El Agave

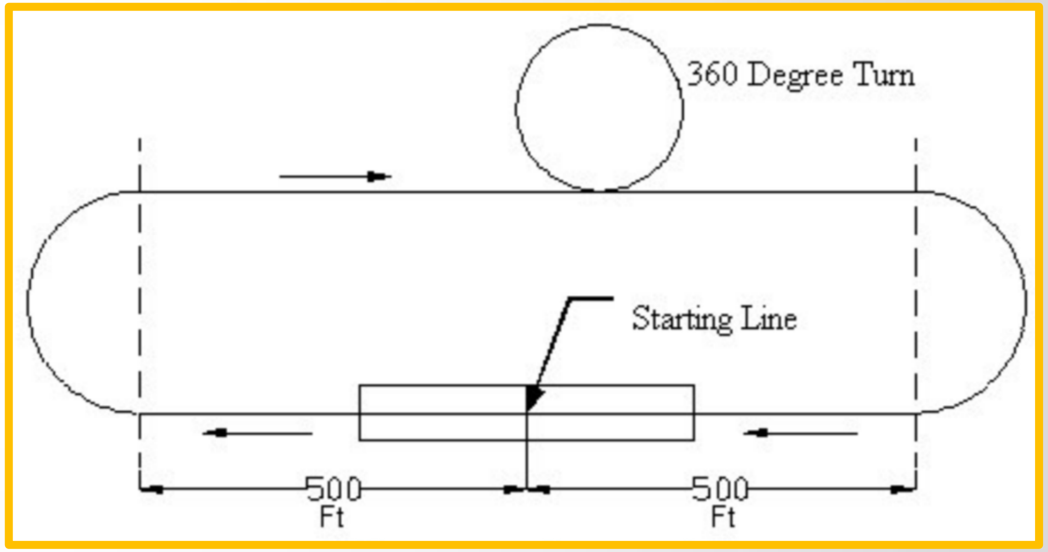
Team 4

Manny Psihountas – Aerodynamics - psihountas.manny@gmail.com
Giovana Bilda Coelho – Propulsion - giovanabilda@gmail.com
Mason Buckmaster – Stability and Controls - buckmastermason@gmail.com
Claudia Rojo Cazorla- Structures – rojocazorlaclaudia@gmail.com

Mission Identification

Mission	Max time (minutes)	Time affects scoring equation?	Laps	Payload	Take off Distance (ft)
Ground Mission	5	YES		Install and remove M2 and M3 payloads	
Mission 1	5	NO	3	No payload	20
Mission 2	5	YES	3	Passengers and luggage	No constraint
Mission 3	10	NO	As many as possible	Banner	20

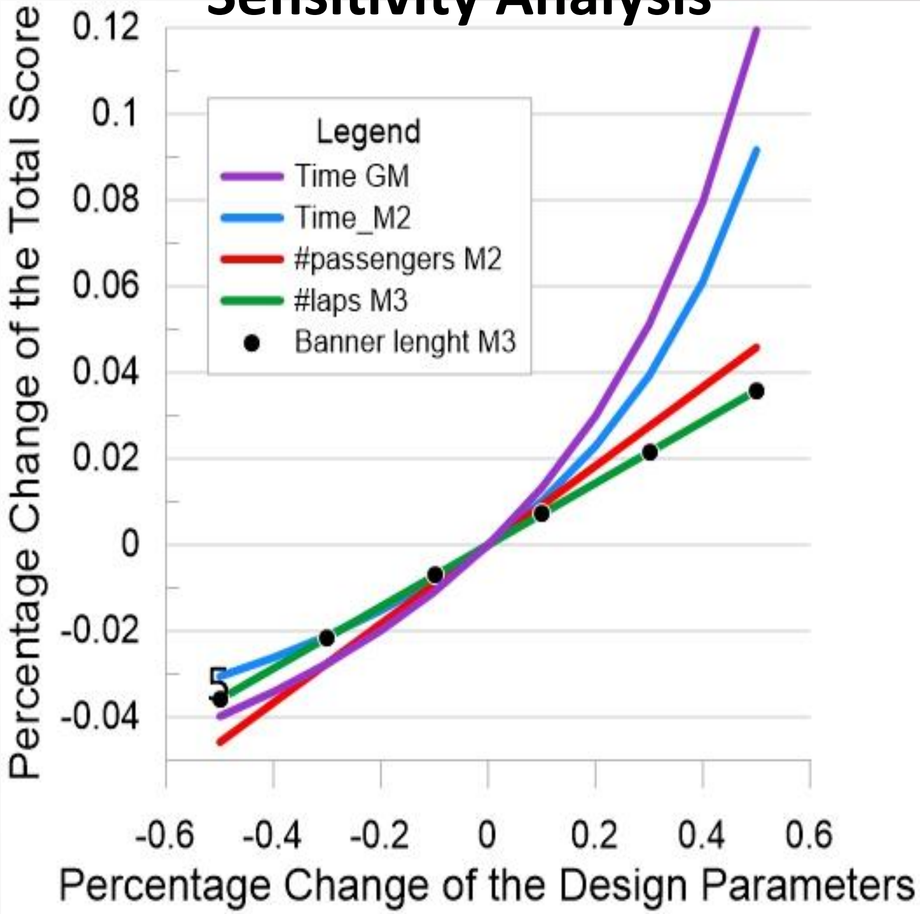
Flying Course



Competition Strategy

After carefully analyzing the mission requirements and constraints, sensitivity analysis was conducted to identify the most critical parameters that impacted the scoring equation the most. The scoring equation is directly dependent on the report score so such factor is taken out of the analysis due to its obvious greater effect on the final score over the mission related parameters. With the results of the sensitivity analysis, the team decided to maximize the score of mission 2, for which a big powerful aircraft was needed, also benefiting the ability of towing a large banner and therefore being very convenient for a big mission 3 score as well.

