Unmanned Aerial Vehicle: Micro Class

MECHANICAL ENGINEERING
UTAH VALLEY UNIVERSITY

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Objectives

Design and construct an Unmanned Aerial Vehicle within the guidelines for the SAE micro-class competition. Maximize the plane's flight score using the competition scoring equation:

- Must fly with 450-Watt power limiter
- Operate within FAA regulations
- Minimize wingspan, takeoff distance, and empty weight
- Maximize payload weight

Scoring Equation:

$$Final\ Flight\ Score = FSS = FS_1 + FS_2 + FS_3$$

Where:

$$Flight\ Score = FS = 3 * W_{Payload} * M + Z$$

$$M = \frac{11}{(W_{Empty} - 1)^4 + 8.9}$$

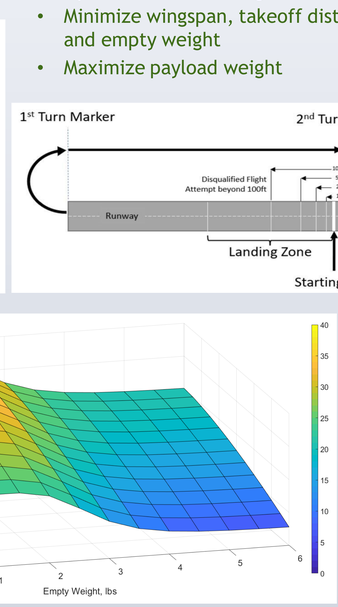
$$Z = B_{Takeoff} - S^{1.5}$$

$W_{Payload} = Payload\ Weight\ (lbs)$

$W_{Empty} = Empty\ Weight\ (lbs)$

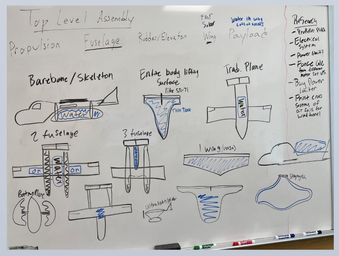
$S = Wingspan\ (ft)$

$$B_{Takeoff} = \begin{cases} 20 & 0 \le x \le 10\ ft \\ 15 & 10 < x \le 25\ ft \\ 9 & 25 < x \le 50\ ft \\ 0 & 50 < x \le 100\ ft \end{cases}$$



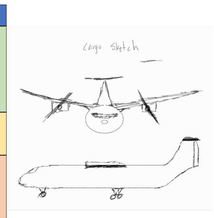
Concept Generation

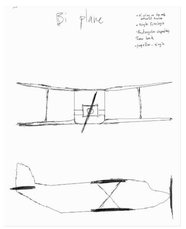
- Using the design requirements and customer needs as a guide, hundreds of ideas were generated.
- Concept generation tools such as brainstorming, morph charts, and scoring matrices were used.
- Some of the ideas generated were inspired by real life aircraft designs as well as biomimicry.



Top 2 Designs

Plane Name	
Cargo	Cargo Plane
Condor	
Dolphin	
High Truss	
Di-Bi	Bi-Cargo Plane
Short Underwing	
Manta Ray	Biomimicry
Sting Ray	
Double Swept	
Dark Star	Unconventional
Double Double	
Rib Cage	

