Team Final Approach

20F12: A2 Aero Micro

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Project Description

- SAE Aero Micro Class Competition: Teams must design and build an electric remote control aircraft that is able to have a sustained flight with a payload while having the lightest aircraft weight possible [1].
- Team Objectives:
  - Design and build an aircraft that is able to have a sustained and controllable flight with added payload.
  - Must achieve the highest payload to dry weight of aircraft ratio possible.
  - Must be simple in design for maximum efficiency in assembly (Must be under three minutes, but more points for faster assembly) and easy repairs or alterations.
  - The team aims to achieve the greatest power to total dry weight of the craft, in order to be able to carry the maximum possible payload, safely and sustainably.

Figure 1: 2020 SAE Aero Competition Logo [2]

Project Description: Stakeholders & Importance

- This project is solely sponsored by the College of Engineering, Informatics, and Applied Sciences (CEIAS).
  - The CEIAS will provide us with the funding need for parts and materials and the Flagstaff Flyers will guide us in the design and flying practice for our pilot.
  - The team has and will continue to received the guidance and expertise from members of the Flagstaff Flyers in their extensive knowledge in the field of remote-controlled aircraft, making them a stakeholder.
  - Other important stakeholders are NAU as a whole, Dr. Trevas (faculty contact), the SAE clubs at NAU, and all members of the team.

- Importance:
  - The concept of aircraft weight to payload ratios is extremely important to airlines as the lighter their aircraft are, the more fuel efficient they are, which saves them a great deal of money and allows for further flight ranges.
  - Additionally, innovations at a micro level can sometimes be applied at a larger scale, which makes this competition a strong source of aircraft innovation.

Background/Current State-of-the-Art

- Previous teams have used extremely lightweight and strong materials to receive the best overall score. Many use a typical airplane design (as we intend to do), but there are also interesting approaches to the design, as seen in Figure 1(a complex design used in previous competitions).
- The issue with the typical airplane design is the lack of flight control, which results in a crash and damaged plane. The team intens to fix this issue by focusing on weight distribution and ensuring the rudder does not lose functionality during flight.
- Some concepts the team will be using is the idea of a door and a hinge to control the rear tail/rudder, as well as the bio inspired concept of maximizing the aerodynamics similar to a bird's wings.

Figure 2: Previous Competition Design [3]

Customer Requirements

- The Micro Aero project is a competition project, and thus the customer requirements come from the rules governing the project.*
- The following are the priority customer (competition) requirements of the SAE Aero Micro project:
  - The aircraft must be assembled in 3 minutes or less
  - All pieces of the aircraft must fit within the desired container dimensions.
  - The aircraft must possess the capability to carry a payload of a piece of pvc pipe.
  - The aircraft must be launched via hand.
  - The aircraft must possess the capability to navigate a designated obstacle course.
- Due to the nature of competition projects, the customer requirements from the rules are all high priority, and thus no ‘nice to have’ needs arise.
  - *The rules for the 2021 competition are yet to be released, therefore the customer requirements are derived from the 2020 rules which are likely to remain unchanged.

Table 1: Customer needs from QFD.

Design Requirements / Customer Requirements	Importance
Assembly time	3
Size of Craft(fits in contianer)	9
Carries a payload	9
Hand Launch	3
Flight Time	9

Engineering Requirements

Using the Customer Requirements derived from the 2020 SAE Micro AERO rules and regulations a list of design requirements necessary to meet customer needs is generated within a QFD. This information has been reformatted into Table 2.

The engineering requirements list, for applicable engineering requirements, includes both the units the requirement will be measured in as well as the target value each engineering requirement must meet in order to meet the customer requirements.

Table 2: Engineering Requirements

	Engineering Requirements	Units	Target
1	Volume	[in^3]	<557.5
2	Assembly Time	[Minutes]	<3
3	Cost	[US Dollars]	<1,500
4	Battery	[cells] & [mAh]	<= 3 & 2200
5	Material Selection		
6	Durability		
7	Packaged Weight	[lbs.]	<10
8	Range	[ft.]	>400
9	Flight Control		
10	Ground Control		
11	Radio Control	[GHz]	2.4
12	Identifying Marks		
13	Lift	[lbs.]	>10
14	Thrust	[lbs.]	
15	Drag	[lbs.]	
16	Fail Safe		
17	Red Arming Plug		
18	Restoration		

Engineering Requirements – Cont.