Sensitivity Analysis

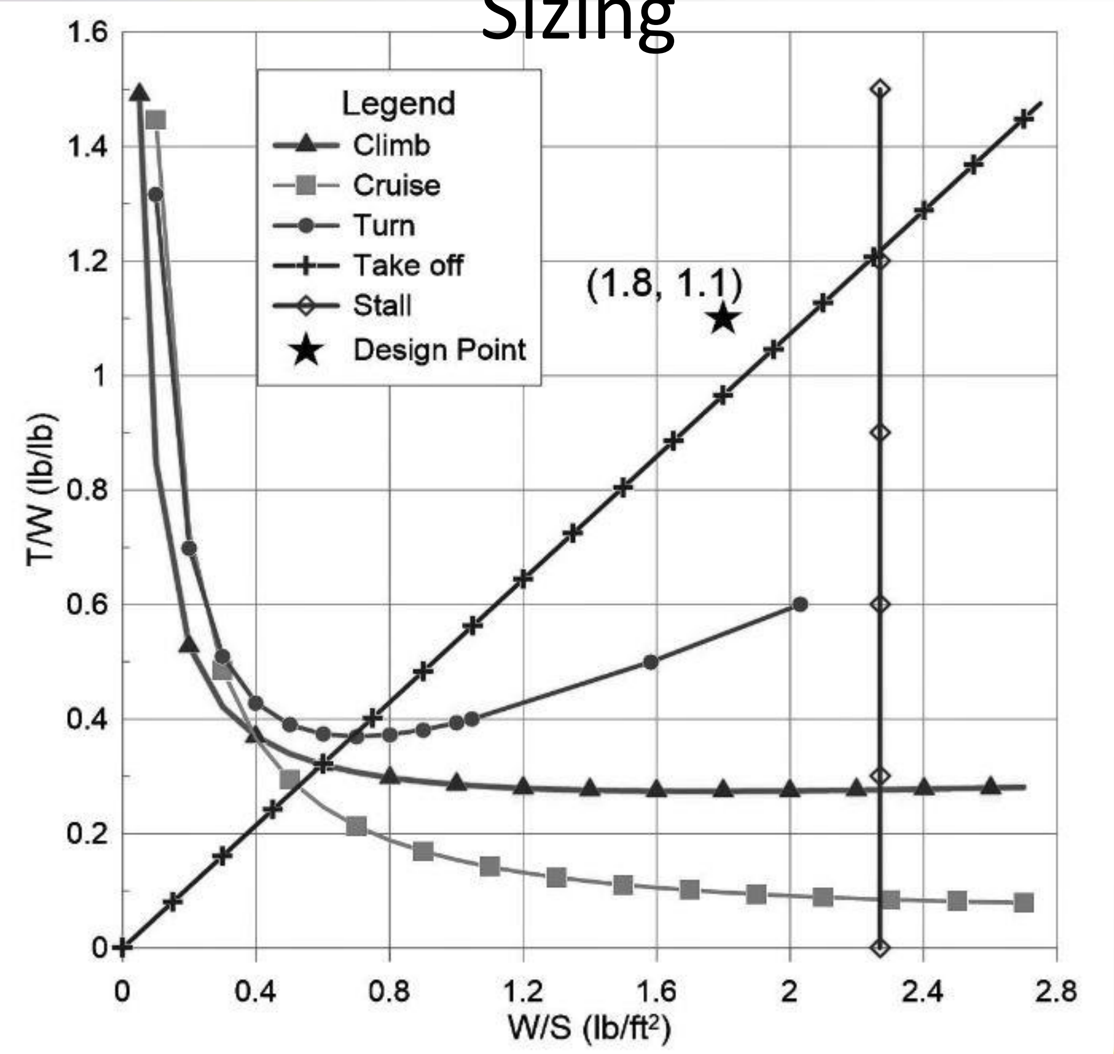


Scoring Equations

- Final Score = (Written Report Score) * (Sum of Mission’s Scores)
- Ground Mission = [time/ (Best team’s time)]
- M1 = 1.0 for successful mission
- M2 = 1 + [(#passengers/time)/(Best team’s (#passengers/time))]
- M3 = 2 + [(#laps*banner length)/(Best team’s(#laps*banner length)]

