MFWF

(Micro Flapping-Wing Flyer)

Micro Flapping-Wing Flyer (MFWF)

Third Year Presentation

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MFWF

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Why Flapping Wing Flight?

MFWF

(Micro Flapping-Wing Flyer)

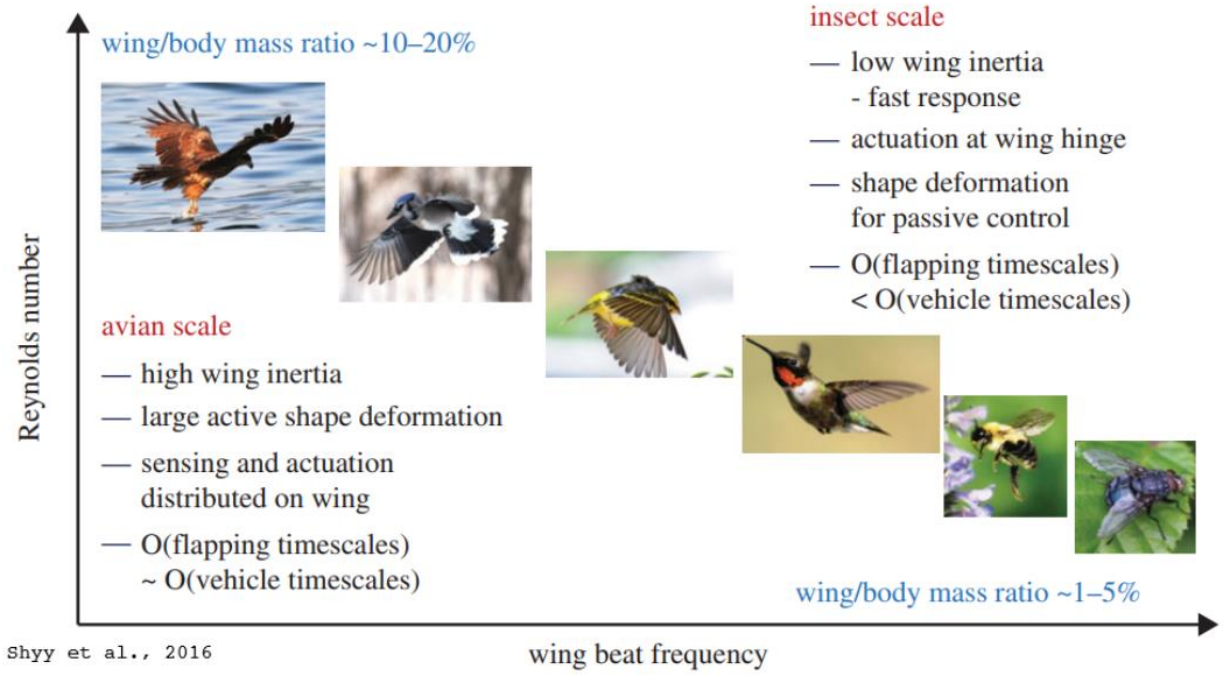
1. Given their potential for subcompact sizes, they can navigate in environments that are inaccessible to other Unmanned Aerial Systems (UASs), such as in dense foliage, small shafts and debris-blocked passageways.

2. They can perform complex maneuvers that are not possible with other aerial platforms.

3. They are environmentally friendly due to their lightweight and high efficiency flapping-wing

4. They possess the element of the stealth for surveillance and monitoring.

5. New potential advantages are still being identified such as the recently found gust-mitigating potential of flapping-wing flight.



Shyy et al., 2016

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Project Objectives

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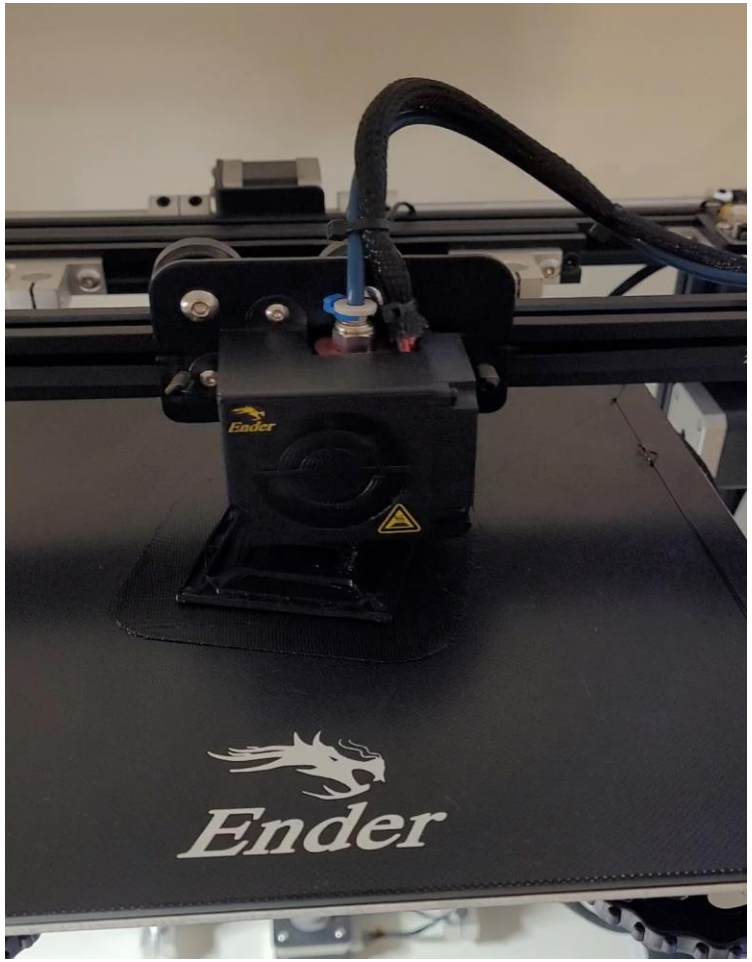
(Micro Flapping-Wing Flyer)

