Modular Fixed-Wing Drone

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Introduction

This project was to provide a conceptual design for a modular fixed-wing drone that can be used in a multitude of applications that require different flight characteristics such as total lift and flight endurance. The analysis in our report was focused on modulating the wingspan of the drone to better suit the flight requirements of the mission at hand. Various subsystems and characteristics of the modular fixed-wing drone were analyzed during our project such as the airfoil, wing spar, propulsion, and flight performance. A prototype wing was also manufactured within the machine shop to test if the wing can be manufactured easily and consistently with the selected wing materials and airfoil cross-section size for our design. A wind tunnel model and wind tunnel test were also created to validate the published airfoil data that we used during our analysis.

Methods

To accomplish the project goal of formulating the conceptual design of a modular fixed-wing drone, five unique design and analysis subsections were created: creating a wind tunnel model and test, sizing and modeling the drone, conducting performance calculations, analyzing various subsystems, and prototype wing manufacturing.

Results

Through our analysis, we determined that the NACA 4412 airfoil would be the most efficient at lower speeds and easiest to manufacture. After completing a mass budget investigation, we modeled our drone with three different wing spans, four feet, six feet, and eight feet. We found that the payload weight could be increased by four pounds for every two feet added to the wingspan. Next, we completed a bending analysis on the wing to determine that a carbon fiber spar with an outer diameter of 0.731 inches and an inner diameter of 0.625 inches would be sufficient to support the loads faced in flight. From the propulsion analysis, we discovered that the optimal cruise velocity of our drone was approximately 70-75 mph and had a top speed of approximately 90-95 mph.

Finally, we were able to compute performance calculations on the drone including the stall velocity, take-off, and landing distances. The average stall velocity was around 27 mph for each of the three wing spans analyzed. The take-off distance increased from 16 feet to 33 feet and the landing distance increased from 179 feet to 221 feet as wingspan was increased. After completing the preliminary design, we constructed a segment of wing to determine an effective manufacturing technique.

Through our capstone report, we hope to show the viability of creating a modular, fixed-wing drone that can complete a variety of mission sets by providing a conceptual design as well as analyzing subsystems within the drone such as the wing spar and wing aerodynamics. During our project, we also developed a machining process to reliably and quickly manufacture wing segments for the drone, as well as perform a parametric analysis for varying flight performance characteristics.