Starting Point

Sizing

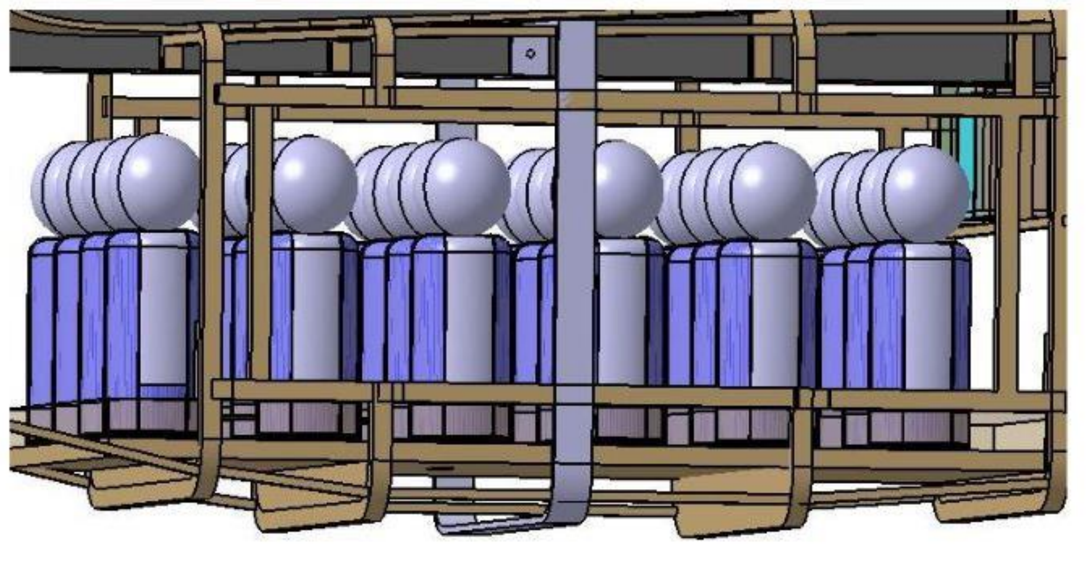


To begin with, certain flight parameters were analyzed to determine a desired design point, and most importantly a design area within the design needs to be in throughout the whole process. In his method, the thrust to weight ratio (T/W) is determined as a function of the wing loading (W/S) for stall, takeoff, climb, cruise, and level turn. From the graph, it is easy to see that the takeoff and stall are the ones limiting the design area the most. Since the stall line determines the maximum wing loading possible, flaps were added in order to obtain a $C_{L_{MAX}}$ of 1.75. The design point chosen was T/W of 1.1 and W/S of 1.8 which means that a wing area of 4.58 ft^2 is required for a takeoff thrust of 10 lb.

Payload Systems – Mission 2

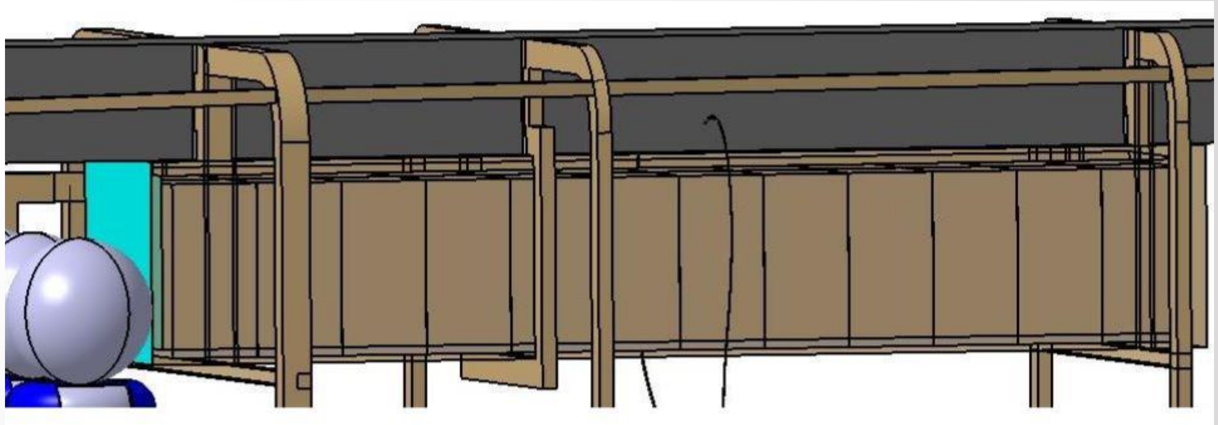
Passengers

- Mounted on balsa plate restrained by payload bay frames.
- Plate has pockets for each passenger with Velcro on the bottom.
- Passengers are fit into a nylon 3-D printed suit, with Velcro on the bottom, a pocket, and a neck fillet for restraining in the vertical direction.



Luggage

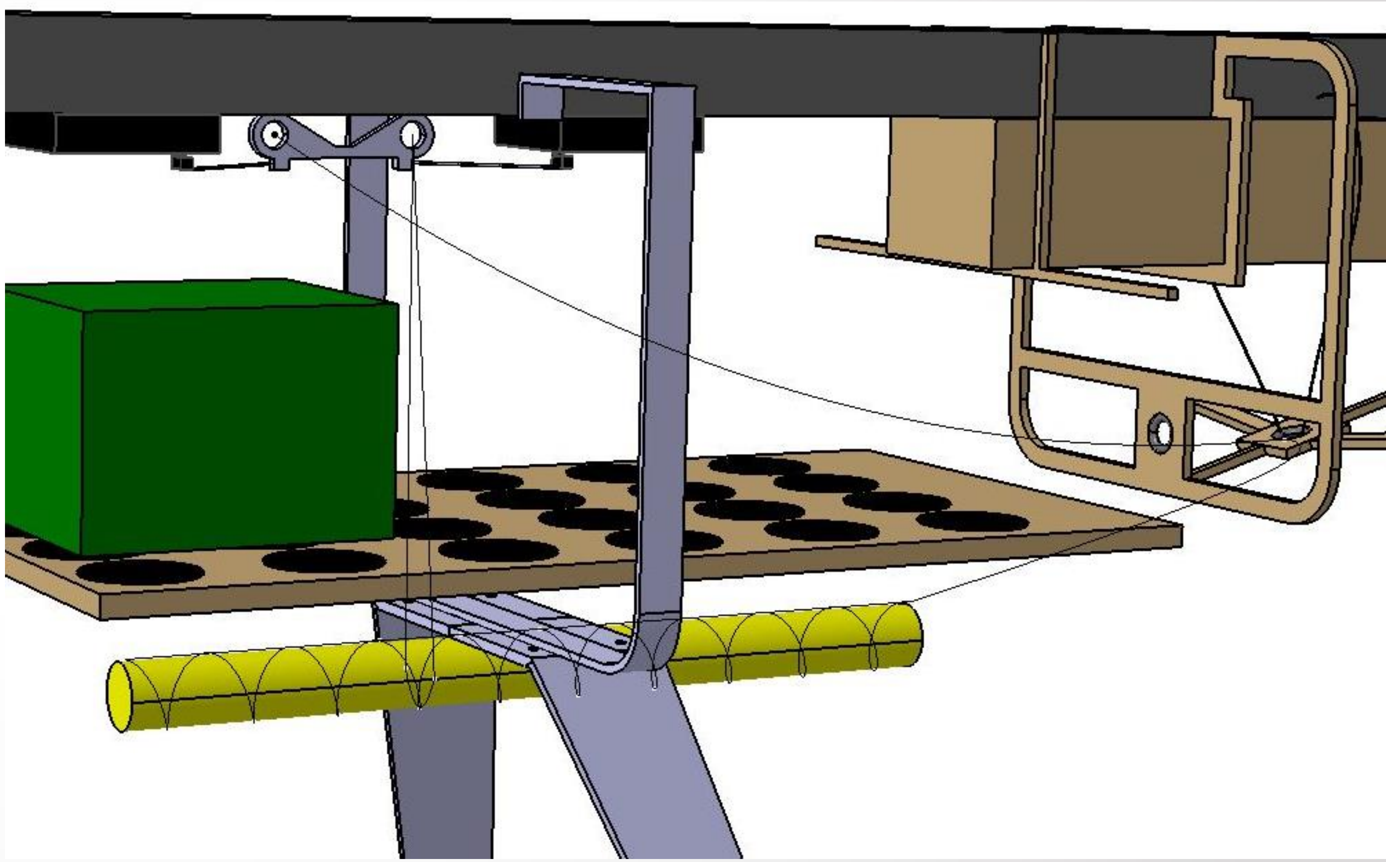
- Located behind the passengers in an elevated bay right below the keel beam.
- The bay is a box with dimensions such that it fits in two rows of 12 suitcases nose to tail.
- The bay has a plastic door that restrains all suitcases inside