- Design a novel Flapping Wing Flyer that:
  - Is Under 40 Grams
  - Has a 1 Minute Hover Time (To Start)
  - Has under 25cm Wingspan
- Primary Objectives for the 2022-2023 Academic Year
  - Build a 6DoF Gimble to measure forces
  - Tune and Gimble test PID Controller
  - Build and Fly a refined Prototype



Team Layout

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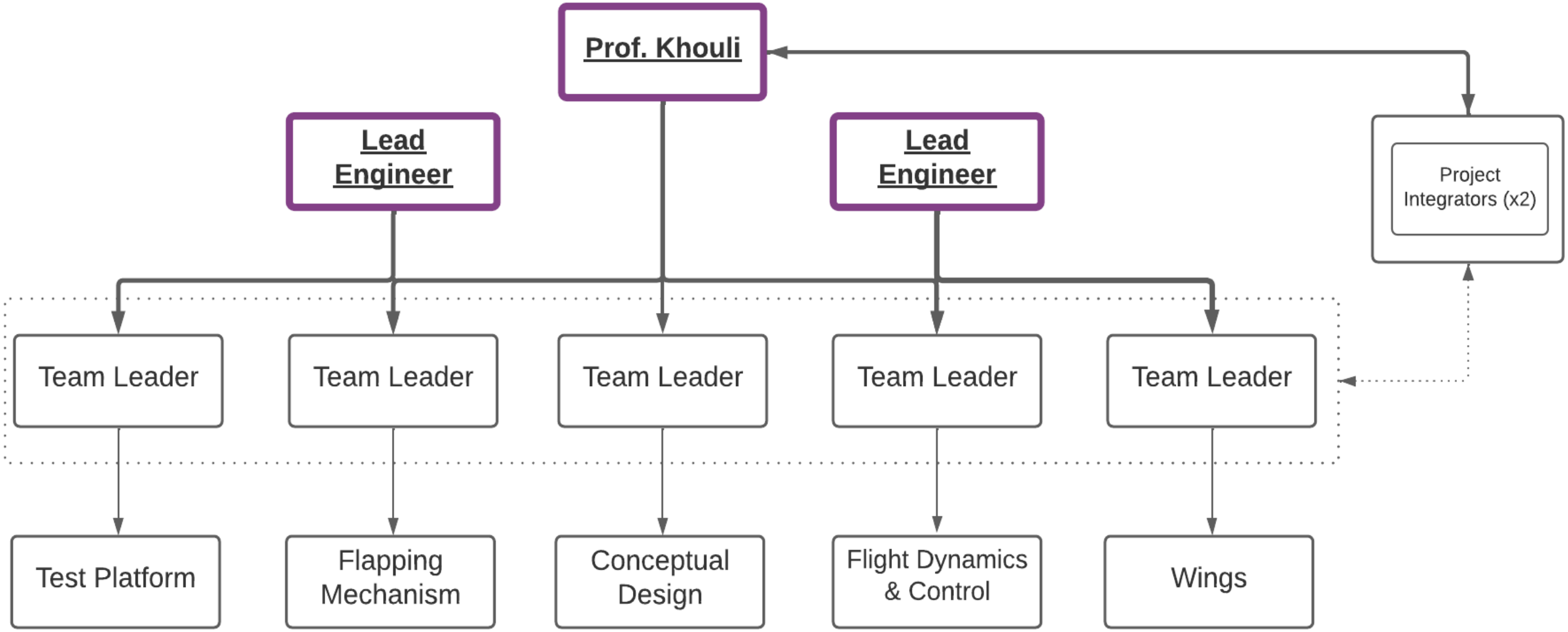

