SWIM / FLY DRONE (PELICAN PADDLER)

Alia Wolken, Andrew Jwaideh, Eduardo Santos, Sha'anan Levy

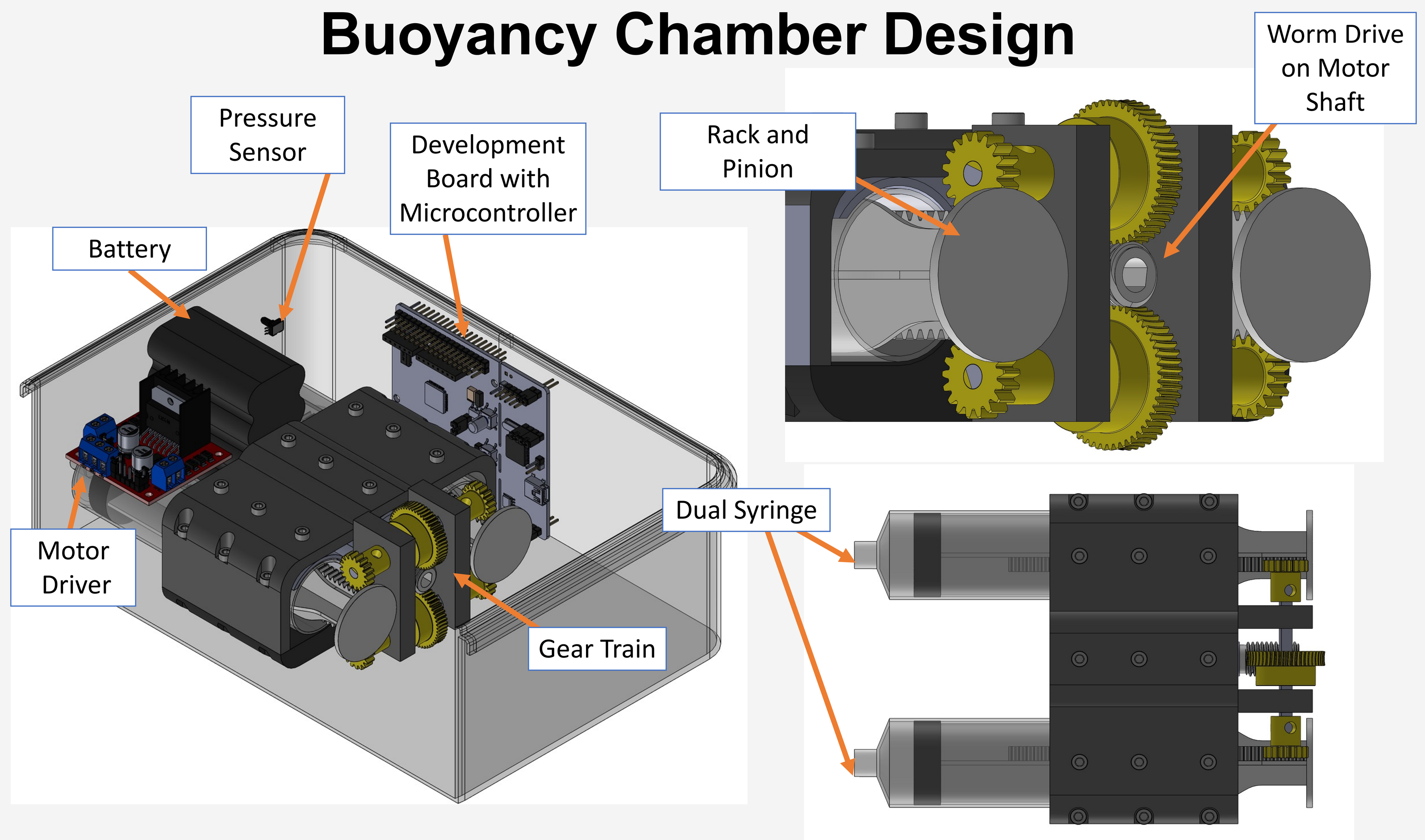
SPONSOR: Dr. Behnam Ghalamchi
January – December 2024

