# Team Final Approach

## 20F12: A2 Aero Micro

Concept Generation and Evaluation

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# Project Description

- SAE Aero Micro Competition: Design and construct a remote controlled airplane that is able to have a sustained flight while carrying the lightest aircraft weight possible.
- Teams are scored on the raw weight of the airplane and the weight of the payload it is able to carry.
- Restrictions include being less than 10 lbs. and the disassembled plane fitting within the specified-volume competition container (12.125 in X 3.625 in X 13.875 in).


**Figure 1: 2020 SAE Aero Competition Logo [1]**

# Project Description - Black Box Model

- Figure 2 shows a simple black box model for a flying airplane.

- Important Inputs: Power, Human Force (hand launching), Plane Components, and signals to control speed, direction.

- Important Outputs: Full RC Plane, Movement, and Energy Outputs (heat, noise, propellor rotation).

- Material inputs helped determine important components to evaluate.

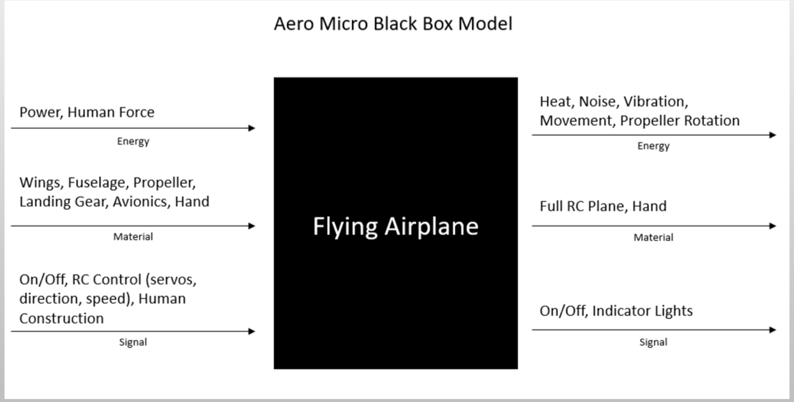


**Figure 2: Black Box Model of Flying Airplane**

# Project Description – Functional Decomposition

- Figure 3 shows simple Functional Model of Design
- All Material components combine to create a flying plane.
- Helped to show how each component interacts.

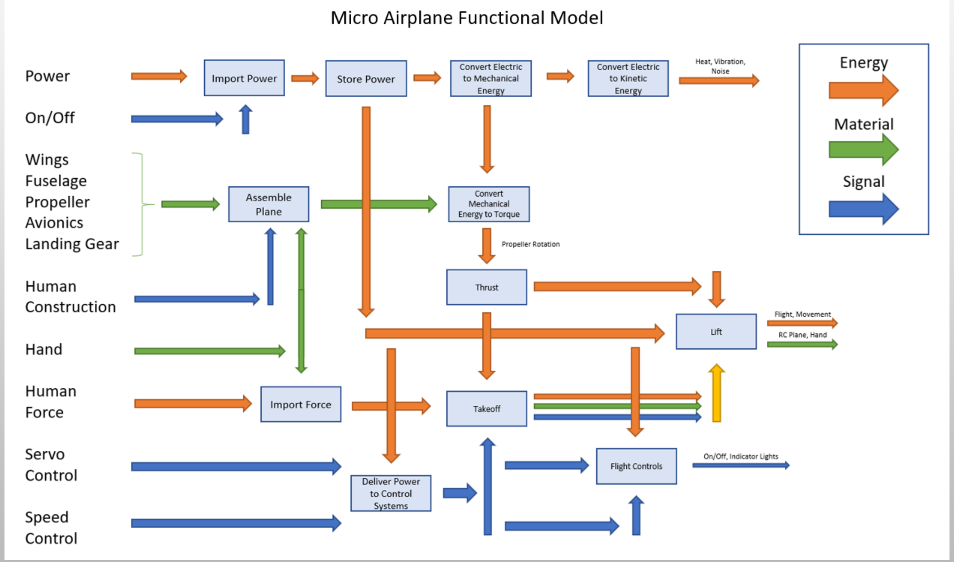


Figure 3: Functional Decomposition of Flying Airplane

# Concept Generation

- Concepts were generated by examining the competition/engineering requirements. If the concept met all requirements, research was done through online forums and the Flagstaff Flyers.
- Visited the Flagstaff Flyers airfield to see hands-on RC airplanes in order to generate our own concepts that are similar to their proven ones.
- Preformed State of the Art reviews of RC airplanes and full size aircraft to understand current proven techniques and how we can apply ideas to our own.