Images

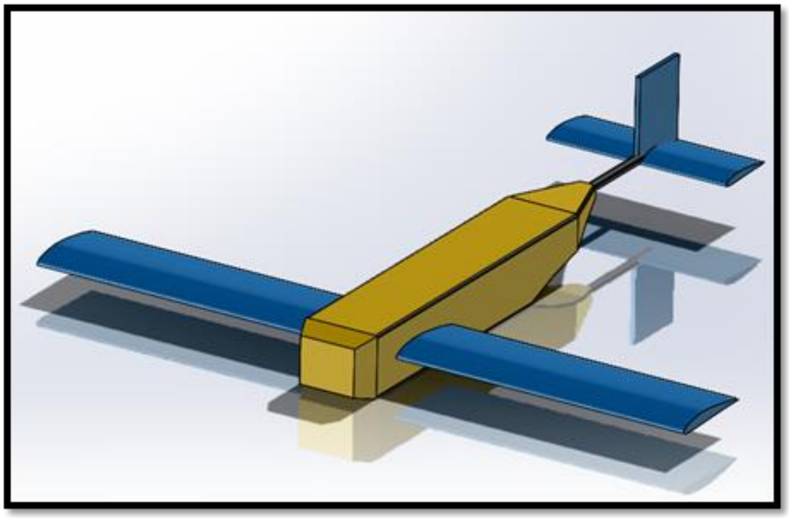

Figure 1: Image of SolidWorks Model

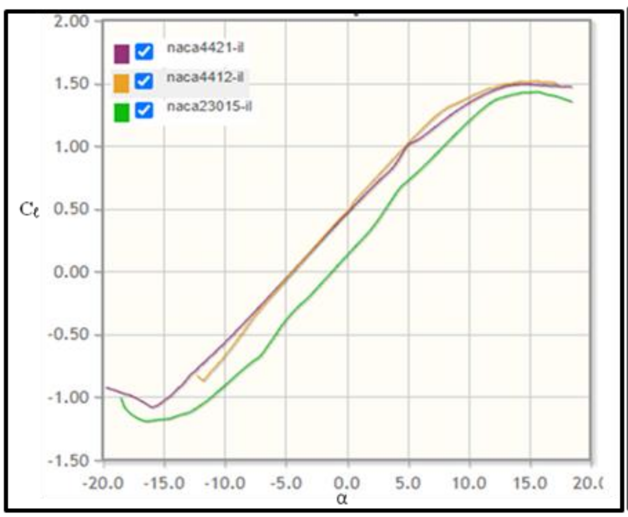

Figure 2: Lift Curve

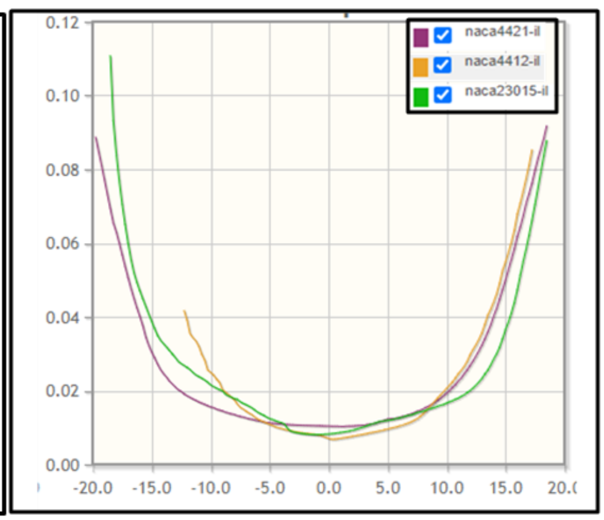

Figure 3: Drag Curve

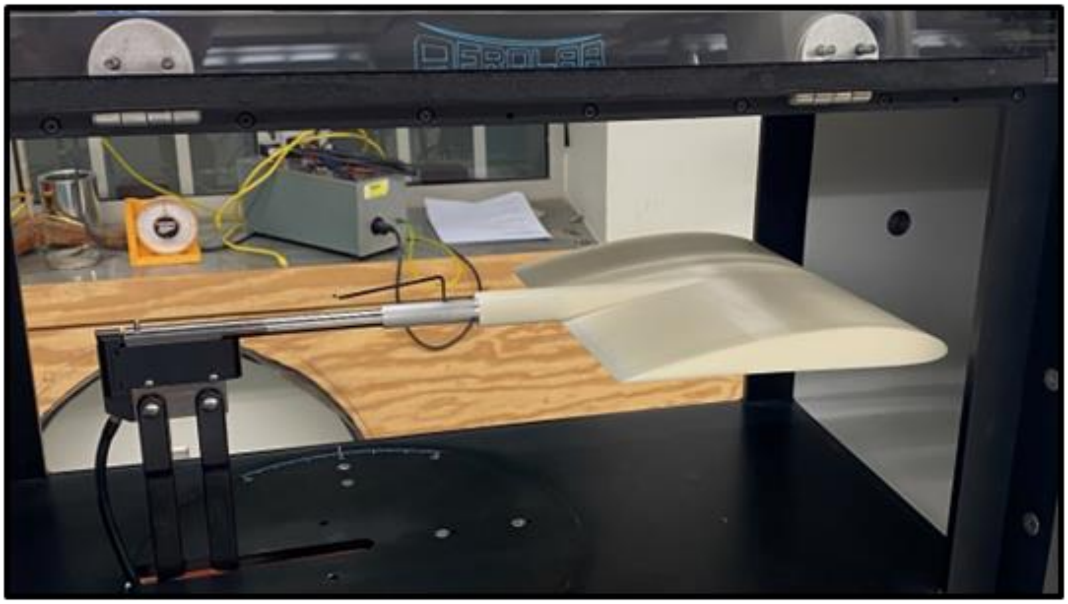