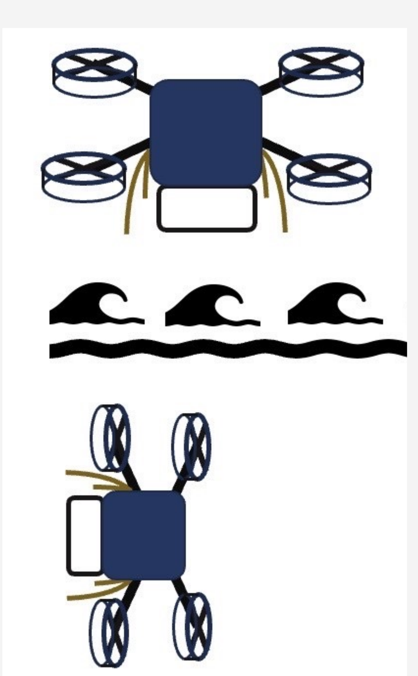
Acknowledgements:
Dr. Peter Schuster, Professor Charlie Refvem, Dr. John R. Ridgely, Dr. Amanda Emberley, Ryan Pettigrew, Kate Baughn

Background

Scope: The Swim/ Fly Drone focuses on designing a versatile drone that can operate both in air and underwater and be used later in tests comparing its added features to a drone without them.
Goal: Waterproof a drone and add a detachable buoyancy chamber that controls the depth of the system underwater. This drone shall also float on the surface of the water for a seamless transition into flight.
Applications: This drone is intended for applications such as marine research, search and rescue and more, providing a multifunctional solution for task that require both aerial and underwater operations.

Buoyancy Chamber Design





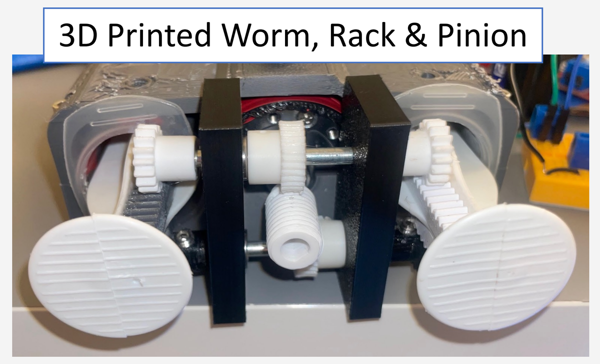
How it Works
- A pressure sensor and a closed loop controller regulate syringe actuation to achieve the desired depth
- By adjusting the volume of water in the syringes we can achieve negative/positive buoyancy

Software Architecture
Main program with Classes: Pressure Sensor, Motor Driver, and Closed Loop Control

Governing Equation
- To descend: Buoyancy force < Drone Weight
- To ascend: Buoyancy force > Drone Weight
- Design Formula: Fb = pgV

Manufacturing
A combination of off-the shelf components and additive manufacturing enabled control over displacement volume and custom fixturing within the system while having reduced weight and lead time as compared to manufacturing with metallic materials.