# Concept Generation - Considered Designs

Figure 4: Conventional Aircraft [2]

Figure 5: Flying Wing [3]

Figure 6: Unique Design [4]

- Conventional is proven and simple, but there is very little creativity.
- Flying wing has very simple manufacturing, but it lacks control and stability.
- Unique allows for extreme creativity, but there is a high risk the design doesn't fly properly.

# Concept Evaluation - Airfoil

- Four Main Classes of Airfoil: Symmetrical, Semi-Symmetrical, Flat Bottomed, and Undercambered

- Decision Matrix used to determine best airfoil class:
  - Maximum Lift is the highest weighted criteria, followed by maneuverability.
  - Flat Bottomed and Under-Cambered airfoils are the highest weighted total in decision matrix, since they provide the best lift possible.

**Table 1: Decision Matrix of Airfoil Selection**

| Airfoil Selection Decision Matrix | | | | | |
|---|---|---|---|---|---|
| Criteria | Weight | Symmetrical | Semi-Symmetrical | Flat Bottomed | Undercambered |
| Maximum Lift | 0.5 | 1 | 2 | 4 | 5 |
| Minimal Drag | 0.1 | 3 | 3 | 2 | 1 |
| Maneuverability | 0.3 | 4 | 4 | 3 | 1 |
| Ease of Creation | 0.1 | 3 | 3 | 4 | 3 |
| Total: | 1 | 11 | 12 | 13 | 10 |
| Weighted Total | | 2.3 | 2.8 | 3.5 | 3.2 |

# Concept Evaluation - Airfoil

- Two Airfoils to Consider: Flat Bottomed and Undercambered
- Data shows undercambered airfoils are provide much more lift, but what do the experts think?
- Flagstaff Flyers (RC group in Flagstaff) all recommend using flat bottomed airfoils, since they provide much more mobility.
- The Clark Y [5] flat bottomed airfoil will be used since it provides strong lift and maneuvers well enough that the team can actually get it in the air.

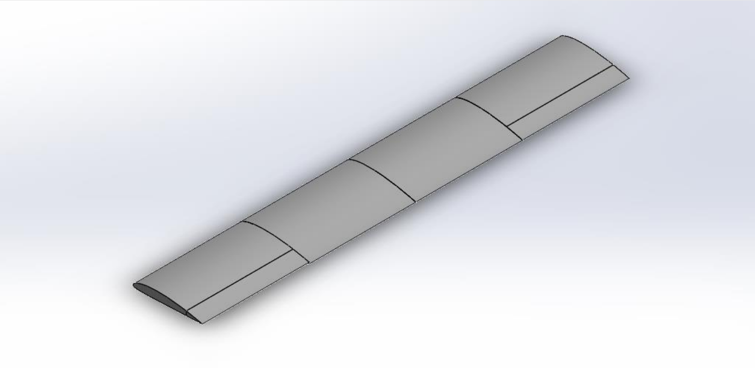

**Figure 7: CAD Model of Clark Y Airfoil**

# Concept Evaluation - Tails

**Table 2: Decision Matrix of Airplane Tail Designs (Designs Found in Appendix A)**

| | | Conventional | | T-Tail | | Cruciform | | Dual | | Boom | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Criteria | Weight | Rating | Weight Score | Rating | Weight Score | Rating | Weight Score | Rating | Weight Score | Rating | Weight Score |
| Ease of Manufacturing | 0.25 | 5 | 1.25 | 4 | 1 | 3 | 0.75 | 2 | 0.5 | 1 | 0.25 |
| Weight | 0.1 | 4 | 0.4 | 4 | 0.4 | 4 | 0.4 | 3 | 0.3 | 2 | 0.2 |
| Power Saving (less servos) | 0.25 | 5 | 1.25 | 5 | 1.25 | 3 | 0.75 | 3 | 0.75 | 3 | 0.75 |
| Drag Efficiencies | 0.15 | 3 | 0.45 | 4 | 0.6 | 3 | 0.45 | 5 | 0.75 | 3 | 0.45 |
| Stability | 0.25 | 3 | 0.75 | 3 | 0.75 | 2 | 0.5 | 5 | 1.25 | 5 | 1.25 |
| Total | | | **4.1** | | **4** | | **2.85** | | **3.55** | | **2.9** |

- Each design meets all competition/engineering requirements. Weighted decision matrix used to narrow options.
- Conventional and T-Tail are the only two options the team moved forward with. Conventional tails have a slightly easier manufacturing process due to the placement of the horizontal stabilizer.

