3D Printed Aircraft Competition

Team Hot End Aeronautics

SDSU San Diego State University

Department of Mechanical Engineering

2022-2023

HOT END AERONAUTICS

Project Overview

- The objective of this project is to design and manufacture a fully 3D printed fixed-wing aircraft with the goal of prolonged flight. The competition restricts the aircraft's fly space (300'Wx160L'x35'H) as well as its motor run time (8 seconds).
- To remain competitive, the team incorporated glider-like characteristics into their design. As a result, an emphasis is placed on optimizing the aircraft's strength-to-weight ratio.
- 3D printing manufacturing effortlessly yields complex geometries which would be difficult or near impossible to obtain via other methods. The team explored various material properties, "grain" orientations, print settings and other 3D printing advantages.

Meet the Team

Josh Gipson

Henos Hussien

Matthew Owens (Team Lead)

Alexandre Balensi

Alexander Brown

Acknowledgments

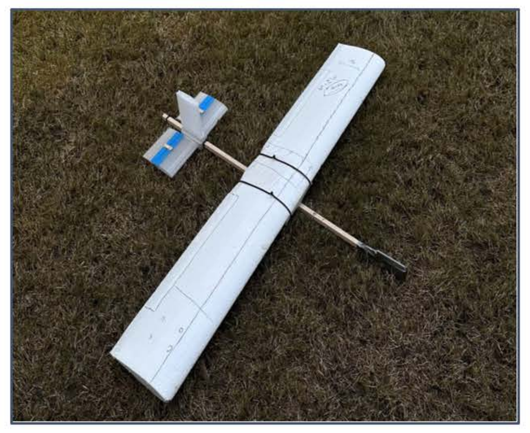
Team Hot End Aeronautics would like to thank the following:

- **Dr. Scott Shaffar** for arranging and advising this project.
- **Division of Student Affairs and Campus Diversity** for providing the funds to purchase competitive components and materials.
- **Dr. Chuck Norris** for sharing his extensive knowledge and experience with the team in regards to remote control aircraft control.
- **Erica Binder** for her Generous donation to both 3DPAC Teams.
- **Mark Owens** for supporting the team by providing an additional 3D printer and materials.
- **Cal State LA** for hosting this year's 3DPAC Competition.

Prototypes

1st Prototype

- *Balsa Wood and Foam Wing*
- *No electronics*
- *600 grams*



2nd Prototype

- *Foam wing and 3D printed fuselage*
- *No electronics*
- *1300 grams*

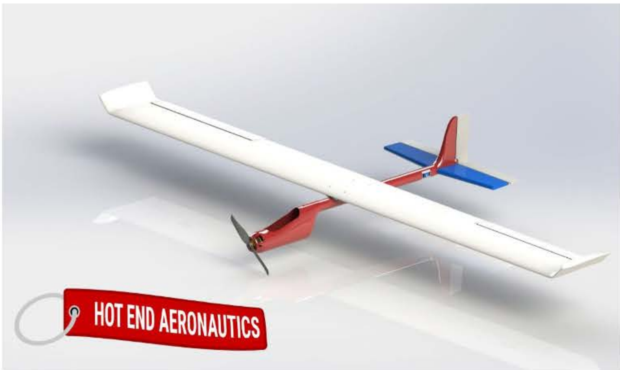
3rd Prototype

- *Fully 3D printed aircraft with PLA and LW-PLA.*
- *Electronics connected*
- *1100 grams*

4th Prototype

- *Fully 3D printed aircraft with PLA+*
- *Full electronics*
- *3-axis stabilization*
- *1200 grams*

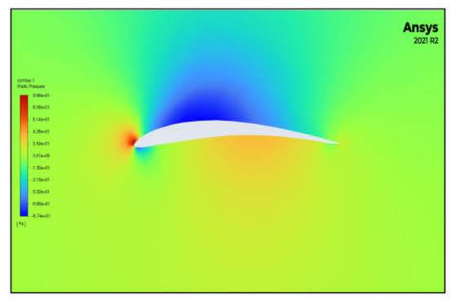
Final Design

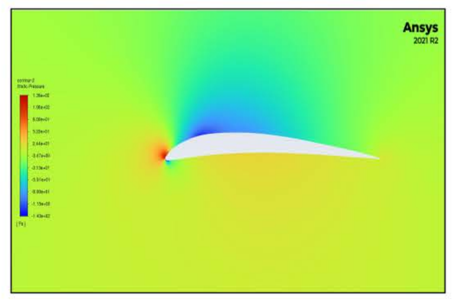


- Fully 3D printed with PLA+ and LW-PLA
- 3 channel control surfaces (Ailerons, rudder, elevator)
- SMART® and AS3X® Technology
- 1200 Grams

Airfoil Selection

In the early stages of this project, the team needed to select an airfoil which would provide sufficient lift while maintaining rigidity. The team performed fluid flow analysis using ANSYS across numerous geometries comparing their respective lift-to-drag ratios. As a result, the **SD7037 airfoil** yielded a desirable performance and was selected. Images from the analysis can be found below.