Payload Systems – Mission 3

Banner Mechanism

- Banner is folded as an accordion and upheld with the belly of the fuselage.
- Banner is made from nylon fabric and has a weight on the front bottom side, so it stays vertical.
- Two fishing lines are used to hold the banner folded and to attach the banner to the aircraft.
- A double side pin holds both fishing lines in place.
- Two servos with connecting pins open each side of the double side pin when its time for deployment and detachment

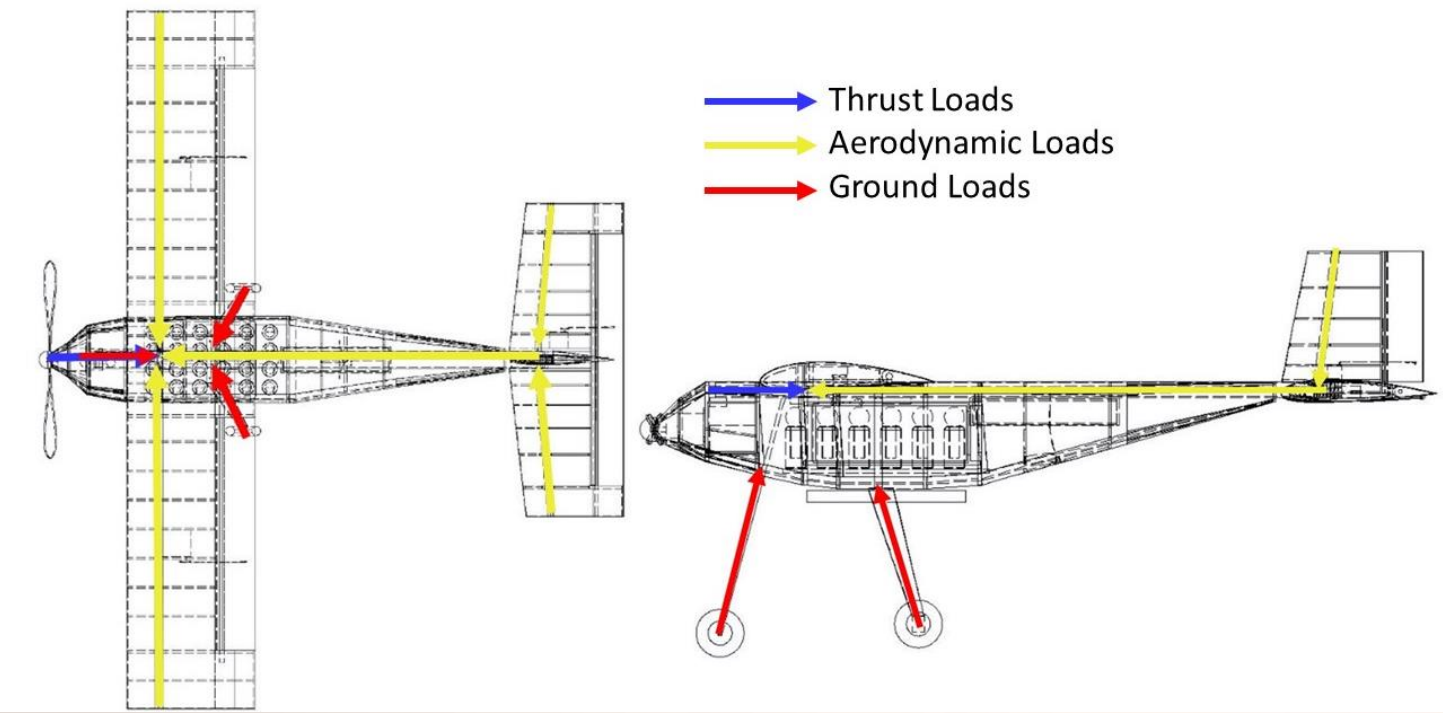


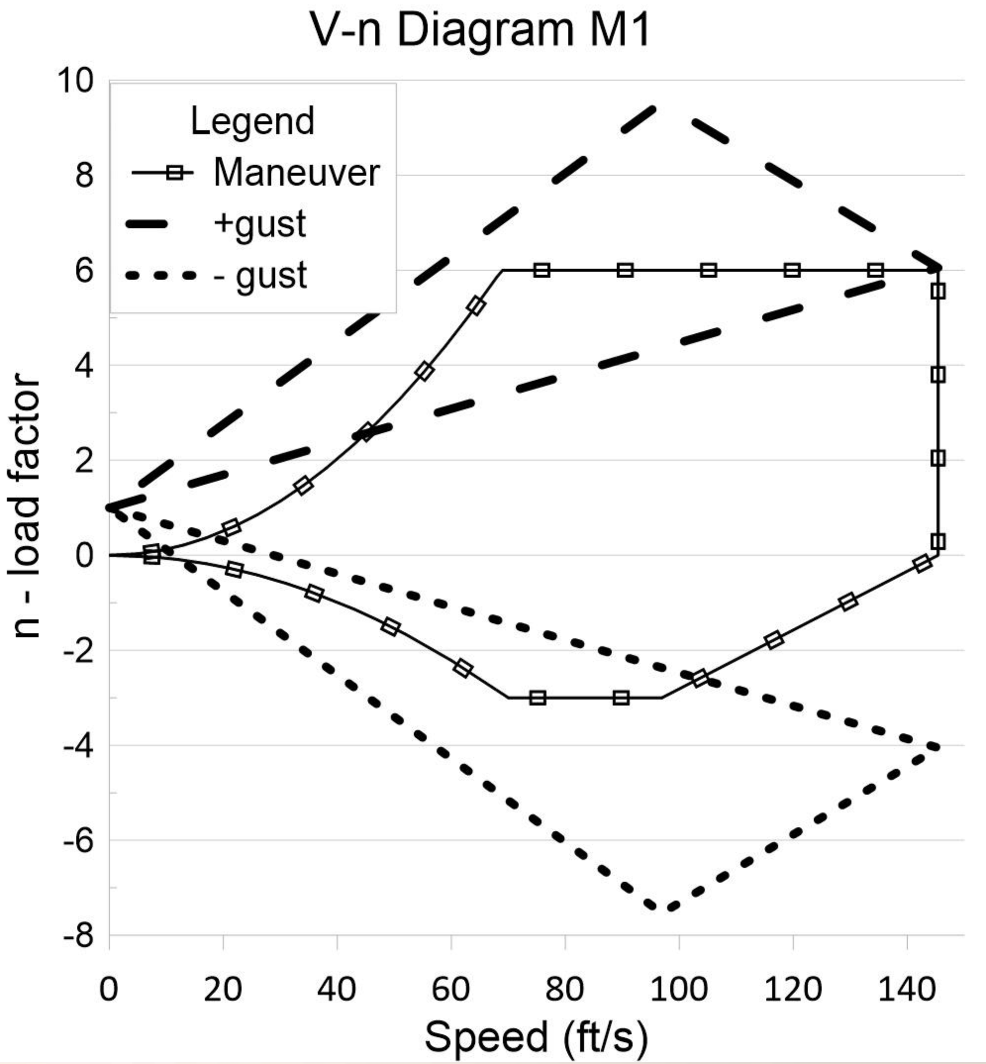
Aerodynamics

- **Airfoil: NACA 4415**
  - Chosen because of the high $C_{l\text{-}Max}$ value of 1.3 at low Re, with relatively low drag numbers.
- **High aspect ratio**
  - The maximum wingspan allowable of 5 ft. Chord length is 11" to meet sizing parameters. Our wing has no taper.
  - The wing aspect ratio is 5.6.
  - The horizontal tail aspect ratio is just under 3.
- **C_{D0}**
  - C_{D0} of the entire aircraft came out to be 0.042 found from wind tunnel testing.
- **Banner effects on Drag**