Conceptual Design

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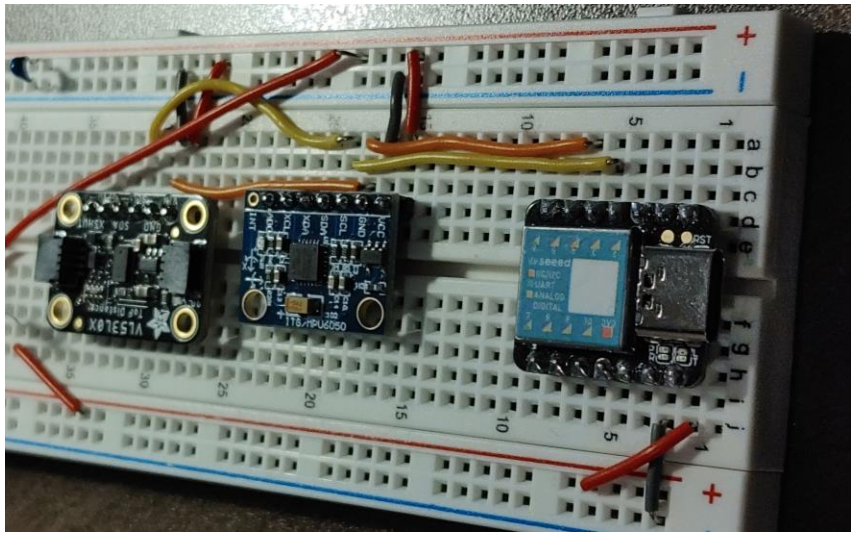
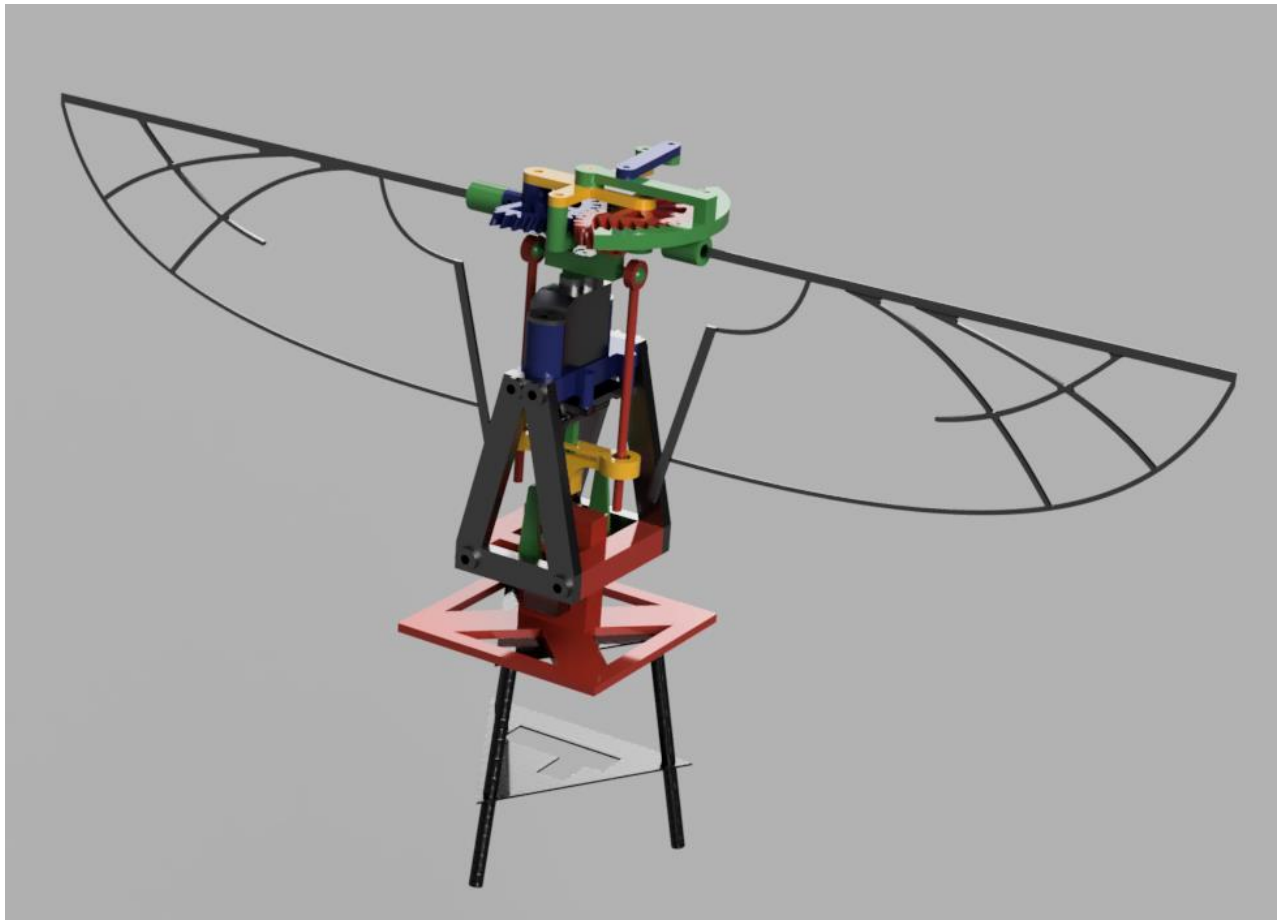
Objectives:

- Defining the system-level layout of the MFWF
- Sizing aircraft for performance matching