Filament Used

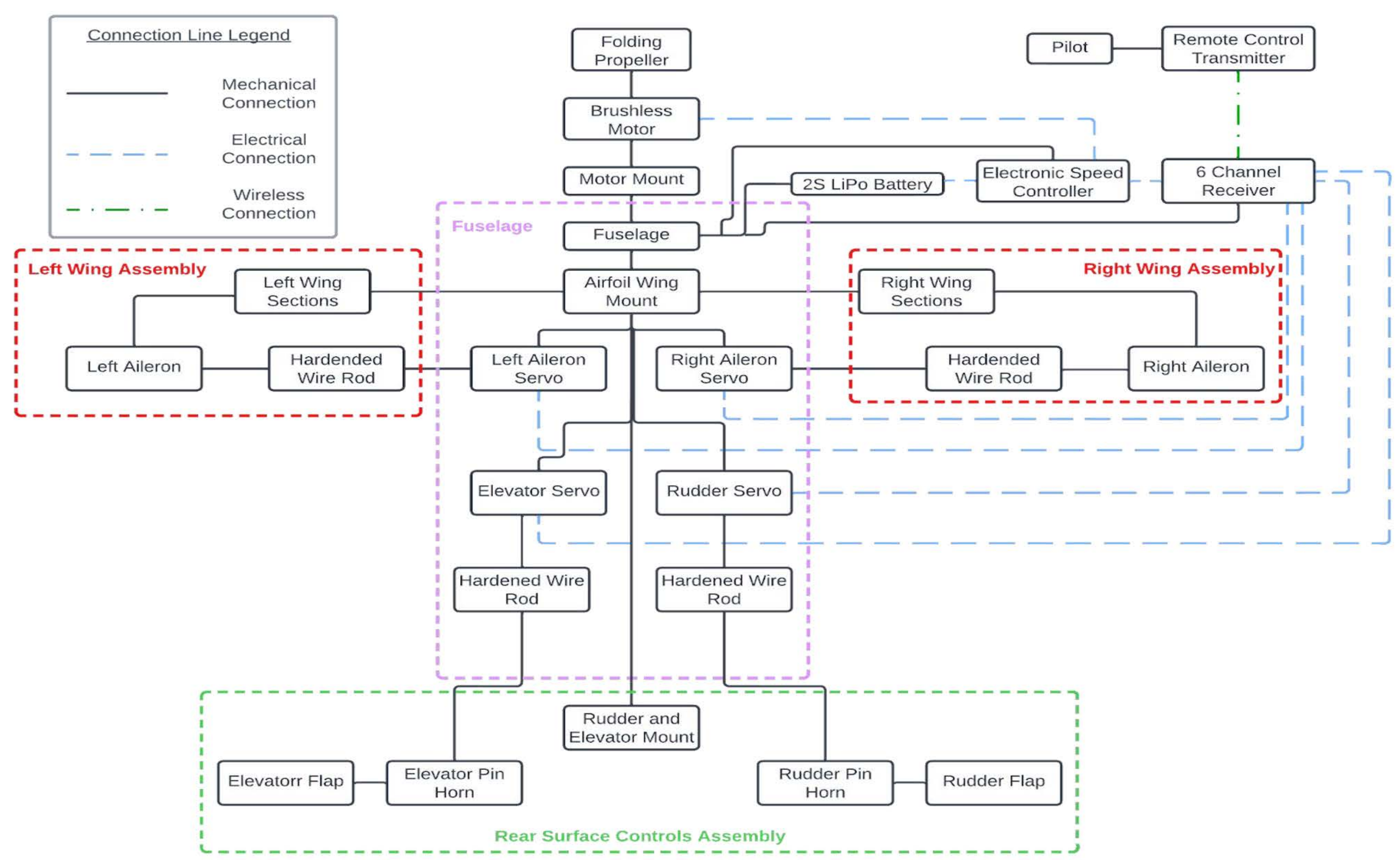
PLA+ - Similar to regular PLA but with better interlayer adhesion properties. Stiff/brittle but heavier than foam.

LW-PLA *(Light-weight PLA)* - As this special PLA passes through the hot nozzle, the filament foams up, ultimately reducing its density while maintaining similar dimensions. This filament resulted in a **60% weight reduction**.

TPU - TPU filament if flexible similar to a bike tire. TPU was used for the living hinges found between the control surfaces to provide sturdy and reliable support.

Carbon Fiber Infused Nylon - This special material is very rigid and lightweight. Which is optimal for the spars running through the length of the wing.

System Level Diagram



The system level diagram displays the connections between the various systems in the aircrafts designs.

- The two ailerons on the left and right wing are responsible for the aircraft's **roll.**
- The elevator is responsible for the aircraft's **pitch** or elevation change.
- Lastly, the rudder is responsible for the aircrafts **yaw.**

Wing Loading Test

To ensure that our wing design would be able to withstand the weight of the fuselage and forces experience during flight, the team performed a wing loading test. Weights were added evenly across the wingspan until the point of failure. The wing was able to withstand 2800 grams before breaking. Which is slightly over twice the weight of the aircraft. The test was successful.

Adjustable Wing Location

For an aircraft, a proper **center of gravity** is crucial. A helpful feature during the prototyping process was the adjustable wing location system. This allowed the team to adjust the center of gravity of the aircraft on the fly without having to add weights or print new parts.

Spring 2023