  - For mission 3 will increase substantially due to the banner. With a required aspect ratio of 2, experimental studies done by Hoerner point to a C_{D0} of 0.1 for the banner; which will increase the C_{D0} for the aircraft to 0.142.

Load Analysis

- **Load Paths** - Identifying the members that will carry the main loads.
- **Flying envelope** – Analyzing wind gusts and maneuver to identify the most critical load factor of all missions, which was applied throughout the design.



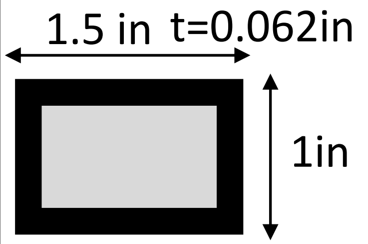
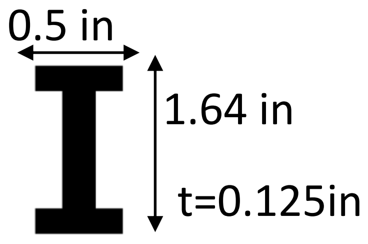


Structures

Fuselage
- Keel beam is the main structural member of the entire aircraft.
- Balsa frames on critical locations transfer loads to the keel beam.
- An aluminum frame and nylon screws support landing loads.
- Firewall serves as frame and as support for motor loads.
- Skin of the fuselage is Monokote.
- Doors are made from plastic and tape for weight saving purposes.

Aerodynamic Surfaces- Wing and Empennage
- Main Spars carry bending stresses.
- Ribs and skin carry torsional stresses.
- Wing has balsa skin, empennage has just Monokote.

Fuselage to Wing and Empennage Joints
- Mechanical joints strengthened with adhesive connections.
- Nylon screws to avoid breaking of main structures.

