Team Final Approach

20F12: A2 Aero Micro

Midpoint Presentation

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Project Description

- The Aero Micro capstone is based upon the SAE Aero Micro competition.
- The goal of the competition is to design a micro airplane that flies an air circuit while carrying maximum payloads, taking off from a small platform, and completing a portion of the circuit as fast as possible [1].
- The team recently dropped out of competition due to changes in the competition timeline.
- With the drop from competition, the team is looking to make changes to optimize the plane as if the competition was happening, while working to design and implement optimizations for the following years teams including the design and construction of thrust and lift/drag test stands.

Figure 1: SAE aero design logo (note that the date has not been updated by SAE to the actual competition date)

Design Description - Overview/Fuselage

- Main design of craft is standard, single-motor monoplane.
- Large fuselage design to carry maximum amount of a cargo, in a designated, pre-dimensioned cargo container.
    - The cargo container within the fuselage has dimensions of 6”x6”x4.5”
    - Cargo must be secured within fuselage and must not sustain damage at any time.
- Constructed out of foam board and balsa wood for minimized weight, strength, cost, and ease of manufacturing.

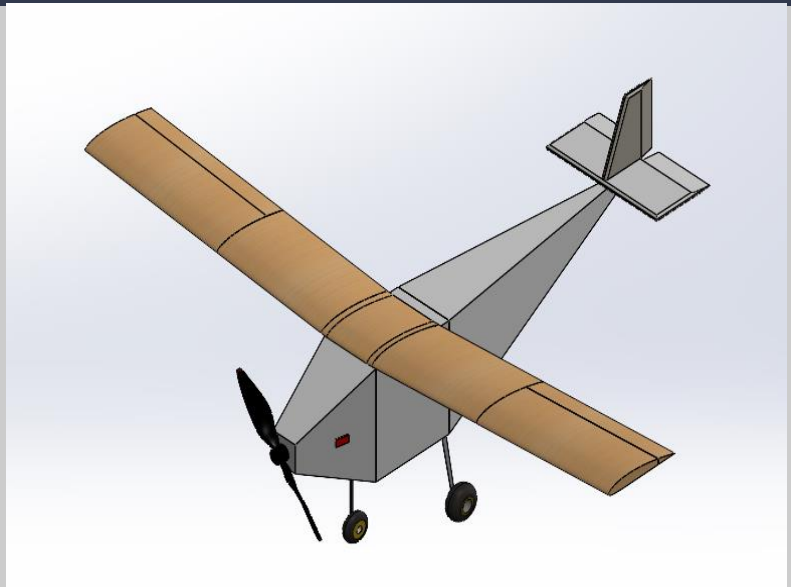

Figure 2: CAD Model of Completed Prototype

Design Description–Wings/Landing Gear

- Wings of the craft were constructed out of balsa wood and foam board for their light weight, high strength, and ease of manufacturing.
- Wings have been constructed with a wingspan of 47.5” to be within 0.5” of the competition limit of 48”.
- Dihedral has been added to the airfoil to increase stability of the craft during flight.

- Landing gear is set in a tricycle configuration (one wheel in front and two behind).
    - Rear wheel set is located just behind the center of gravity and lone front front wheel is located
- Landing gear is constructed out of lightweight aluminum with with 2.75” diameter rubber wheels.

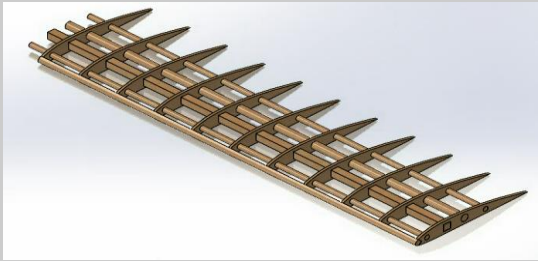

Figure 3: CAD Model of Unwrapped Wing

Figure 4: Rear Landing Gear

Design Description–Drive System

- Selection of a new motor and propellers were made to match the regulations of the competition.
- With the elimination of the 450-Watt power limiter from the craft, a smaller motor was needed to simulate competition conditions.
    - Flite Test "Radial" 2218B 1180kV Brushless Motor was selected for its lighter weight and peak wattage use of 400-Watts compared to the 850-Watts of the previous motor.
- A Larger propellor was selected for increased thrust and reduced speed.
    - A slow-flying propellor with a diameter of 10” and a pitch of 4.7”, 1” greater diameter than the previous propellor.
- A new 4-cell 2300mah 14.8-Volt battery was chosen for its reduced weight and smaller dimensions, compared to the previous battery.