Conceptual Design

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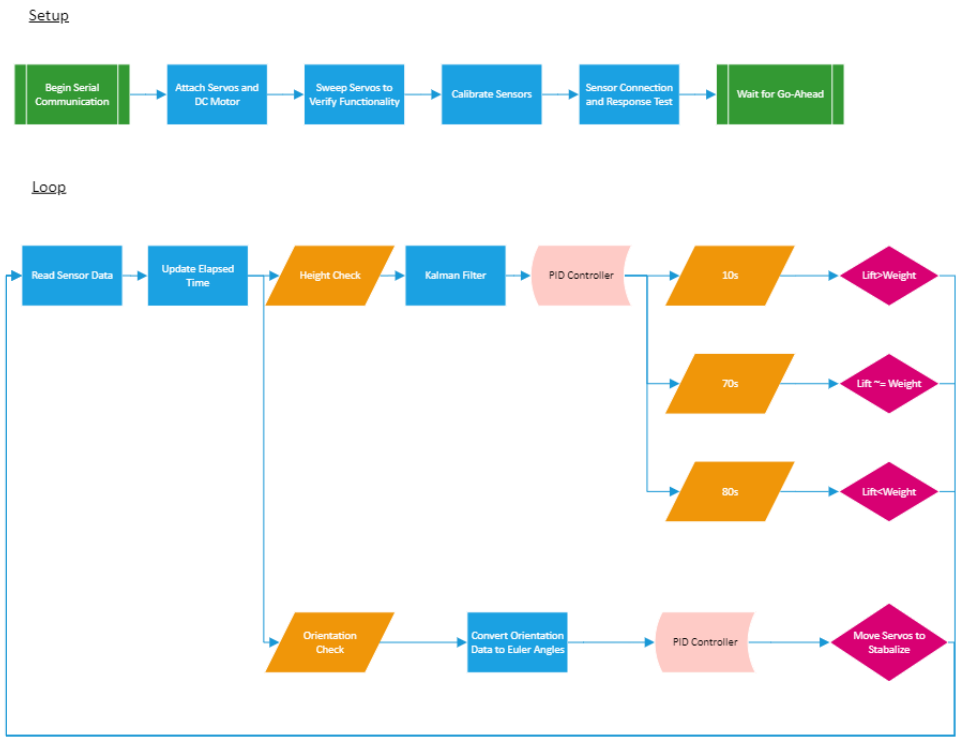
- Exploring alternative technologies for energy storage and management
- Optimize
  - the Geometry of the design
  - program relating to power consumption
- Customize PCB design to optimize power and weight efficiencies of sensors



Current program layout

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Flapping Mechanism

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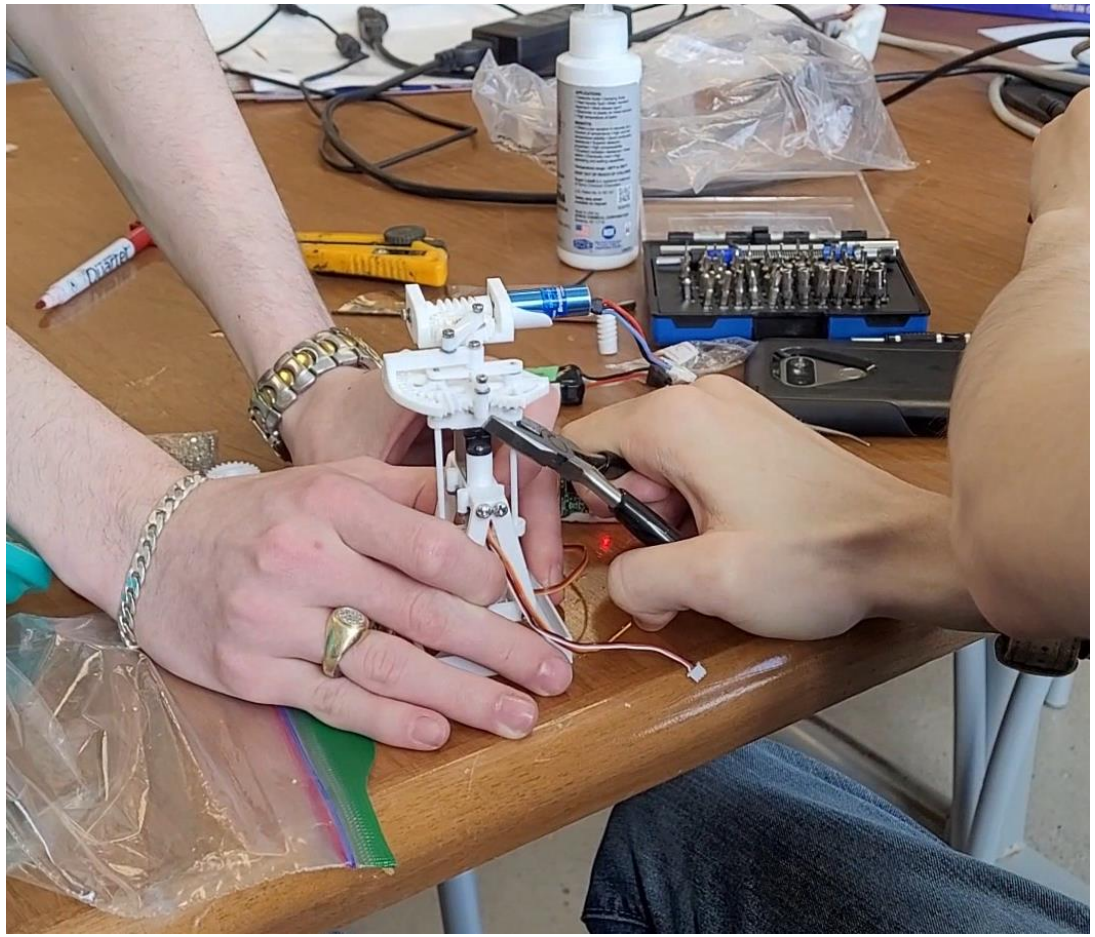