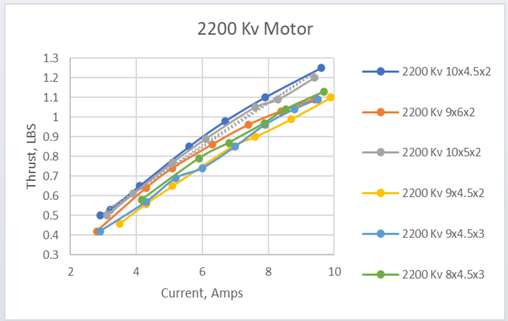


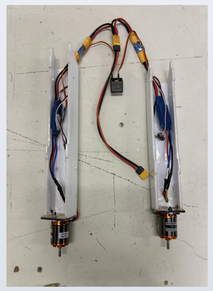


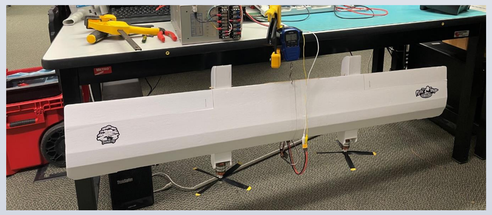
Design and Testing

Motor and Propeller Selection

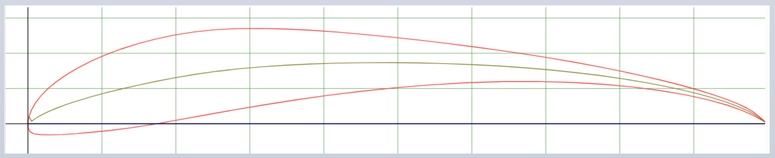
- Motor and propeller configurations for were tested to determine which combination would give the most thrust given power limitations.



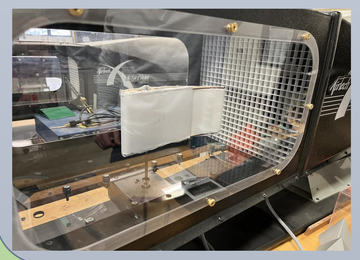




Airfoil Development



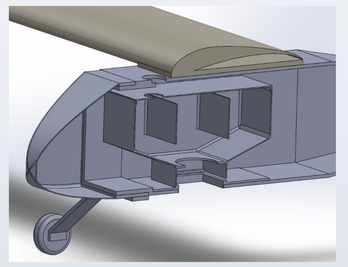
Chord length (inches)	Re number at 25 mph	C_l @ alpha = 10	Lift force (lbf)		C_d @ alpha = 10	Drag force (lbf)	
8	149801	2.15	7.93	11.90	0.04	0.26	0.39
12	224724	2.25	12.47	18.70	0.035	0.19	0.29
14	262163	2.25	14.54	21.82	0.025	0.09	0.14
			48	72		48	72
			Wingspan (inches)			Wingspan (inches)	

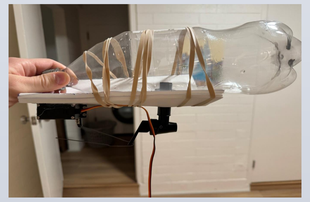


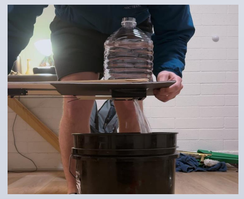
- Researched airfoil characteristics and properties to determine optimal airfoil shape
- Selected the S1223 Airfoil
- Tested selected airfoil in wind tunnel to measure lift force
- Calculated lift values with different airfoil and wingspan sizes

Iterations

- The team worked hard to prototype, learn, fail and iterate as quickly as possible, using this method contributed greatly to the success of the project







Conclusion

- All competition requirements were met, and positive flight score was achieved.
- Met all Customer and design specifications.

Criteria	Flight 1	Flight 2	Flight 3
Empty weight	3.3	3.3	3.3
Payload weight	4.41	4.41	4.41
Wingspan	4	4	4
Takeoff distance	49	47	48
Takeoff score	9	9	9
Payload score	4.41	4.41	4.41
M	0.30	0.30	0.30
Z	1	1	1
Single Flight Score	4.95	4.95	4.95
Final Flight Score	14.8		

Specification	Minimum Value	Actual Value	Units	Measurement Tool
Fluid tank must carry water.	≥ 2	2	Liters	Beaker
Take off length.	≤ 100	48	Feet	Measuring tape
Tank must drain.	≤ 60	5	seconds	Stopwatch
Gross weight.	≤ 55	3.3	pounds	Scale
Must fly in winds (sustained).	≤ 5	7	Miles per hour	Anemometer
Must fly in winds (gusts).	≤ 10	16	Miles per hour	Anemometer