SAE Aero Design Micro Class – Flapjacks #329

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SAE INTERNATIONAL

Introduction

The goal of this project was to create a micro aircraft capable of completing the following requirements in one academic year and compete in Van Nuys, California on April 5th at the SAE Aero Design West Competition [1]. The goal was to place in the top 50th percentile at competition and complete multiple test flights.

The requirements are as follows:

1. Must fit within box dimensions: 12.125"L X 13.875"W X 3.625"H
2. Must be electrically powered
3. Must be assembled within 3 minutes
4. Must be radio controlled
5. Payload is 2" PVC standard wall pipe
5 Carry a high payload-to-weight fraction

Initial Design

The first design utilized a Clark Y 11.4% airfoil. This airfoil. Figure 1 shows the first airfoil cross-section with final modifications.

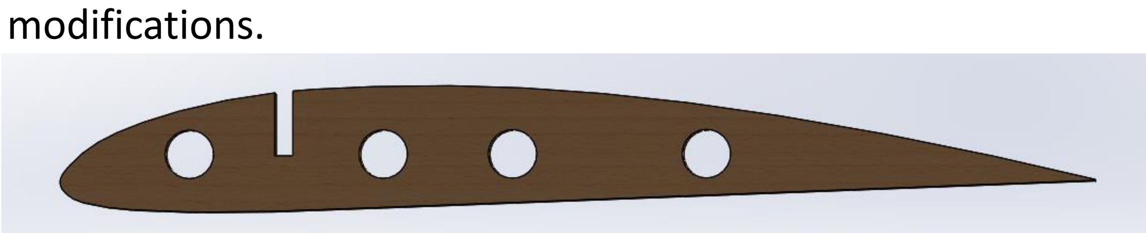

Figure 1: Airfoil cross-section with final modifications

SolidWorks was used to generate a computer aided design (CAD) model that approximated weight and center of gravity (CG). Figure 2 shows the aircraft that was taken to competition that was tested on a CG tester.

Figure 2: Center of gravity testing on the competition aircraft

The aircraft was tested in Flagstaff for a ground take-off which hindered the performance at competition. The aircraft flew in Flagstaff with this ground take-off approach but was unable to fly from a hand launch.

Final Design

After Competition: During competition, 4 flight attempts were made. In each of these flight attempts, the aircraft was unable to reach the speed required for total lift. The needed 1.2 pounds of lift was only reached at 30 mph with this airfoil.

New Design: A new airfoil was selected to generate greater lift at lower speeds. This new airfoil is a Selig S1223 airfoil that is used for high lift at low speeds. Figure 3 shows the S1223 airfoil.

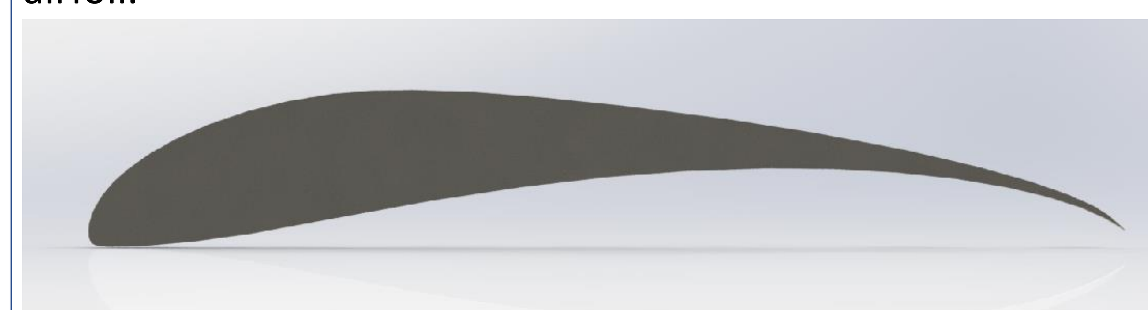

Figure 3: Selig S1223 Airfoil

The initial calculations showed that the lift between the Clark Y and the Selig were minimal. A re-calculation was done and showed that the lift greatly differed at various speeds. Figure 4 shows the lift comparisons.