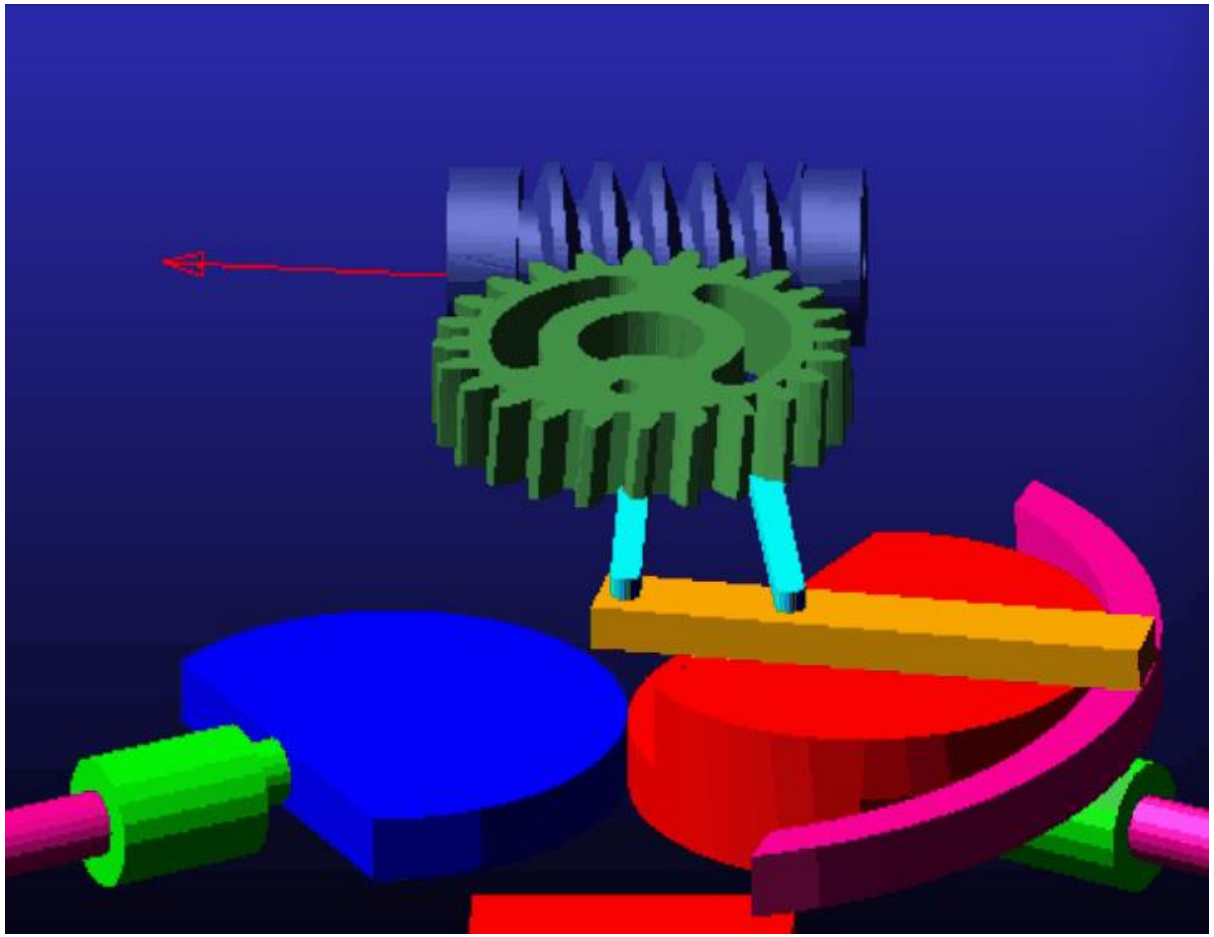

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Flapping Mechanism

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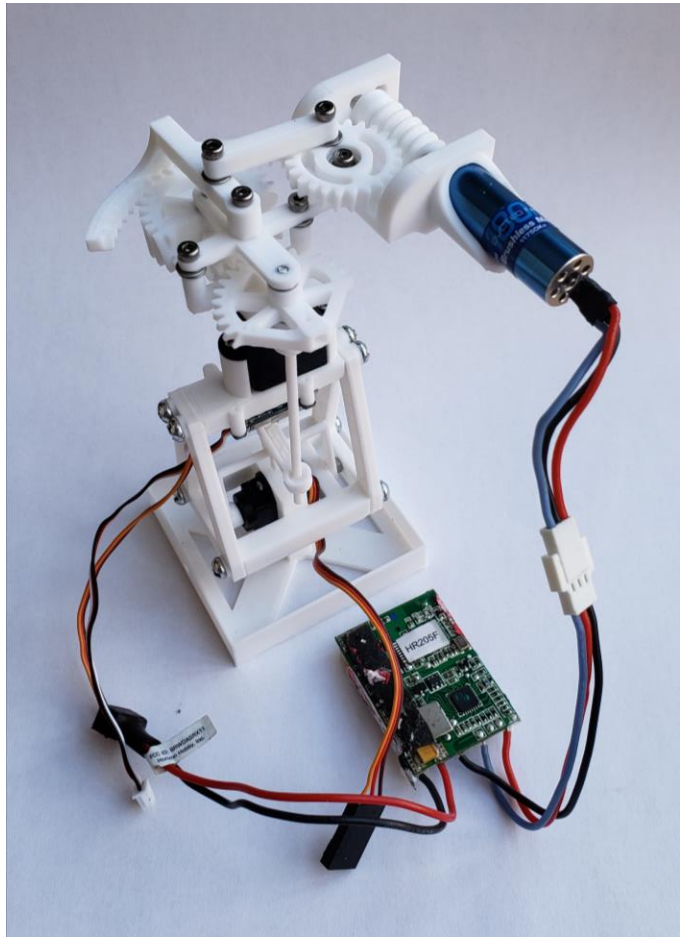
Current Prototype

- Functional 3D Printed Mechanism
- 11750 Kv brushless DC motor produces flapping motion
- Yaw, pitch and roll controlled by micro servos through wing root articulation



Flapping Mechanism

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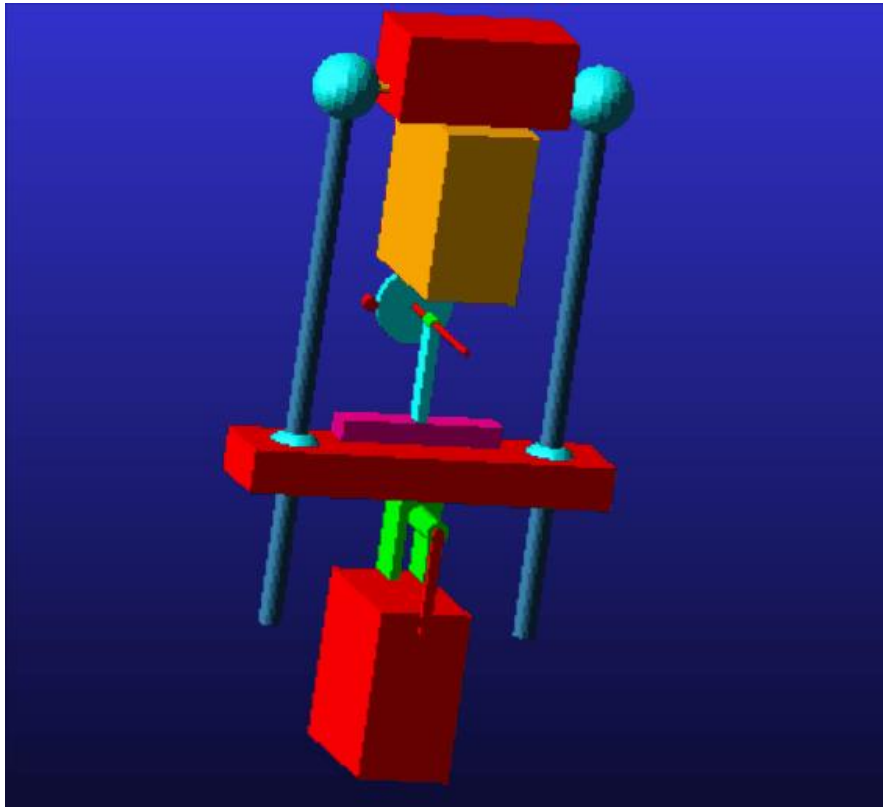
Current Progress:

- Research MFWF
- Design Mechanism (Fusion and Adams)
- Manufacture Prototype

Future Tasks

- Reduce mechanism and frame weight
- Select more suitable materials (greater durability under high speed)
- Refine gear design
- Make prototype flight-ready!



Wing Design

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- Objectives
  - Design, build, test and iterate pairs of wings
  - Wings must be light yet durable enough to withstand continuous flapping
  - Stiffness must be tailored to optimize both lift generation and vehicle controllability