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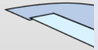

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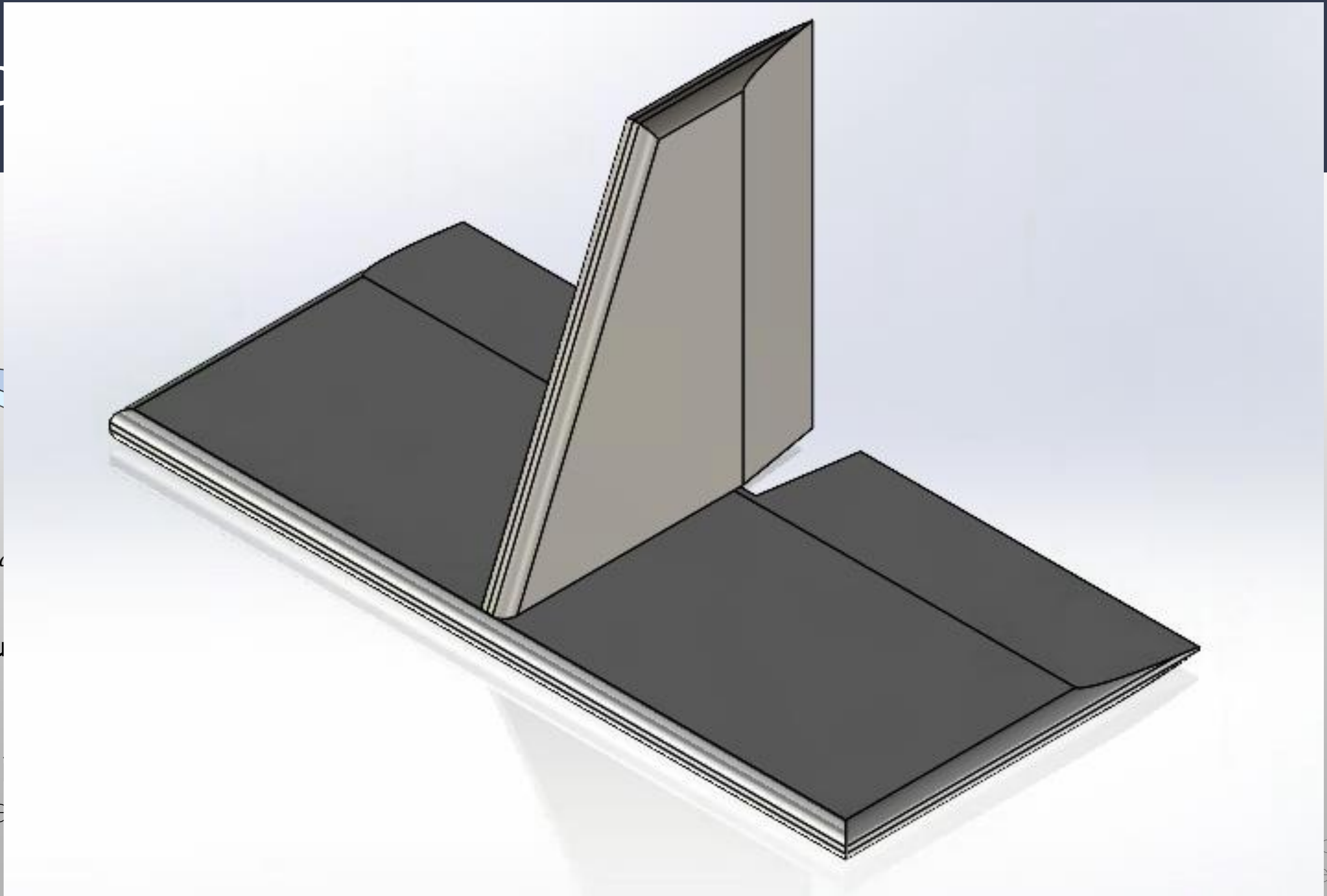


# Concept Evaluation - Landing Gear

- The two primary configurations being evaluated are tricycle and tail dragger.
- Both configurations are viable options for the competition.
- Taildragger is more cost effective and lighter.
- Tricycle ensures a safer landing.