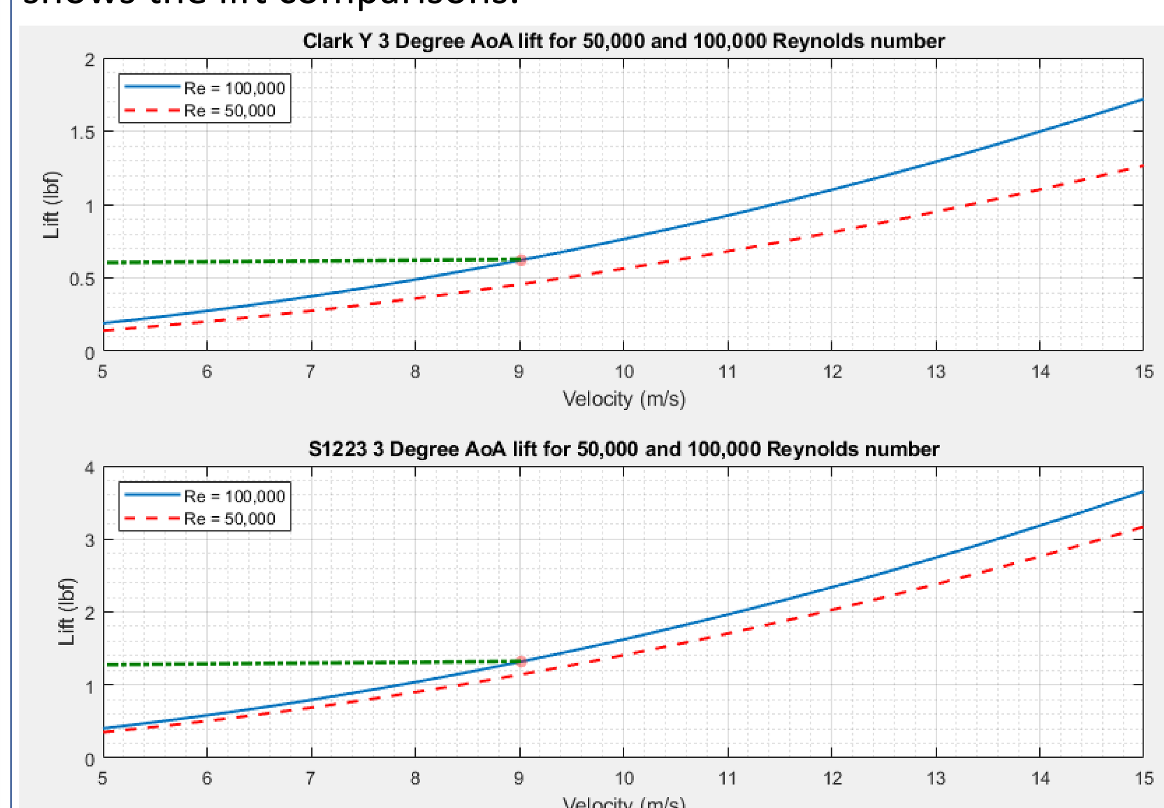

Figure 4: Comparison of lift between the two airfoils. The lift generated by the S1223 airfoil is 2x more than the Clark Y airfoil.

Based on the other competition aircraft, a dihedral was added to the aircraft. This dihedral increases aircraft stability by allowing the aircraft to roll back towards the center during turns. Figure 5 shows the SolidWorks CAD model of the final design with the dihedral effect.

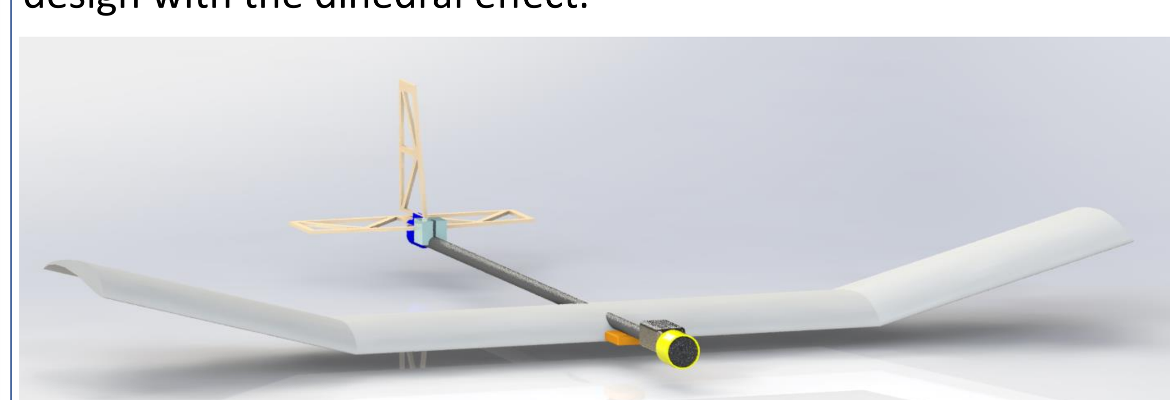

Figure 5: Final CAD design with dihedral

Manufacturing

First Design: The materials used for the first design included balsa and birch wood, aluminum, and 3D printed components. A laser cutter was used courtesy of the Coconino High School engineering group to cut the balsa and birch wood sheets. Figure 6 shows the laser cutter that was used with the wood pieces that were cut.

