SAE MICRO AERO DESIGN

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Abstract

Founded in 1905, The Society of Automotive Engineers (SAE) is a professional association that develops standards and promotes the growth of engineering in various fields. The SAE Collegiate Design Series hosts an annual aeronautics design competition where colleges all over the world design, build, and fly their aircraft with regulations provided by SAE. Examples of the restrictions for the micro class include a 10-pound weight limit, electric propulsion, and to be able to store the aircraft in a compact container. This year, SAE is hosting their competition in Fort Worth, Texas. The competition challenges students to think critically and to find the most optimized design that follows all constraints provided by engineering professionals. The competition consists of a written report, oral presentation, and aircraft performance. Northern Arizona University (NAU) has a design that could potentially win awards at the competition. The team explains the challenges faced from the early stages of design to the competition itself. The group details how challenges were overcome and how unconventional resources were used to make a competitive plane. After the competition, plenty of ideas were generated on how to improve upon the design of the aircraft. Key components are underlined in the following text describing changes that would be made if the team were to enter in the 2018 SAE Aero Design Competition.

SAE Requirements

SAE has three different classes for colleges to participate in: micro, regular, and advanced. Each class has requirements specified towards their project. The main requirements and restrictions for the micro class are listed below.

- **All parts must be able to fit into a container with a maximum cross section of 6 inches.**
- **Plane must be powered by a battery.**
- **No lead is allowed in any part of the plane.**
- **Fully packed container must weigh under 10 pounds.**
- **Must have a payload bay with exact dimensions of 1.5 x 1.5 x 5 ± 0.1 inches**
- **Must have arming plug attached 40%-60% from the nose of the plane**
- **Must have university name and team number on the inside or outside of the aircraft, on the top and bottom of the wing, and on both sides of the tail**

Engineering Design

Design Approach

Early Stages: In the early stages of the team's design process, a square wing design, three-surfaced design, and a flying wing design were the primary options to begin with [2-4].


Figure 1: Square Wing

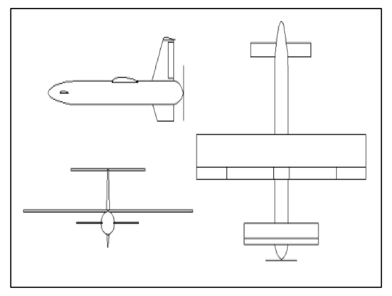
Figure 2: Three-Surfaced


Figure 3: Flying Wing

The team selected the square wing since it would be the easiest to be able to take apart and fit in the container. The team believes that they could make the lightest design out of the square wing.

Intermediate Stages: The team researched and selected specific components for important parts of the plane including the airfoil, motor, battery, and propeller.

Table 1: Selected Components

Component	Selection
Airfoil	NACA GOE 430
Motor	NEMA GM33Y-3612200
Battery	1300 mAh
Propeller	12 in x 6 °
Wing/Tail/Rudder Material	Foamular insulation

During the competition, numerous other teams and judges commented on using foam for the wings and tail. The team decided to use the Foamular insulation. Foamular is a compacted foam that is sturdy but a little heavier than most foams. For the competition, the team agreed that having sturdier wings was more important than having lightweight wings.

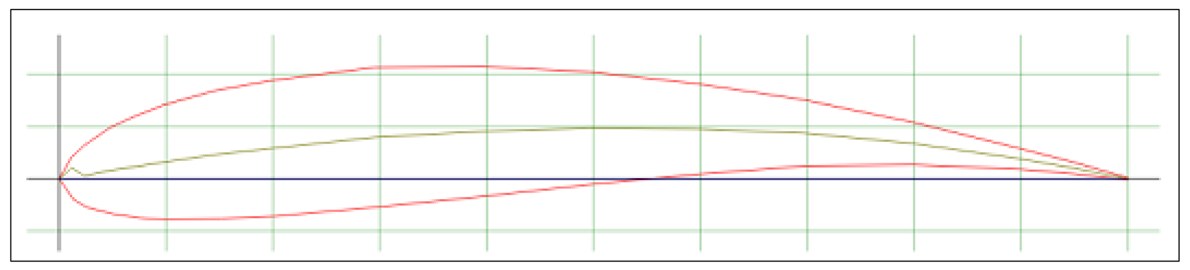
Figure 4: NACA GOE 430 Airfoil

Figure 4 displays the GOE 430 Airfoil that the team used for the foam wings. This particular airfoil is excellent for low speeds and carrying high loads. The team knew that this airfoil would be optimal for the design challenge provided by SAE.