	Keel Beam (Fuselage)	Main Spar (Wing)
Material	Aluminum 6063-T52	Balsa
Cross Section		
Tip Deflection	1.22 in	2.0 in
Deflection	2.61 ° (angle)	DNA
Weight	1.13 lb	0.103 lb
$\sigma_{ultimate}/\sigma$	1.61	1.20

Weights and CG

WEIGHTS (LB)			
Mission	M1	M2	M3
Total Weight	7.47	15.0	8.28
Battery Weight	2.09	2.09	2.34
Structural Weight	3.01		

Weight component build up estimation based on:

- manufacturing specifications of parts purchased
- material densities and dimensions

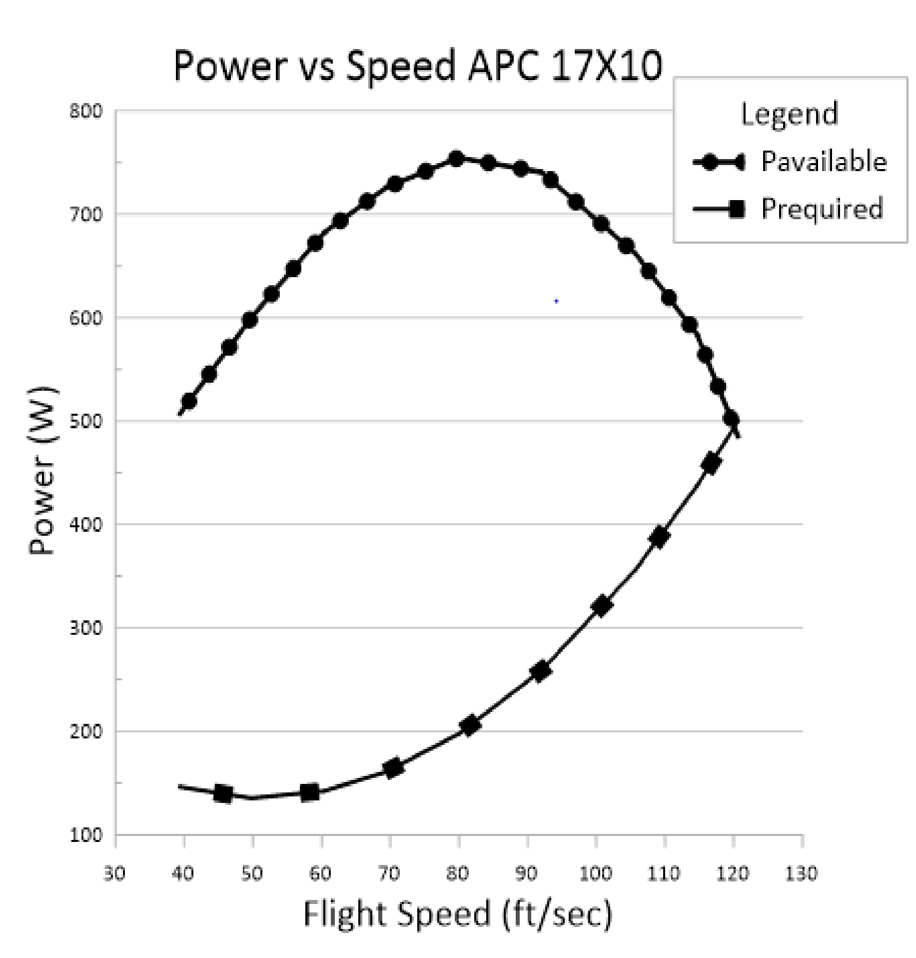
X-CG location characteristics:

- The reference is the **nose of the aircraft**, **datum 0**
- Battery moves back for M1 and M3 to minimize shifting of the X-CG

X – CG Location			
Mission	% chord	inches	feet
1	129	14.2	1.18
2	133	14.6	1.22
3	130	14.3	1.19

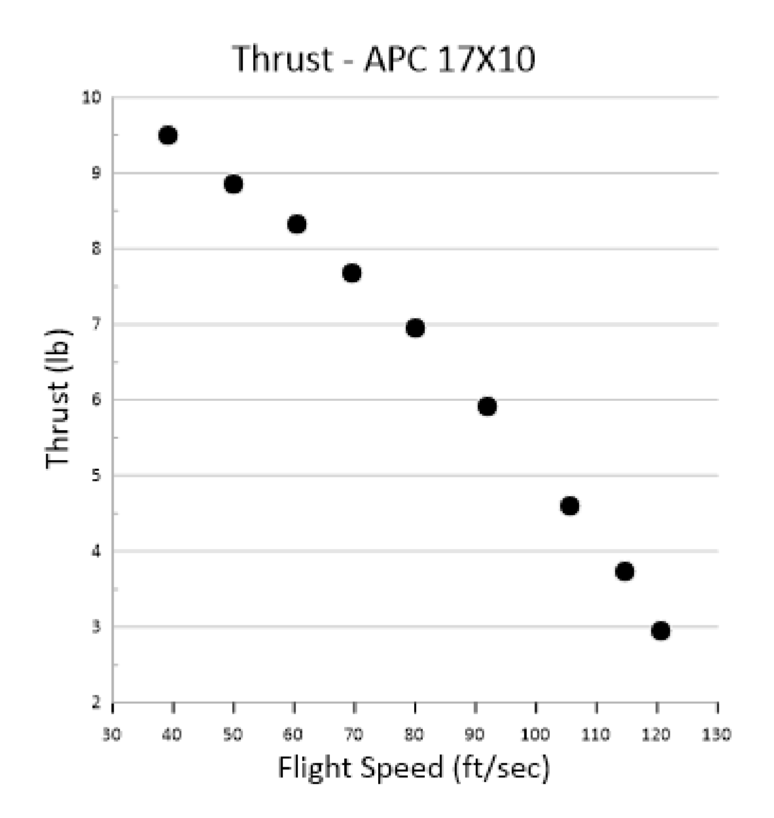
Propulsion

Components	Description
Motor	E-Flite Power 52
Battery	MaxAmps 5S 8,000 mAh 5S 11,000 mAh
Speed Controller	E-Flite Pro Switch 80
Propeller	APC 17X10



The motor was chosen due to its maximum current of which was needed to achieve the necessary thrust for takeoff in 20 ft. Propeller experimental data was used to calculate power available and required as well as the thrust graph.