Figure 5: Flite Test “Radial” 2218B 1180 kV Brushless Motor [2]

Figure 6: 10” x 4.7” Slow-Flyer Prop [3]

Current State of System

- Main materials: foam board, balsa wood, and plywood
- Clark-Y airfoil with dihedral
- Battery eliminating (SBEC) circuit
- 4s 45C 14.8V/2300mAh Battery
- 1180KV Motor
- 10” x 4.7 Propeller
- 184.875 cubic inch Cargo bay
- 2.47 lb. (NO plates)

Figure 7: Current State of System

Figure 8: Front Sub-assemblies

Current State of System: BOM

Table 1: Aircraft Bill of Materials Purchased Items

Item Description	Quantity	Cost Per Unit
ArmSafe Kit w/ 12AWG Wire (Max 80 Amps)	1	$14.50
Balsa wood (rectangular profile)	2	$2.99
Balsa wood (circular profile)	5	$0.69
Dollar General Foam Board	16	$1.00
Dubro Shock Absorbing Steerable Nose Gear	1	$6.99
E-Flight T-28 Nose Landing Gear Set	1	$3.99
Flite Test FT 35A ESC w/XT-60 Connector	1	$25.99
Flite Test 2.75" Airplane Wheels (2)	1	$6.99
Flite Test 16.5" Pushrods (8)	1	$6.00
Flite Test "Radial 2218B 1180Kv Brushless Motor	1	$29.99
HD Prop 10x4.7 Slow Flyer Propeller	3	$4.99
Tattu 4s LiPo Battery 45C (14.8V/2300mAh) w/ XT-60	1	$39.99
	Total:	$148.85

Figure 9: Thrust Test Stand [4]

Current State of System: Notable Action Items

Tyler Darnell:
Servo analysis, SolidWorks updates, wing and airfoil design, and E-drawing implementation.
Colton Farrar:
Vertical and horizontal tail design, airfoil rib and spar design, outer wing assembly, glued foam board pieces, landing gear FEA
Zachary Kayser:
Practice flying with Flagstaff Flyers, Inner-Airfoil Assembly, round profile spar 3D printed joint braces, Soldering final circuit, Arming Plug installation, Delivery Box Assembly, and Rear Landing gear installation.
Thomas O'brien:
Researched power plant, assisted in assembly of tail, fuselage, landing gear, nose, airfoil, and servo installation.
Daniel Varner:
Website Development, Airfoil Test Stand Evaluation, Thrust Stand Evaluation.

Implementation Plan

- Manufacturing taking place at Tim Kelly's residence.
- Team will continue to laser cut foam board for constructing plane and hot glue/super glue all components together.
- Using SolidWorks and LightBurn to design plane and all other components (cargo box, payload plates).
- Manufacture any additional components to continue test flights.

Table 1: Manufacturing Plan

Step #	Item
1	Design in SolidWorks
2	Send files to LightBurn
3	Laser cut foamboard
4	Glue ribs & spars for wings
5	Fold and glue pieces
6	Wire and glue all servos & connecting rods
7	Bind avionics
8	Secure motor/propellor
9	Attach landing gear to fuselage
10	Insert battery, ESC, etc.
11	Secure wings on top of fuselage

Implementation Plan - Future Action

- Tyler - CAD model, airfoil testing
- Colton - New wings, new tails
- Zach - Further develop piloting skill, wiring/soldering
- Thomas - New fuselage, connecting servos
- Daniel - Airfoil testing, adjustments to avionics

Figure 10: Simplified Airfoil Test Stand [5]

Testing Plan

- The team will require delivery boxes, and metal plates for cargo to simulate competition procedures.
  - Boxes have been laser cut out of foam board to match the dimensional specifications of the competition.
  - Metal plates will be fabricated to meet the weight specifications of the competition.
- For location the team will use the Flagstaff Flyers Airfield
  - Mock competition flights will be conducted following the procedures and regulations listed in the competition rules.
  - Incremental weight increase will allow the team to measure changes in performance and safely monitor the design limitations of the craft.