Figure 4: 3D Printed Airfoil in Wind Tunnel

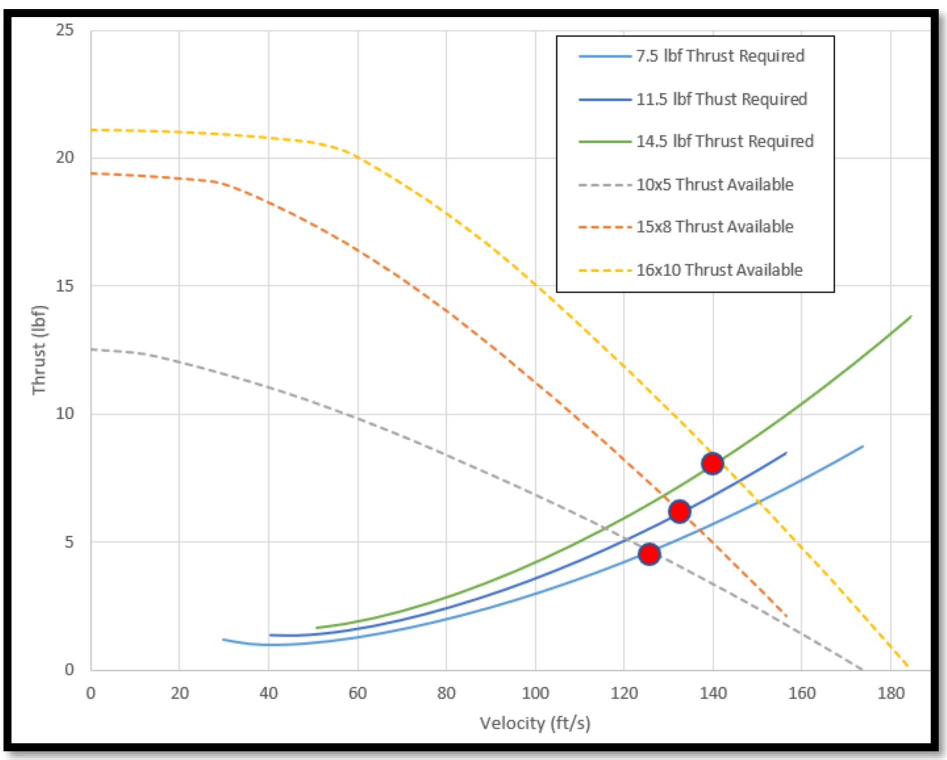

Figure 5: Thrust required and thrust available at different velocities

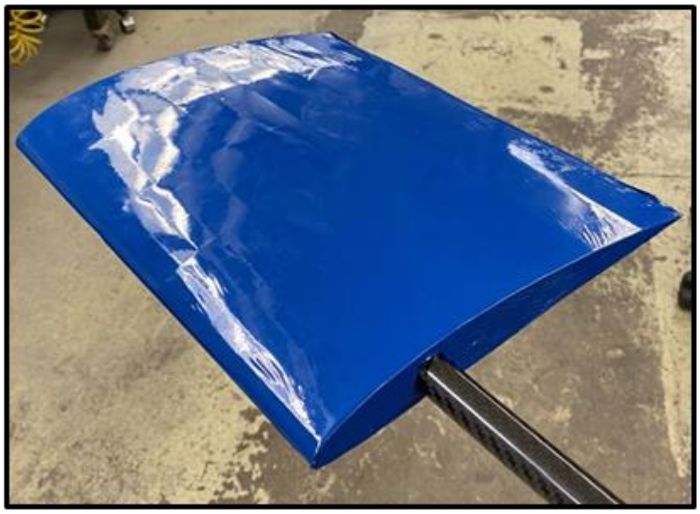

Figure 6: Manufactured Wing Section