E-Flite Power 52	
Kv	590
Watts	1650 W
Maximum current	65 A



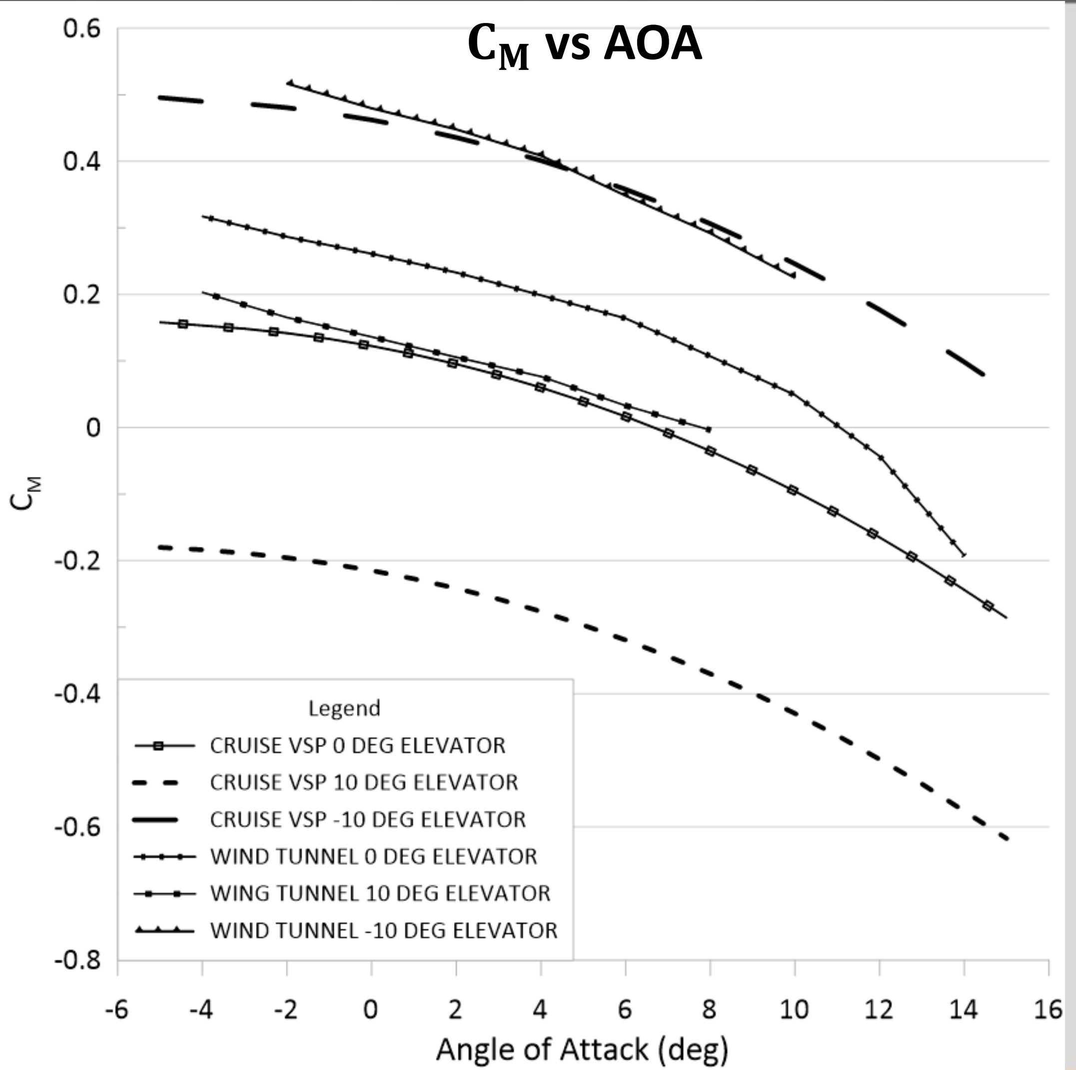
Stability and Controls

- **Static Stability**
  Static stability characteristics are determined based on the relative size and location of the empennage
- **Empennage**
  Conventional empennage configuration. Empennage sized to drive static stability derivatives into the desired zones
- **Control**
  Control of the aircraft comes from the elevator, rudder, and flapperons
- **Elevator sizing**
  The elevator was sized such that it would be able to counter the moments of the wing with fully extended flapperons at 10 degrees of deflection leaving plenty of extra deflection for maneuverability
- **Rudder Sizing**
  The rudder was sized such that the aircraft would be able to counteract a 38ft/s gust at 20 degrees from the flight path
- **Flapperon Sizing**
  The flapperons were sized to allow the wing to produce the lift desired for short takeoff