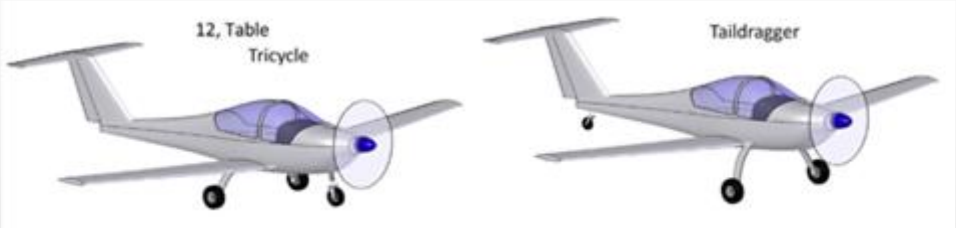



**Figure 10: Landing Gear Configurations [7]**

**Table 3: Decision Matrix of Landing Gear Configurations**

| Concepts | | Tricycle | | Tail Dragger | |
|---|---|---|---|---|---|
| **Criteria** | **Weight** | **Rating** | **Weight Score** | **Rating** | **Weight Score** |
| Landing Preformance | 0.3 | 5 | 1.5 | 2 | 0.6 |
| Cost | 0.15 | 4 | 0.6 | 5 | 0.75 |
| Weight | 0.25 | 2 | 0.5 | 3 | 0.75 |
| Size | 0.3 | 3 | 0.9 | 4 | 1.2 |
| **Total** | | 14 | **3.5** | 14 | **3.3** |

# Concept Evaluation - Landing Gear

**Figure 11: Front Portion of The Tricycle [8]**

**Figure 12: Rear Portion of The Tricycle [9]**

# Concept Evaluation - Propulsion

The objective of this competition is to have a lightweight plane that can fly with a weighted payload, therefore a motor and propeller combination must be chosen to generate sufficient thrust for our craft.

- Large diameter propellers will generate greater thrust and allow the craft to fly at slower speeds, and will therefore be easier to control and land..
- A high thrust-to-weight ratio is highly desired as it will allow for more payload to be .
- High propeller diameter will increase thrust, but may also overload the motor and battery.
- Motor and propeller combination may change based on alterations to weight and dimensions.

| **Propeller** | |
|---|---|
| Static Thrust: | 1903 g |
| | 67.1 oz |
| Revolutions*: | 10329 rpm |
| Stall Thrust: | - g |
| | - oz |
| avail.Thrust @ 72.5 km/h: | 1022 g |
| avail.Thrust @ 45 mph: | 36 oz |
| Pitch Speed: | 94 km/h |
| | 58 mph |
| Tip Speed: | 544 km/h |
| | 338 mph |
| specific Thrust: | 4.22 g/W |
| | 0.15 oz/W |

**Figure 13: Thrust Generated from Scorpion 2520 Motor w/ 11” Dia. 6” Pitch Propeller[10]**

# Concept Evaluation – Fuselage

- The Fuselage is the core of the plane, and must hold up to the stresses of flight.
  - ABS plastic yield strength: 25 MPa [11]
  - Balsa Wood yield strength: 1 MPa [12]

- The Flagstaff Flyers recommend a balsa wood fuselage to reduce weight

**Table 4: Decision Matrix of Fuselage Material**

| Concepts | | 3-d Printed | | Balsa Wood | |
|---|---|---|---|---|---|
| Criteria | Weight | Rating | Wight Score | Rating | Weight Score |
| Weight | 0.4 | 1 | 0.4 | 4 | 1.6 |
| Yeild Strength | 0.3 | 2 | 0.6 | 1 | 0.3 |
| Reproduciblitity | 0.2 | 3 | 0.6 | 2 | 0.4 |
| Cost | 0.1 | 4 | 0.4 | 4 | 0.4 |
| Total | | 10 | 2 | 11 | 2.7 |

# Concept Evaluation - Fuselage

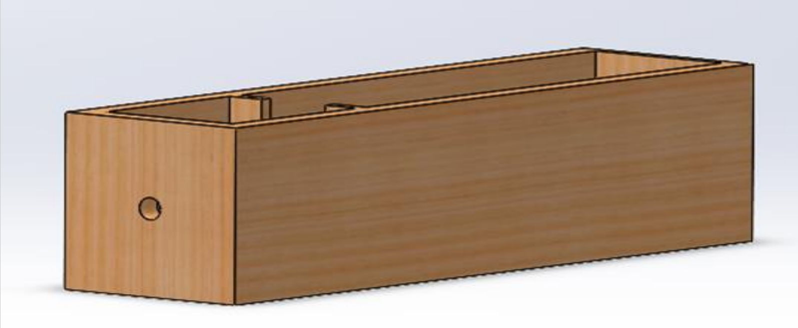


Figure 14: CAD Model of Fuselage (Isometric View)