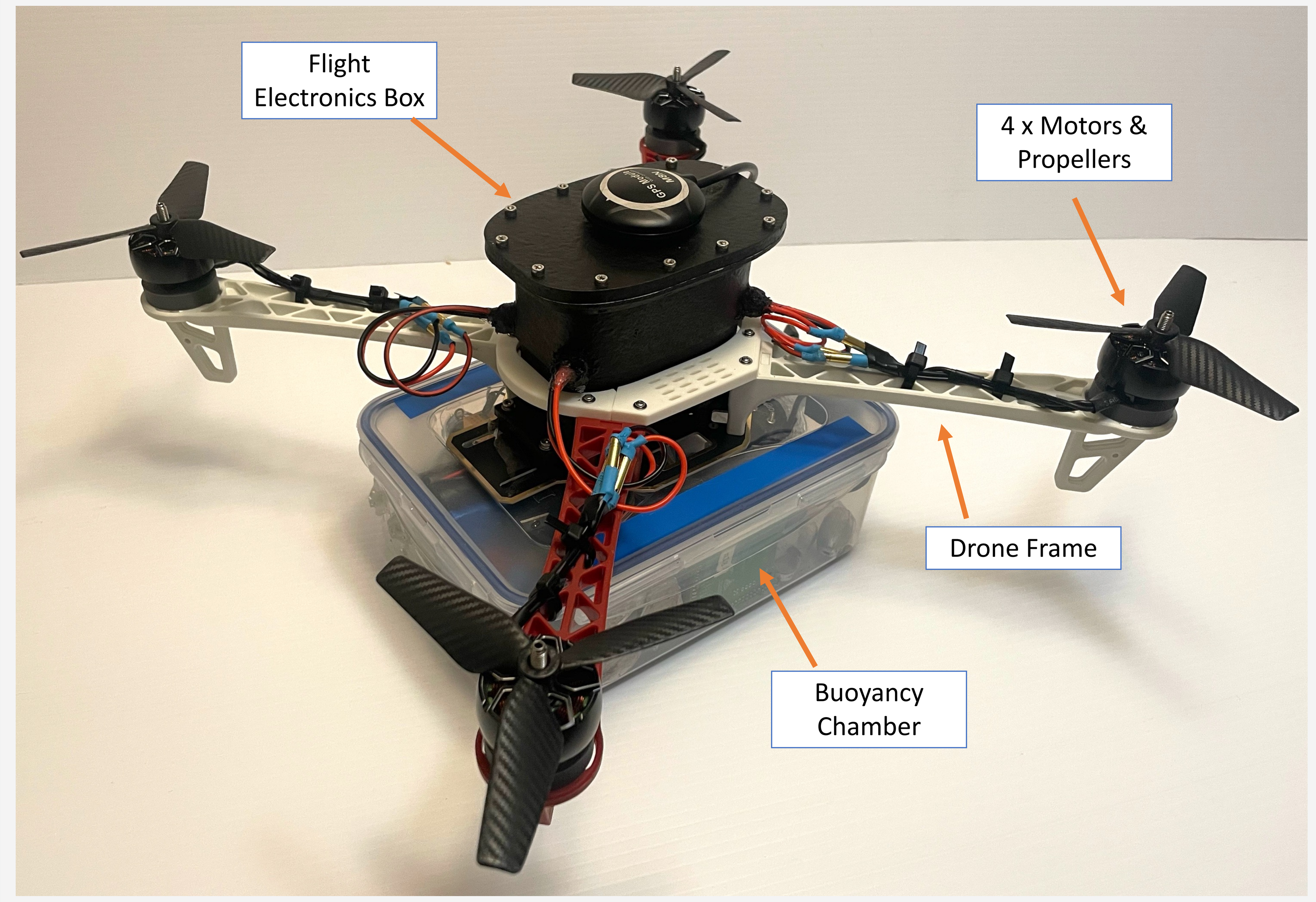
3D Printed Worm, Rack & Pinion

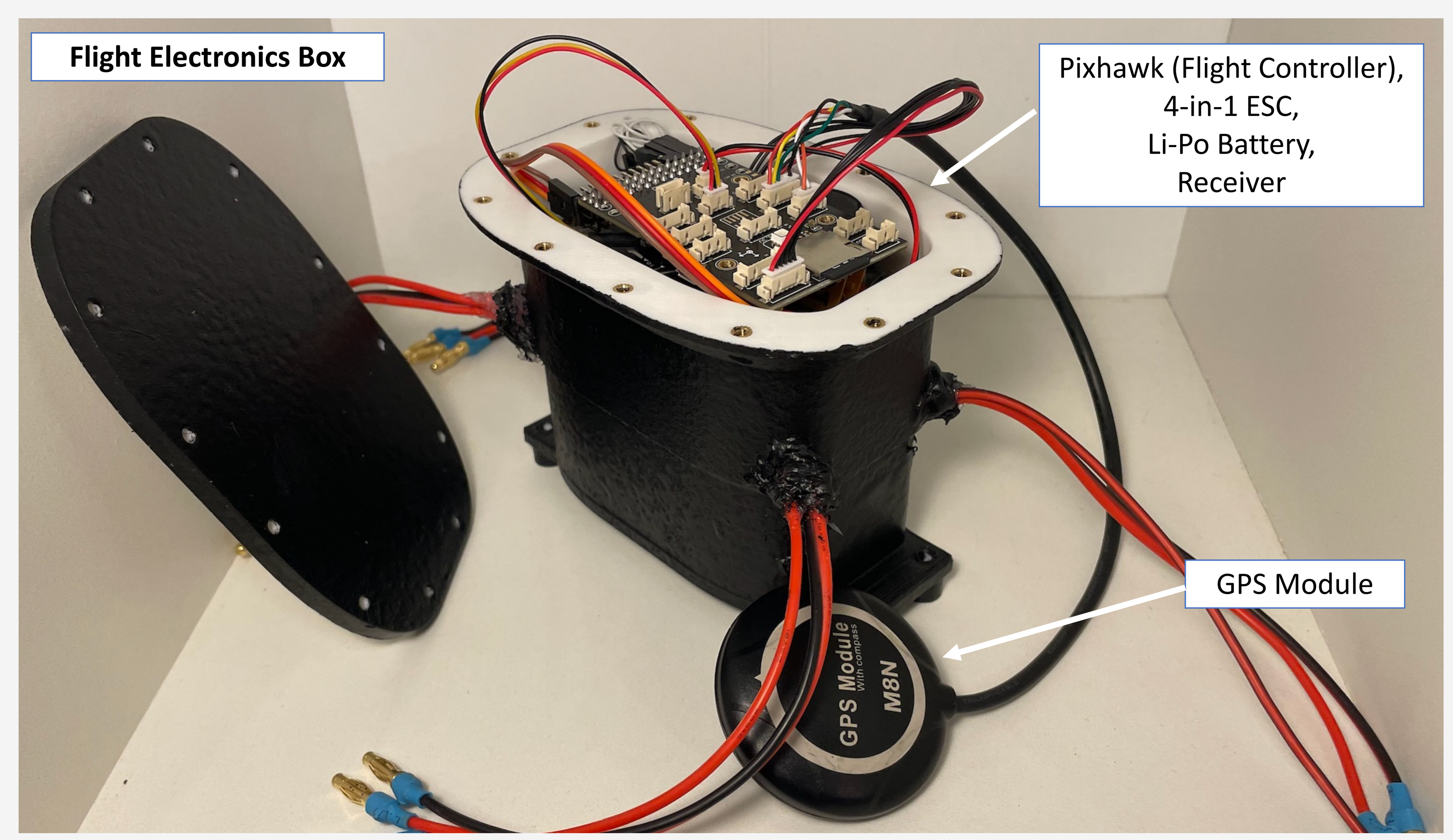


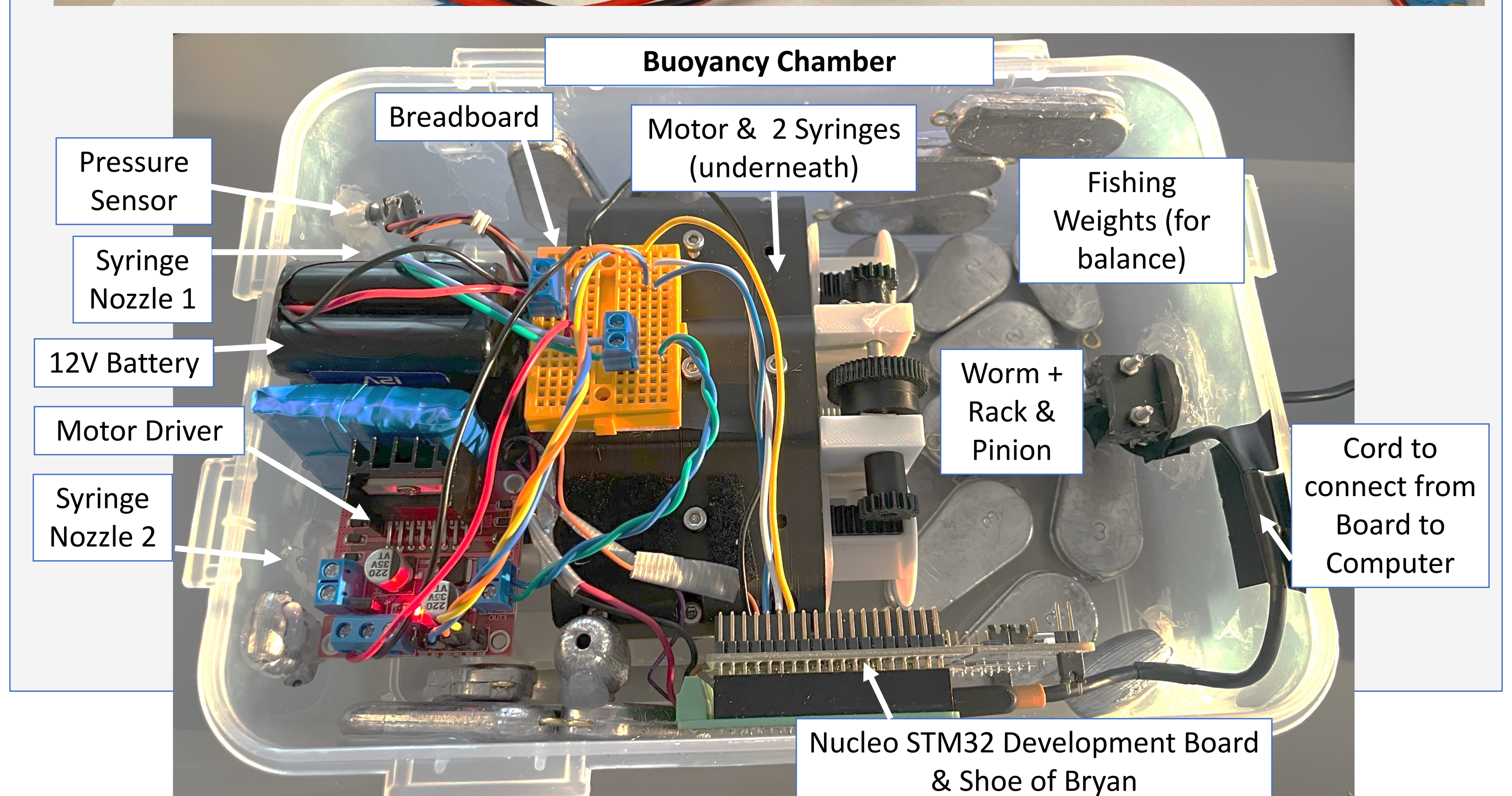
References

- *Hamzeh Alzu'bi, Iad Mansour, and Osamah Rawashdeh*, "Loon Copter: Implementation of a Hybrid Unmanned Aquatic-Aerial Quadcopter with Active Buoyancy Control," Oakland University
- *Jeremiah Karpowicz*, "Meet the Naviator – A Drone that Can Fly Just as Easily as it Can Swim," Commercial UAV News
- *Brick Experiment Channel*, "RC Submarine 4.0"