Wind Tunnel Testing Results

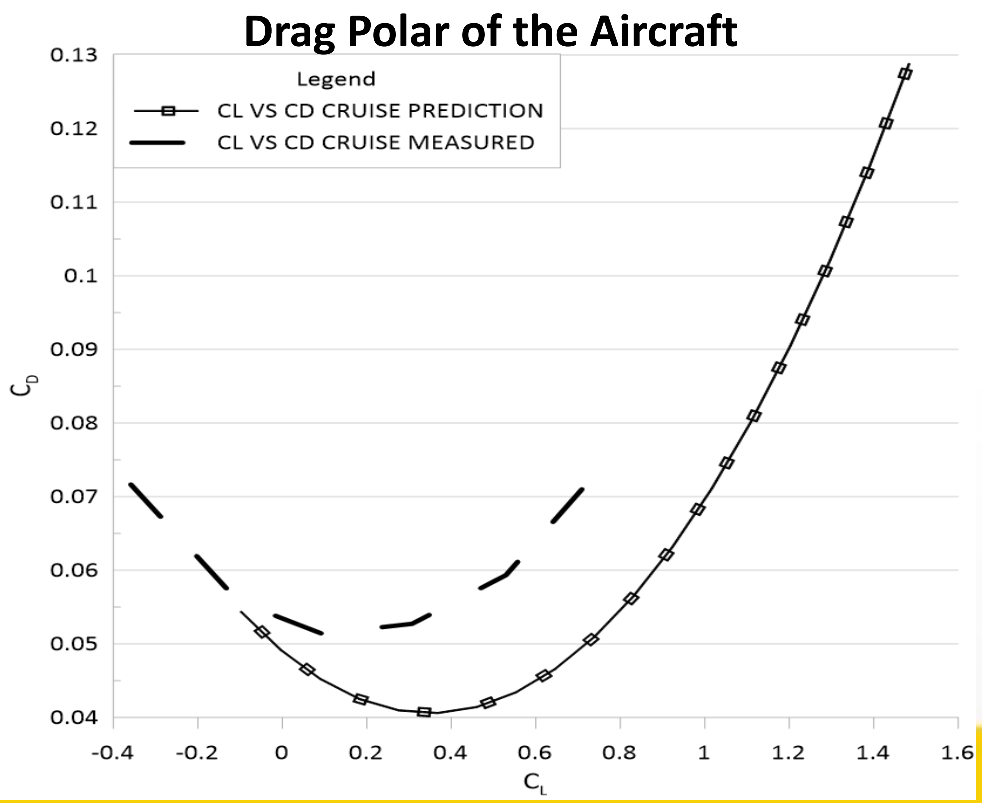
- **Wind tunnel testing was conducted to validate our work**
  - Tests needed to be conducted for every configuration and situation the aircraft might encounter.
  - Takeoff cruise and maneuver speeds.
  - At elevator deflections that encompasses a wide range of possible deflections.
  - The wind tunnel did not allow for lateral directional validation.

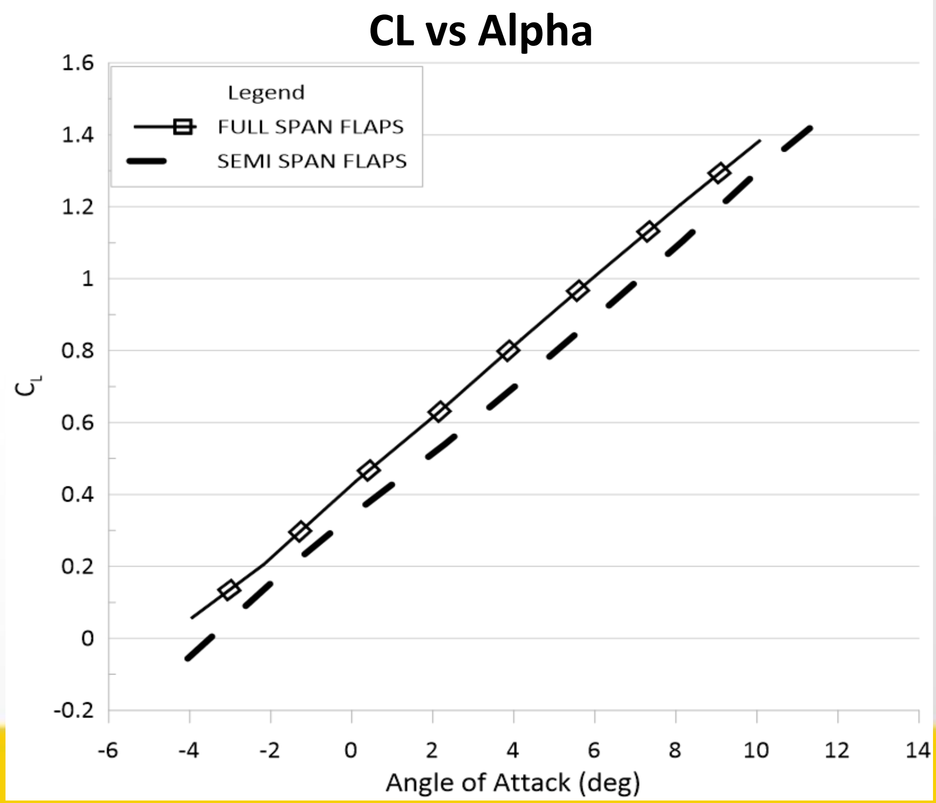
- **The graph validates the stability and controls estimations**
  - $C_{M\propto} < 0$
    - The aircraft is stable in the longitudinal static mode.
  - C_M can be 0 (with appropriate elevator deflections)
    - The aircraft can be trimmed in flight.



Wind Tunnel Testing Results

- The experimental results for our showed about a 20% increase in C_{D0} from our predictions. We expect this to be a result of flow separation from the taper aft of the fuselage.
- Another test was ran comparing full span flaps to flaps that were 5% away from the wing tips, as we estimated that not much lift would come from that section anyway. Our results showed an increase in C_{L0} from 0.3 to 0.4 which made the decision easy to implement the full span flaps on our model.





Design Table and Estimated Performance

Parameters	M1	M2	M3
Wing Area (ft^2)	4.6		
Wingspan (ft)	5		
C_{D0}	0.042	0.042	0.142
C_{L-max}	1.75		
$C_{M-\alpha}$ (per radian)	-0.75		
Static Margin	12%		
W/S (lb/in^2)	1.62	3.26	1.86
T/W	1.34	0.668	1.21
Vstall (ft/s)	28	40	29
Vcruise (ft/s)	95	95	65
nmax	9.5	6.3	9
Turn Radius (ft)	26.6	40.4	17
Endurance	11 min 48 sec		
Lap Time (sec)	31	35	45
Score	1	1.56	2.62
Total Mission Score	5.74		