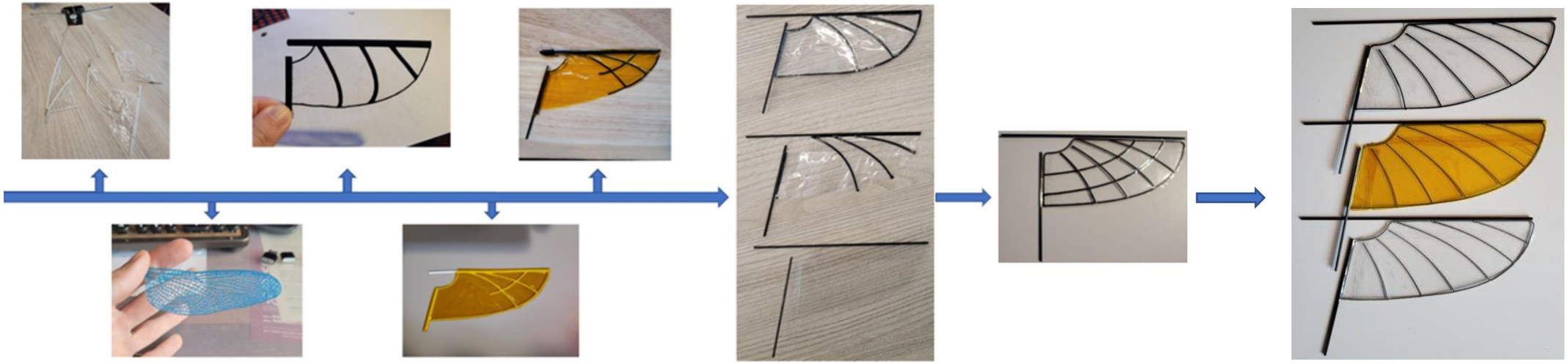

Figure 1: Evolution of wing design

Wing Design

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- Current progress
  - Developed a consistent manufacturing procedure
  - Tested various materials and structural schemes
  - Testing to determine the wings' structural characteristics
- Future Tasks
  - Utilize flapping test stand to gather data
  - Begin aerodynamic tailoring of wings using test results
  - Continue iterating wing design

Flight Dynamics & Control

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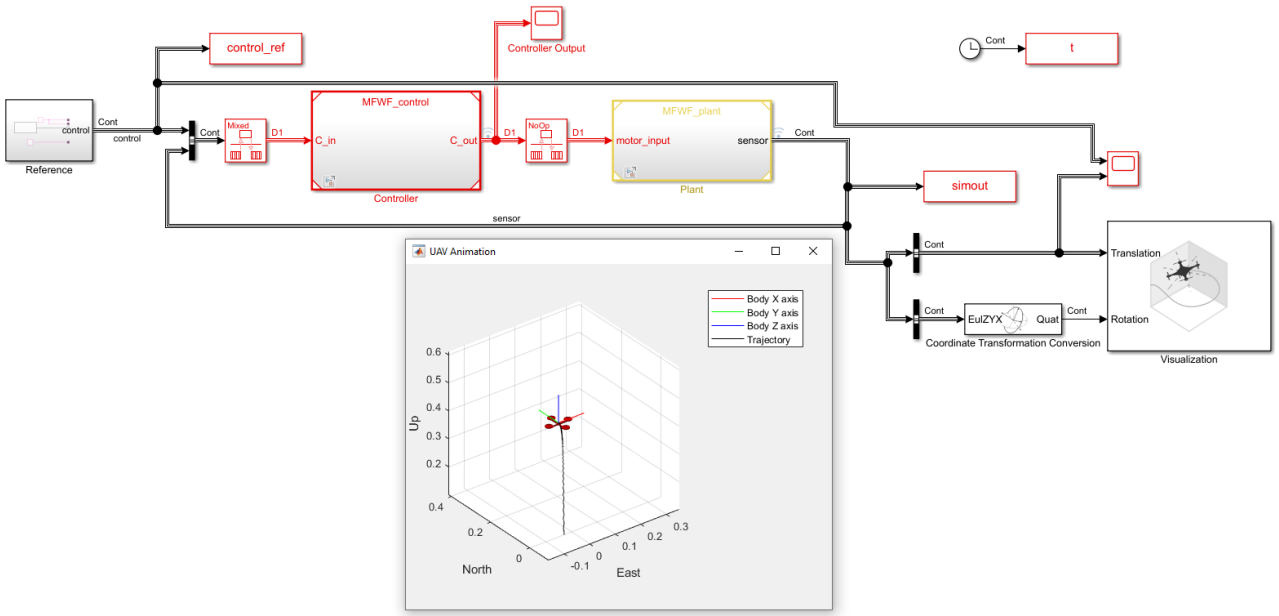
- Objectives
  - Design and tuning of the MFWF's controller
  - Creating a simulation environment and models in Simulink
  - Exporting controller to Arduino
  - Simplified aerodynamics model of flapping wing
  - Rigid body model of the MFWF



Current simulation environment

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Flight Dynamics & Control

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- Current progress
  - Developed a basic model of the flyer
  - Created a simplified Simulink model of the aircraft
  - Began testing of Physical Components
- Future Tasks
  - Integration of test stand data into design
  - Verification of the aerodynamic model
  - Tuning the controllers to improve MFWF stability
  - Full 3D waypoint movement
  - Hardware testing