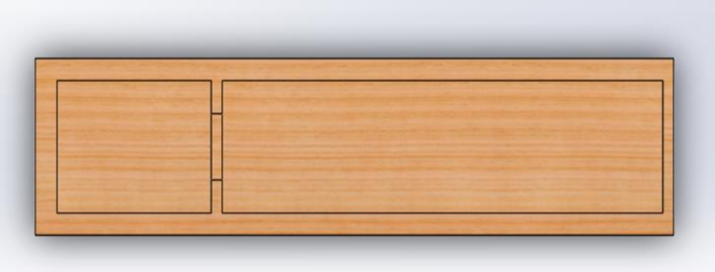


Figure 15: CAD Model of Fuselage (Top View)

- The Fuselage is the core of our design.
  - Goal: Minimize volume and weight
  - Contains: Motor, ESC, Receiver, and LiPo Battery

# Concept Evaluation - Tentative Final Design

- The Tentative Final Design shown in Figure 16 is a combination of the optimal designs from the concept evaluations performed by each team member.
- In theory, this assembly of components should fly and meet most of our engineering and customer requirements from our QFD (Appendix B).
- This tentative design is very likely to change as the team continues their work.

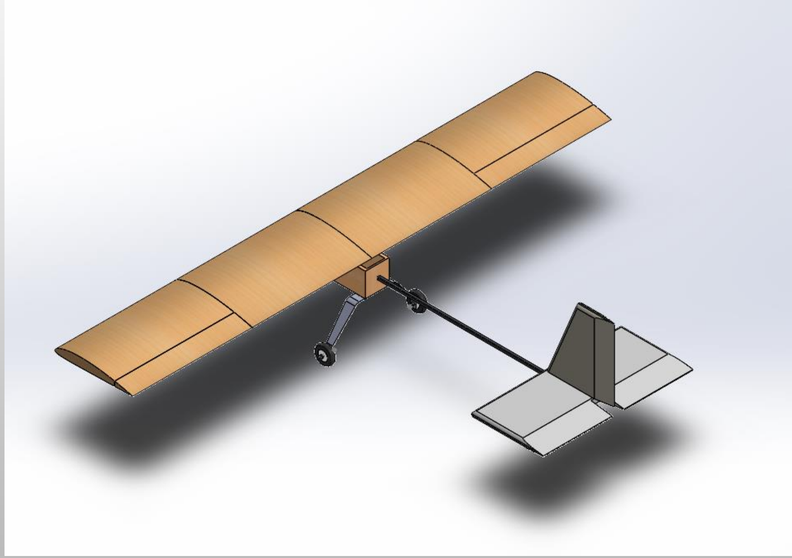


**Figure 16: CAD Model of Tentative Final Design**

# Budget Planning

- The current material budget is setup to accommodate for crashing during testing.
- The cost to enter competition is $1100.
- Factoring that into the budget the current total project cost is approximately $2100.

**Table 5: Breakdown of the Material Costs for the Project [13]**

| Materials | | | |
|---|---|---|---|
| Components | Quanitity | Price | Cost |
| Motor | 1 | 30 | 30 |
| Prop | 10 | 5 | 50 |
| Battery | 1 | 30 | 30 |
| Servos | 8 | 60 | 480 |
| Electronic Speed Controller(ESC) | 1 | 25 | 25 |
| Controller | 1 | 150 | 150 |
| Monokote | 1 | 50 | 50 |
| Bass/balsa Wood | 1 | 30 | 30 |
| Landing Gear | 2 | 10 | 20 |
| | | total cost | 865 |

# Conclusion

- The team now has a tentative final design to work with, but there is a lot more work to do.
- The next step will be to prototype our design, and see if the decisions we made result in a flying RC plane.
- Once the team develops a working design, we can continue to make adjustments to the design to increase the weight to payload ratio in order to score better at competition.

# Works Cited


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

[2] L. S. U. , ***Louisiana State University***. Accessed: Oct. 12th, 2020. [Online]. Available: https://www.lsu.edu/eng/news/2018/05/lsuaerofourth.php.

[3] "Micro Aircraft Competition Design · Neil Pomerleau," ***Neil Pomerleau***. Accessed: Oct. 12th, 2020. [Online]. Available: https://www.neilpomerleau.com/posts/micro-aircraft-competition-design/.

[4] clc3qy, "Team History," ***Miner Aviation***, 29-Apr-2020. Accessed: Oct. 13th, 2020. [Online]. Available: https://mineraviation.mst.edu/team-history/.