Final Stages: The team added final touches including 3D printed body improvements, landing gear, tail mount, and the fuselage.

Manufacturing

The team's primary manufacturing tools were a custom made hot wire cutter and 3D printing. The team made the hot wire cutter out of wood, wire, and springs. The cutter was powered with a car battery. Figure 4 displays the hot wire cutter. The team used this primarily to make the wings of the aircraft.


Figure 4: Hot Wire Cutter

Northern Arizona University has multiple 3D printers in Cline Library. The team utilized the printers to make the body and the tail mount of the aircraft. The team believed that 3D printing was the best option because the team can get accurate sizing using the printers. Since the payload bay must have specific dimensions, the printers made it easy for the team to follow that requirement. Figure 5 and 6 display the body and the tail mount, respectively.

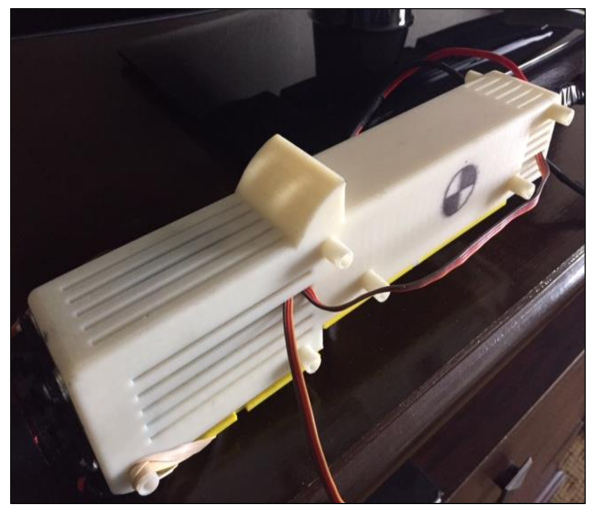
Figure 5: 3D Printed Body

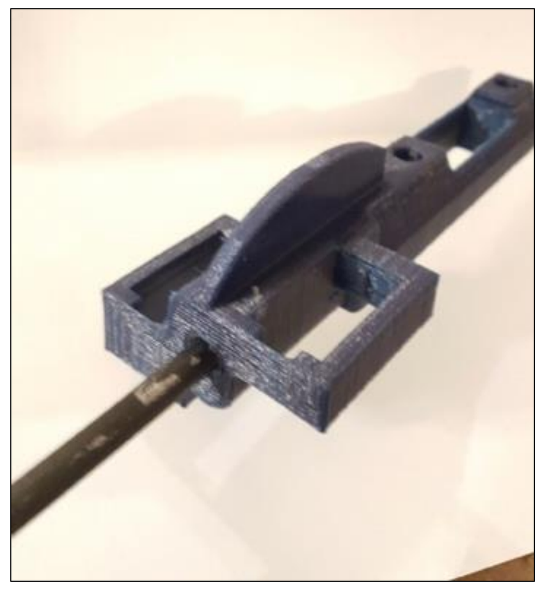
Figure 6: 3D Printed Tail Mount

Final Design

Figure 7: Final Design

Testing/Results

The team tested the plane on February 27, 2017 in order to be ready by the competition on March 10. The team did the testing in Flagstaff, Arizona. The main differences between Flagstaff and Fort Worth was the elevation. Different elevations have different temperatures, pressures, and densities, causing different flight results. The team was successful in testing in Flagstaff.

Table 2: Properties differences in Flagstaff and Fort Worth

Property	Flagstaff, Arizona	Fort Worth, Texas
Temperature (°F)	25	45
Density (lb/ft^3)	0.058	0.074
Pressure (psia)	11.3	14.4
Wind Speed (mph)	13	29

During the competition, the aircraft's power source became disconnected during the first flight. The aircraft crashed nose first and broke the wing, tail mount, and the propeller. The team attempted to epoxy broken parts as a quick fix for following flights. Upon evaluation, the epoxy added extra weight towards the tail effectively throwing of the balance of the plane. Following the crash, the team was unable to record a successful flight.

Conclusion

Proceeding the SAE Aero Design competition, multiple adjustments were made to the final design for improvement. The carbon fiber rod used to connect the fuselage to the tail mount was changed from two rectangular rods to a circular rod. The tail mount itself was changed to include a round stopper on the bottom to prevent servo interference during landing. The team did more testing following the competition and was successful.

References

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