Aerodynamics Test Platform

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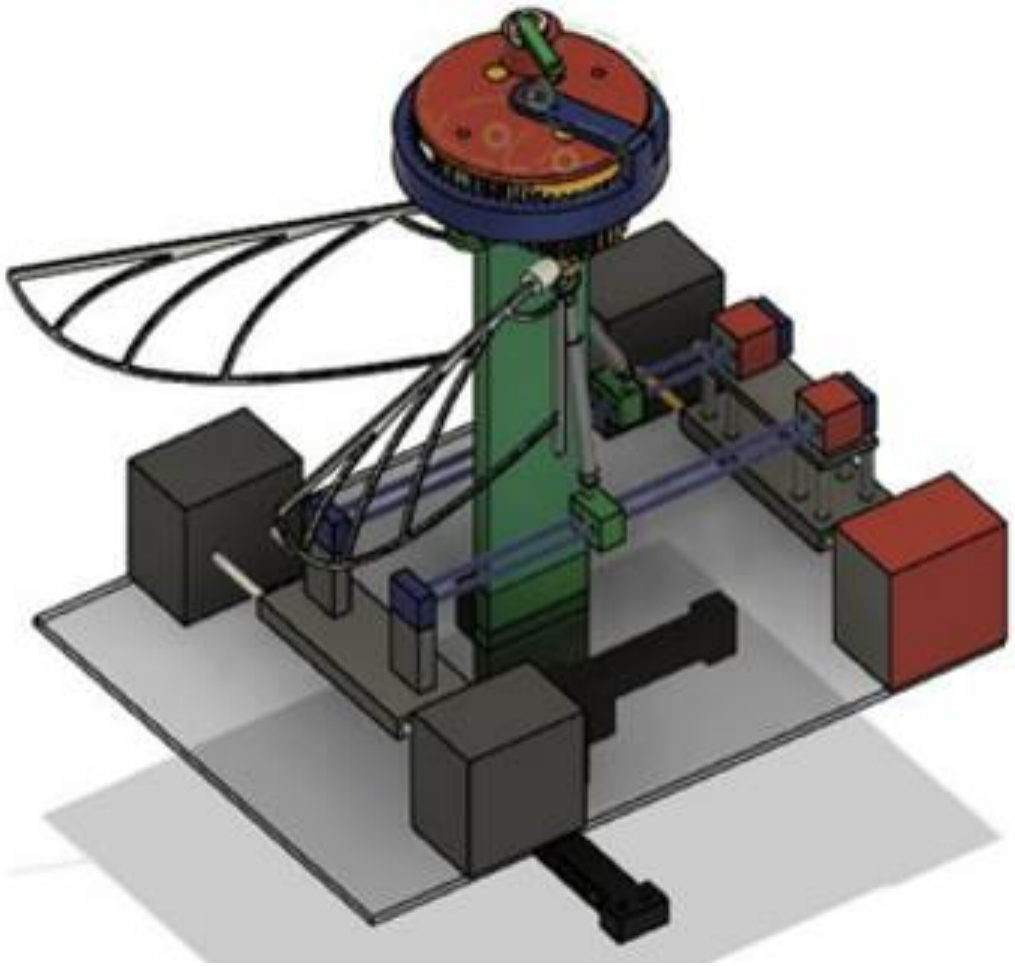
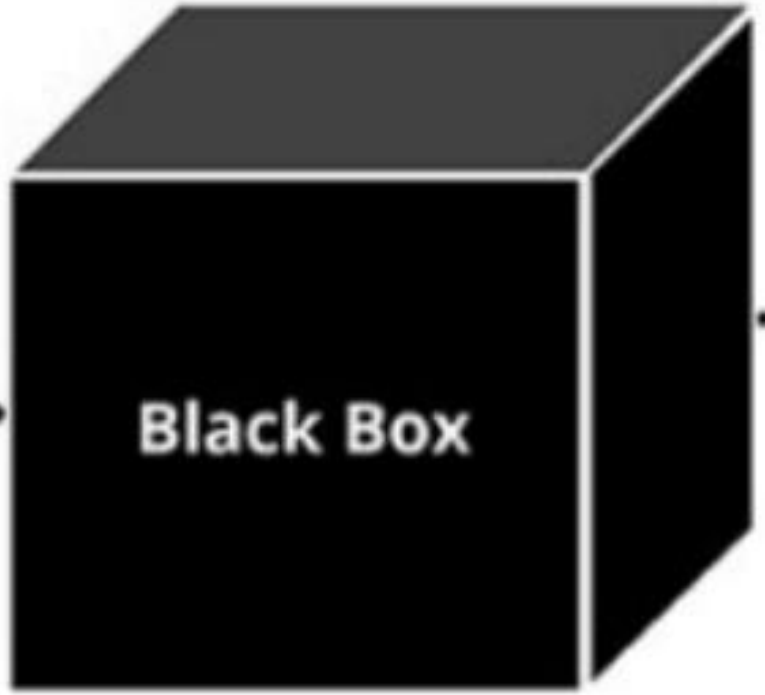


Wing Kinematics



Aerodynamic Forces

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Aerodynamics Test Platform

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- Current progress
  - Developed a 3DoF platform
  - Analyzed response of current sensor capabilities under dynamic loading
  - Created a prototype stand to begin testing of wings in September 2022
- Future Tasks
  - Refine the 3DoF Test Platform and confirm predicted lift of Wing
  - Design 6 DoF gimble for measurement of Flight Moment Loads
  - Refine PID Controller with 6DoF Gimble fitted with flyer

Further Reading

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(Micro Flapping-Wing Flyer)

A. Thomas A. Ward and M. Rezadad and Christopher J. Fearday and Rubentheren Viyapuri
Review of Biomimetic Air Vehicle Research: 1984-2014
International Journal of Micro Air Vehicles, **3**, 375–394 (2015).

Questions?

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