System Design

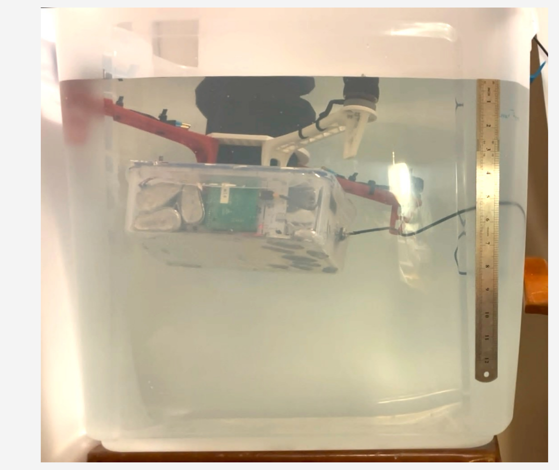






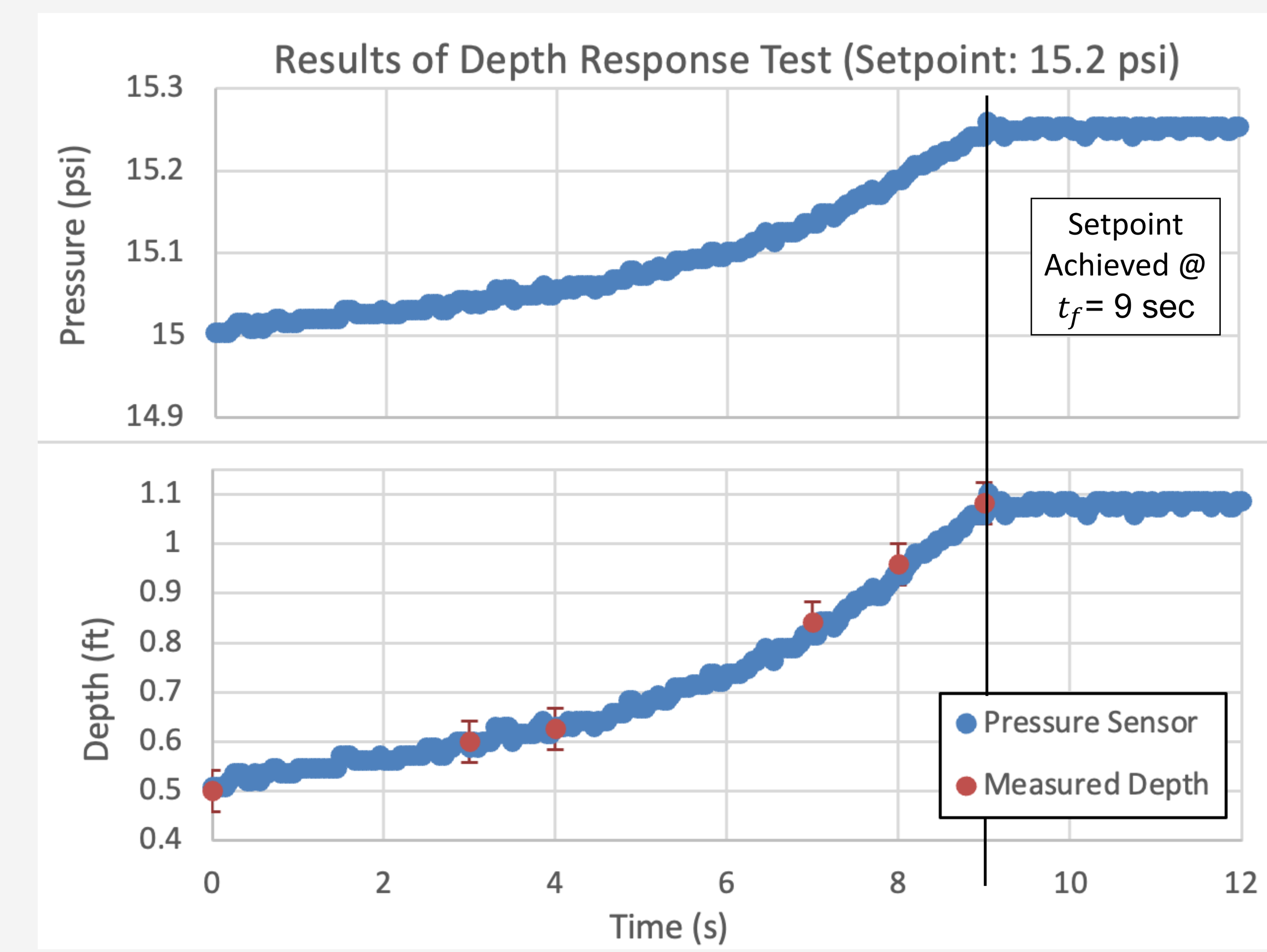
Analysis & Testing

Depth Response Test: Ensured proper mechanical responses to desired pressure changes (representing depth), or "setpoints", from the controller input. The system was successfully tested descending to 15.2 psi and ascending to 14.7 psi (atmospheric pressure).
Photos from Test, with Desired Setpoint of 15.2 psi



Floating (t_i= 0 sec)

Submersion (t_f= 9 sec)

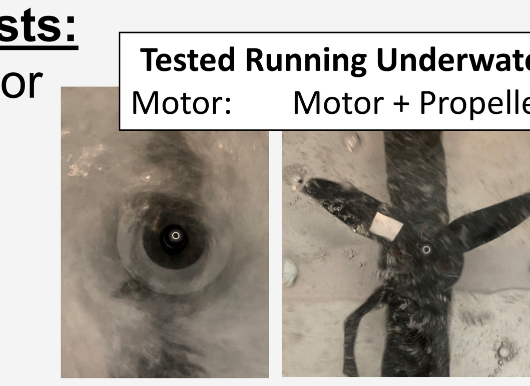


Results of Depth Response Test at 9 seconds (15.2 psi Setpoint)

2 Methods of Measurement:	Depth [ft]	Pressure [psi]	% Diff from Setpoint P
Pressure Sensor	1.086	15.25	0.33%
Depth from Visual Inspection	1.083	15.17	0.20%

Underwater & in Air Motor/Propeller Tests:
Tested different propeller options with motor to find which was able to carry the most weight in the air.
1 Propeller + Motor lifts: 840 g
Whole System can lift: 3360 g (7.41 lb.)

Tested Running Underwater



Conclusion & Takeaway

Air chamber provides safe transient response between air & water. This could be useful for heavier drones entering the water.

Next Steps

- Interface buoyancy chamber software with Pixhawk to have one software system
- Compare the energy usage between the two systems, the drone with the air chamber and without, to hold itself underwater.
- Test water to air transition between the two systems, to see which lifts system out of water better.