- The Engineering Requirements were mapped to customer requirements in the QFD shown in Appendix A. Some basic mapping are as follows:
  - Size of Aircraft maps to engineering requirements such as material selection, volume, and even durability.
  - Carries Payload maps to engineering requirements such as thrust, drag, lift, weight, and others.
- Table 3 shows the units of each requirement which are how certain requirements are quantified. For those that have no units, they may be quantified in other ways such as:
  - Durability: Number of Flights before failure
  - Fail Safe: Pass or Fail

Table 3: Select Engineering Requirements and their importance.

Volume	Assembly Time	Cost	Battery	Material Selection	Packaged Weight
3	9	1	1	3	1
9	3	9	1	1	3
3	1	3	3	3	3
1	1	3	3	1	3
1	1	9	9	9	9
129	75	201	129	129	147
7%	4%	11%	11%	11%	8%
557.5	3	1,500	3 & 2200		10
in^3	min.	$	cells & mAh		lbs.

Conclusion

- The concept of the project is fairly straightforward: design a fixed wing micro airplane that carries the largest payload possible while also being as light as possible. However, this simple concept comes with many requirements.
- The customer requirements are derived from the competition rules and regulations, and this simple list has allowed the team to develop many engineering requirements that must be satisfied.
- The team will continue work on the project, using the background, customer requirements, and engineering requirements to drive the further steps of the project.

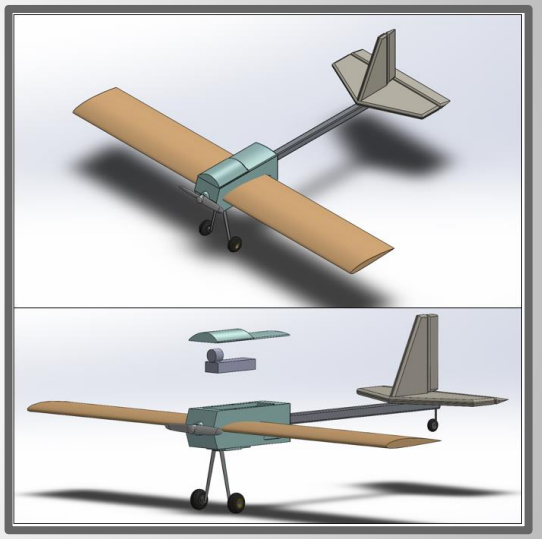

Figure 3: A preliminary design created from the EGR 386 Aero Micro Team [4].

Works Cited

[1] "SAE Aero Design West - SAE Aero Design West," SAE International ®, 10-Sep-2019. [Online]. Available:
https://www.sae.org/attend/student-events/sae-aero-design-west/about.

[2] "SAE Aero Design West." SAE International. [Online]. Available:
https://www.sae.org/attend/student-events/sae-aero-design-west/

[3] N. Pomerleau, "Micro Aircraft Competition Design " [Online]. Available:
https://www.neilpomerleau.com/posts/micro-aircraft-competition-design/.

[4] C. Farrar, et al. "Final Design Proposal for SAE Aero Micro", Northern Arizona University, Flagstaff, AZ,
USA. March 2020.

Appendix A: QFD

Design Requirements / Customer Requirements	Importance	Volume	Assembly Time	Cost	Battery	Material Selection	Packaged Weight	Durability	Range	Flight Control	Ground Control	Radio Control	Identifying Marks	Lift	Thrust	Drag	Fail Safe	Red Arming Plug	Restoration	Customer Competitive Assessment				
																				1 Worst	2	3	4	5 Best
Assembly time	3	3	9	1	1	3	1	1	1	1	1	3	1	1	1	1	3	9	1					
Size of Craft(fits in contianer)	9	9	3	9	1	1	3	1	3	1	1	3	1	1	1	1	1	3	1					
Carries a payload	9	3	1	3	3	3	3	1	3	1	1	1	1	9	9	9	1	1	1					
Hand Launch	3	1	1	3	3	1	3	3	3	9	3	3	1	3	3	3	1	3	1					
Flight Time	9	1	1	9	9	9	9	3	3	3	3	3	1	9	9	9	1	1	1					
Technical Importance: Absolute		129	75	201	129	129	147	57	93	75	57	81	33	183	183	183	39	81	33					
Technical Importance: Relative		7%	4%	11%	11%	11%	8%	3%	5%	4%	3%	4%	2%	10%	10%	10%	2%	4%	2%					
Target Value		557.5	3	1,500	3 & 2200		10		450			2.4		40	20	5								
Units		in^3	min.	$	cells & mAh		lbs.		ft.			GHz		lbs.	lbs.	lbs.								