Testing Plan

- Thrust, drag, and lift test stand
  - To assist next years team the team is investing in developing test stands
  - First a stand to assess the thrust of a teams motor.
    - A thrust stand is being purchased
  - Second a stand to test the lift generated from an airfoil.
  - Thirdly a stand to evaluate drag will be constructed
    - Both the lift and drag stands will utilize strain gauges or load cells

Figure 11: Thrust Test Stand Backside and Data Ports[4]

Conclusion

- While the team is disappointed that the competition was changed so suddenly, the hope is that the work completed in the remaining 8-9 weeks will benefit rising seniors.
- The final changes to the airplane should give upcoming capstone teams a plane to analyze and fly before building their own.
- The test stands should give the upcoming seniors the ability to test their motor and wings before implementing them.
- In conclusion, while the the project has taken many turns throughout, the overall results have been satisfactory and should leave a great foundation for those to come after us.

Figure 12: Current prototype before test flights on 2/21/2021

Thank you!

- The team will now take questions as the powerpoint cycles through the references, appendices and a video of the first test flights of the airplane.

References

[1] "2021 - SAE Aero Design - Rules," SAE International, 21 Sept. 2020. [Online]. Available: https://www.saeaerodesign.com/cdsweb/gen/DocumentResources.aspx (Accessed: Feb. 28th, 2021).

[2] W. Broderick et al., "Flite Test "Radial" 2218B 1180kV Brushless Motor," *Flite Test*. [Online]. Available: https://store.flitetest.com/flite-test-radial-2218b-1180kv-brushless-motor-flt-3036/p846362?gclid=CjwKCAiAm-2BBhANEiwAe7eyFL_zEOfcsPf9ybMYLj5iwC5whbQaSxeWGm5k7Xn7HCODWpnbhNtRgBoCni0QAvD_Bw. (Accessed: Feb. 28th, 2021).

[3] "Slow Flyer Propeller,10 x 4.7 SF," *Modeler's Depot*. [Online]. Available: https://modelerdepot.com/slow-flyer-propeller-10-x-4-7-sf/?sku=10047SF&gclid=CjwKCAiAm-BBhANEiwAe7eyFFf4kr9tLm41LKCOtna7gR2nkILpjU3sqsFBqXBEn3LkxKpTZ0cPacxoC794QAvD_BwE. (Accessed: Feb. 28th, 2021).

[4] Banggood.com, "Racerstar Brushless Motor Thrust Stand V3 For 11mm-59mm Outrunner Motor," *www.banggood.com*. [Online]. Available: https://usa.banggood.com/Racerstar-Brushless-Motor-Thrust-Stand-V3-For-11mm-59mm-Outrunner-Motor-p-1168758.html?cur_warehouse=CN (Accessed: Feb, 28th, 2021).

[5] "Wing Test Stand," *PITSCO EDUCATION*. [Online]. Available: https://www.pitsco.com/Wing-Test-Stand. (Accessed: Feb. 28th, 2021).

Appendix A -Bill of Materials (purchased)

Item Description	Quantity	Cost Per Unit
ArmSafe Kit w/ 12AWG Wire (Max 80 Amps)	1	$14.50
Balsa wood (rectangular profile)	2	$2.99
Balsa wood (circular profile)	5	$0.69
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Tattu 4s LiPo Battery 45C (14.8V/2300mAh) w/ XT-60	1	$39.99
	Total:	$148.85

Appendix B - Bill of Materials (free of charge)

Item Description	Quantity	Cost Per Unit
Apex RC Products #1030 "Y" Harness (3)	1	$0.00
Control Surface Control Horn	4	$0.00
Plywood (1/8" Thick)	1	$0.00
Plywood (1/4" Thick)	1	$0.00
Rear Landing Gear	2	$0.00
Spectrum DX 8e Transmitter	1	$0.00
Spektrum Receiver	1	$0.00
XT-60 (Female) Connector	1	$0.00
9g Servo	5	$0.00
	Total:	$0.00

Appendix C - First Test Flights