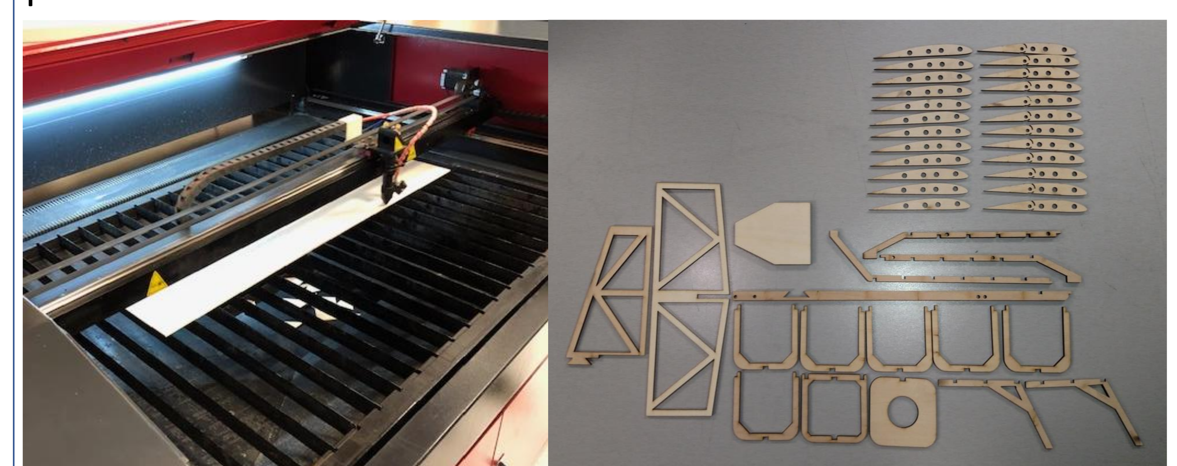

Figure 6: The laser cutter (left) and the pieces needed (right).

A material called Monokote was applied over the wood which acts like heat shrink and creates a hard, semi-flexible surface. The Monokote is the blue and yellow that is prominent in figure 2.

Aluminum inserts were created to connect the end wing sections to the middle section. This allowed the wing to be put together with minimal hardware. Figure 7 shows the aluminum inserts that slide over wooden dowels within the wing sections.

Figure 7: The aluminum inserts being turned on the lathe (left) and the inserts size compared to a standard pen (right).

Final Design: Due to the aircraft crashing at competition, new parts needed to be made to conform to the CAD model in figure 5. The parts that were needed for the new plane was a boom (fishing rod), mounts (3D printed), and a wing. Manufacturing of the wing involved foam cutting sections with a saw and then applying a fiberglass mesh to increase wing strength. A foam cut section is shown in figure 8.

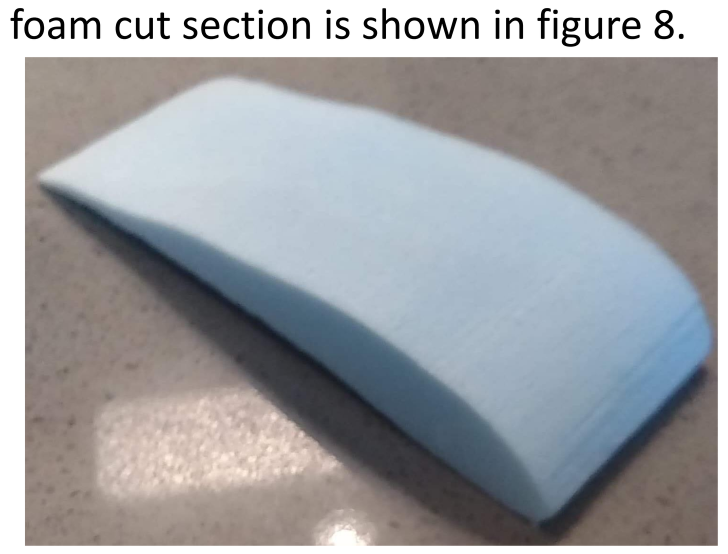

Figure 8: A 3" foam cut section of the S1223 airfoil.

Testing & Results

A ground take-off was performed on March 18th, 2019 and the initial design was able to perform a successful test flight. However, air properties at Van Nuys, CA (sea level) and Flagstaff, AZ (7,000 feet) have a significant impact on flight performance. This results in a roughly 20% decrease in performance at Flagstaff compared to sea level.

During competition in Van Nuys, California, the initial design attempted flight 4 times. Each of these flight attempts resulted in crashes at hand launch. Once returned from competition, the final design was implemented and constructed before the end of the academic semester. A flight was performed and completed in Flagstaff.

Conclusion

The initial design did not perform as expected and crashed 4 times at competition. This resulted in competition being a learning experience on how to construct a new micro aircraft.

From the learnings, a new airfoil was selected, a dihedral was implemented, and a new center boom was inserted. The final design was tested in Flagstaff with and without payload and resulted in completed test flights.

References

[1] *2019 Collegiate Design Series SAE Aero Design Rules.* SAE Aero Design. 2019. [E-Book] Available: http://www.saeaerodesign.com/cdsweb/gen/DocumentResources.aspx

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