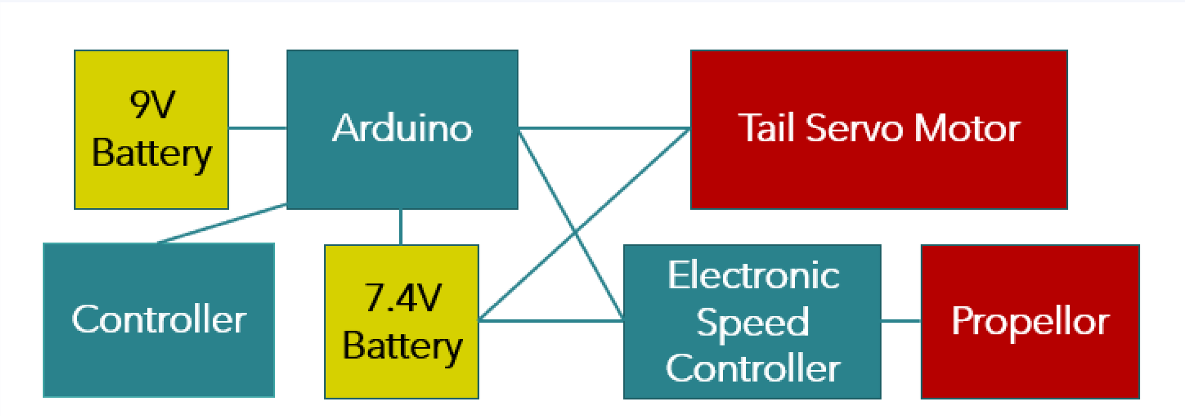
Features
- Detachable head for ease of access
- Individual tail sections to access servo mounting and driving locations
- Bottom cavity to separate ballast and servo motor
- Top cavity to add floatation foam



Propulsion Design via Propeller

Inspiration
We were concerned that with the previous design there was no speed or direction control. We wanted to redesign GUPPS to allow for surface control while GUPPS was swimming in the water to be able to change direction and speed in the water.

Systems

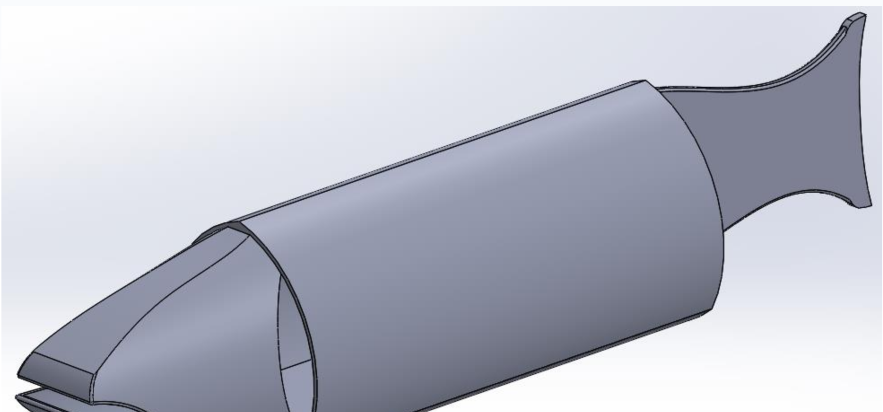


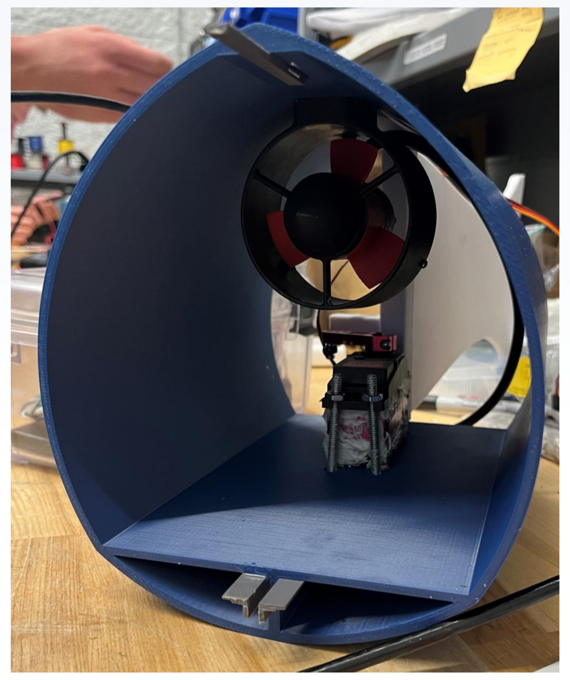
Electronic Systems Wiring Diagram

Components Design
- Propeller mounted to top of inside with large range of speed control
- Servo motor in rear that controls tail motion.
- 50 degrees of motion in the tail.
- Dry box secured in front side of body.
- Tether protruding from dry box with 3 dry seal
- 15-foot 4 wire tether from dry box

Specifications
- 32" long, 6.5" at widest
- Top Speed: 2 m/s

Components
- Otterbox 3500 Dry Box
- 7.4V LiPo battery
- 60 kg digital servo
- Arduino Uno
- Hawk Hobby Underwater Propellor





Biomimicry

GUPPS is modeled after *Oncorhynchus mykiss*, commonly known as a steelhead trout. Steelhead trout are anadromous ray-finned fish that are native to the northeast region. They spend two to three years in freshwater followed by two to three years in the ocean, they are typically larger than rainbow trout.

The body conformation has a fusiform shape which helps the fish's propulsion through the water. The fusiform body shape is rounded or torpedo shaped and streamlined, which is an ideal shape for fast, continual swimming. Fish with this body shape are well adapted for feeding and survival in open water because the fusiform shape creates minimal drag as the fish swims. The fin was shaped. Since steelhead trout is in the salmonid family the tail was designed to have subcarangiform propulsion. This means that most of their propulsion is mostly provided by their tail but some from body movement. The way the fin enables the fish to create lift as they move forward through the water because of the pressure difference above and below. This helps regulate neutral buoyancy.

Future Work

Autonomy as an overall goal for all systems within GUPPS. Control of each system can generally be achieved with the use of an Arduino. The buoyancy control system needs continued development to be placed inside the head of GUPPS.

Now that GUPPS can swim in a straight line, code needs to be developed to refine tail motion to enable autonomous turning control. In addition to lateral control, a buoyancy device and pectoral fin motors will be added to allow for vertical positioning control. Finally, sensors will be added to monitor environmental conditions when deployed

The future work of the Propulsion Design via Propeller should consist of adding 2 additional servo motors to the mid section of the fish in order to control height within water column, followed by surveillance sensors to achieve the final mission of observation underwater areas.

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