[5] "CLARK-Y 11.7% smoothed," ***CLARK-Y 11.7% smoothed (clarkysm-il)***. Accessed: Oct. 12th, 2020. [Online].
Available: http://airfoiltools.com/airfoil/details?airfoil=clarkysm-il.

[6] "File:Tail of a conventional aircraft.svg," ***File:Tail of a conventional aircraft.svg - Wikimedia Commons***.
Accessed: Oct. 12th, 2020. [Online]. Available: https://commons.wikimedia.org/wiki/File:Tail_of_a_conventional_aircraft.svg.

[7] A.Gudmundsson, General Aviation Aircraft Design: Applied Methods and Procedures, Waltham, Ma: Butterworth-Heinemann, 2014, pp. 548-572

[8] E. Vaidya,"GrabCad Community," GrabCad, 11 May 2019. [Online]. Available: https://grabcad.com/library/landing-gear-47

# Works Cited


[9] M. Kharudin. “Main Landing Gear” GrabCad, 12 Oct. 2020. [Online]. Available: https://grabcad.com/library/main-landing-gear-7

[10] Motor and Propeller Thrust Values (eCalc.com). [Online]. Available: https://www.ecalc.ch/motorcalc.php?ecalc&lang=en&weight=1361&calc=auw&motornumber=1&warea=16.77&elevation=2134&airtemp=21&motor=scorpion&type=8|hk-2520-1360&gear=1&propeller=apc_electric&diameter=11&pitch=4.5&blades=2&batteries=lipo_2200mah_-_30/45c&s=3&esc=max_50a&cooling=good (Accessed September 27, 2020)

[11] L. L. C. Engineers Edge, “ABS Plastic Filament Engineering Information,” Engineers Edge - Engineering, Design and Manufacturing Solutions, 18-Dec-2017. Accessed: Oct. 12th, 2020. [Online]. Available: https://www.engineersedge.com/3D_Printing/abs_plastic_filament_engineering_information_14211.htm.

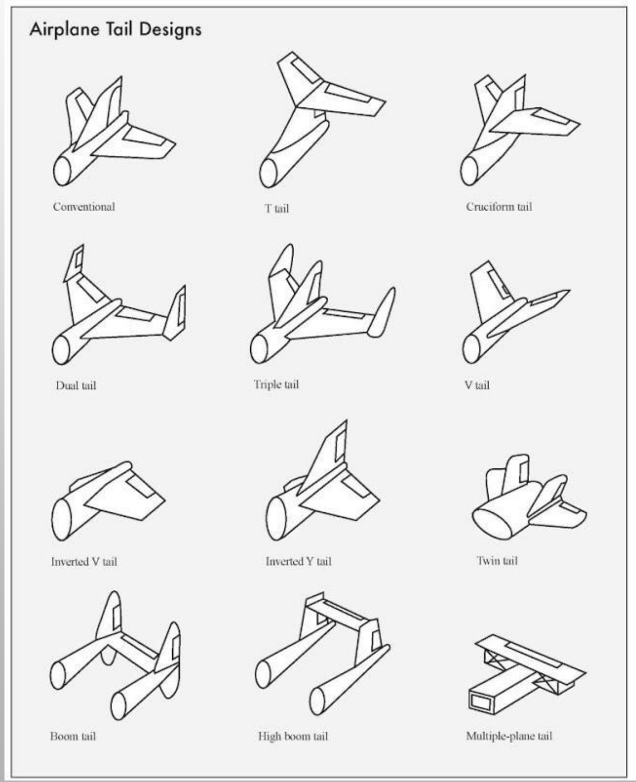
[12] Tropical Balsa Wood. Accessed: Oct. 12th, 2020. [Online]. Available: http://www.matweb.com/search/datasheet_print.aspx?matguid=368427cdadb34b10a66b55c264d49c23.

[13] Flite Test Store. Accessed: Oct. 12th, 2020. [Online]. https://store.flitetest.com/?gclid=Cj0KCQjwoJX8BRCZARIsAEWBFMKpKi4lxj1DYaCBPKwcTRPHhKUvFS4JgjNM9EoaUX1DcNmqlzp2kwwaAqmaEALw_wcB.

[14] C. Farrar, et al. “Final Design Proposal for SAE Aero Micro”, Northern Arizona University, Flagstaff, AZ,

# Works Cited

# Appendix A: Airplane Tail Designs



# Appendix B: QFD

| Customer Requirements \ Design 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | | | |