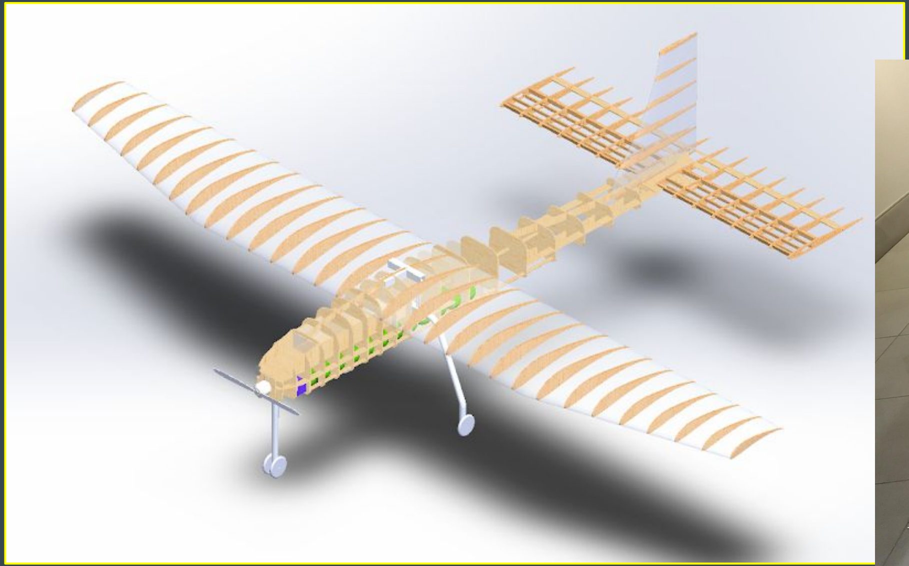
University of Tulsa
Mechanical Engineering Department
Aero Design Team

•••

Olivia McGraw
Brian Haiduk
Garrett Carson
Sanyam Sethi
Liandong Wang
Ryan Ogilvie
Jarrod Braun
Kelly Shelts
Glenn Lane
Gann Swan
Al-yaqadhan Al-shukaili

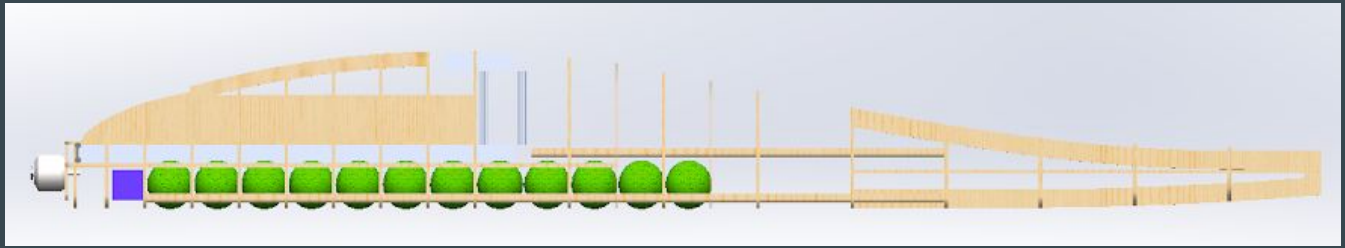


University of Tulsa's:

The "Dragonfly"

Specifications: Mission Requirements

- Aircraft must successfully complete a minimum of one 360° circuit.
- Takeoff distance must not exceed 200 ft.
- Landing distance must not exceed 400 ft.
- Aircraft must remain intact during takeoff, the circuit of the field, and landing.



$$FS = \$100P + \$50C - \$100E \text{ for each flight}$$

Specifications: Design

Two types of required payload:

- Passengers (tennis balls)
- Luggage (steel plates)

These must be stored in the “passenger cabin” and “cargo bay.”

An average luggage weight of ½ lb or more must be carried for each passenger carried.

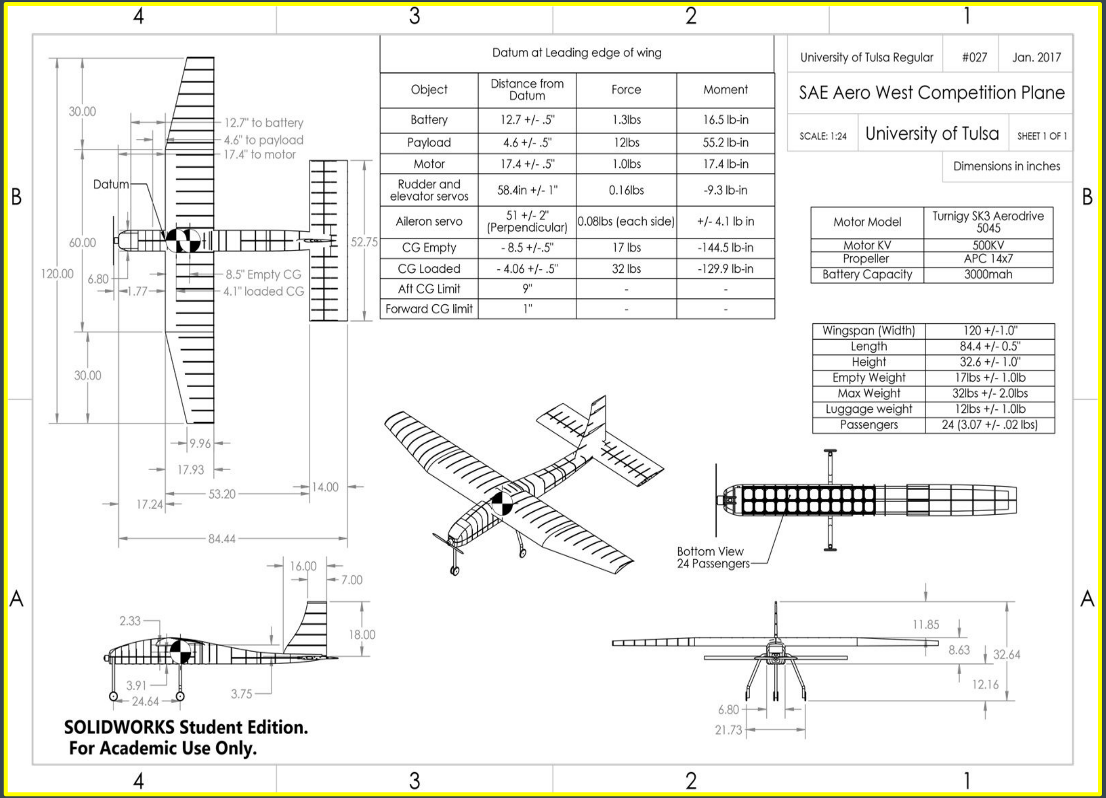
The compartments must be designed for ease of access.

Engineering Specifications & Design Criteria

Criterion	**Value**
Empty Weight	< 15 lb
Payload	≥ 15 lb
Takeoff Distance	< 200 ft
Overall Factor of Safety	1.33

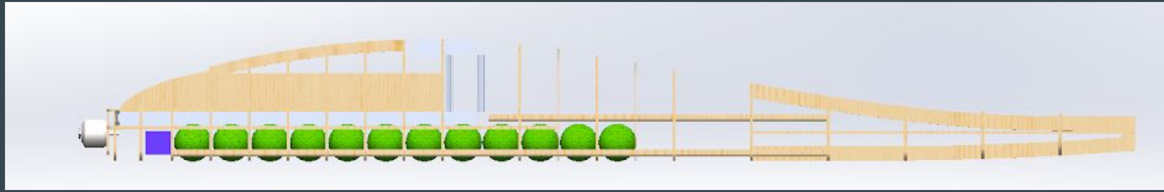
Design

- Mono wing
- Tricycle Landing Gear
- Wing Mounted on top for stability
- Fuselage streamlined to tail to reduce drag
- Puller Configuration

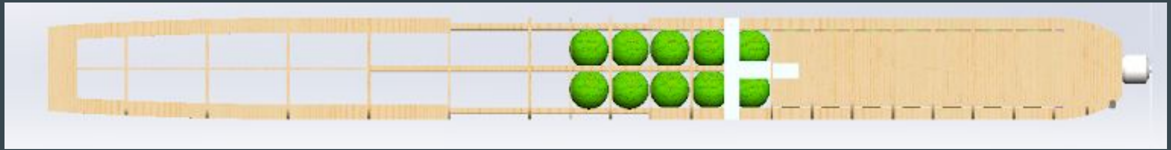


Passengers/Cargo Storage

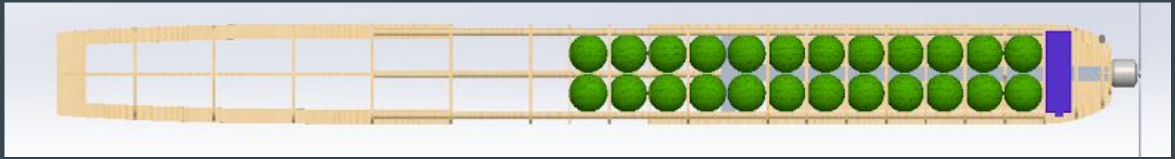
- Tennis balls (passengers) will be loaded from underneath via a hatch door
- Fuselage ribs are spaced at 2.7” (the diameter of a tennis ball) to space out passenger seats.
- Plates (luggage) will be loaded from the front and housed above the tennis balls



Side View

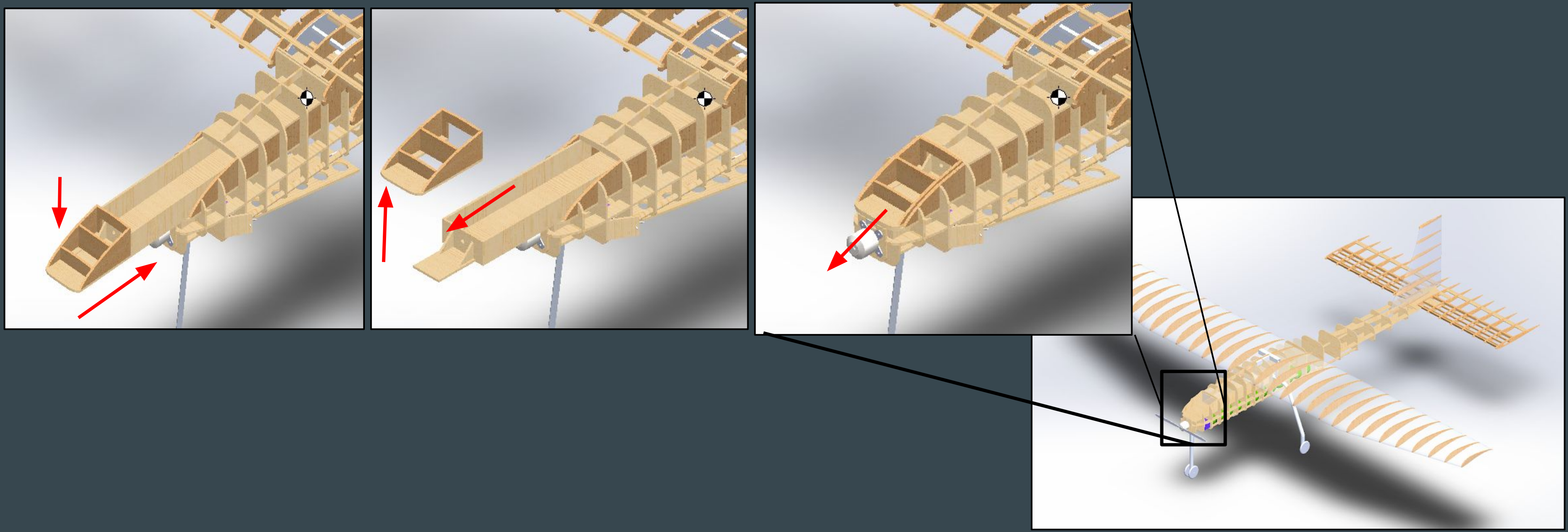


Top View



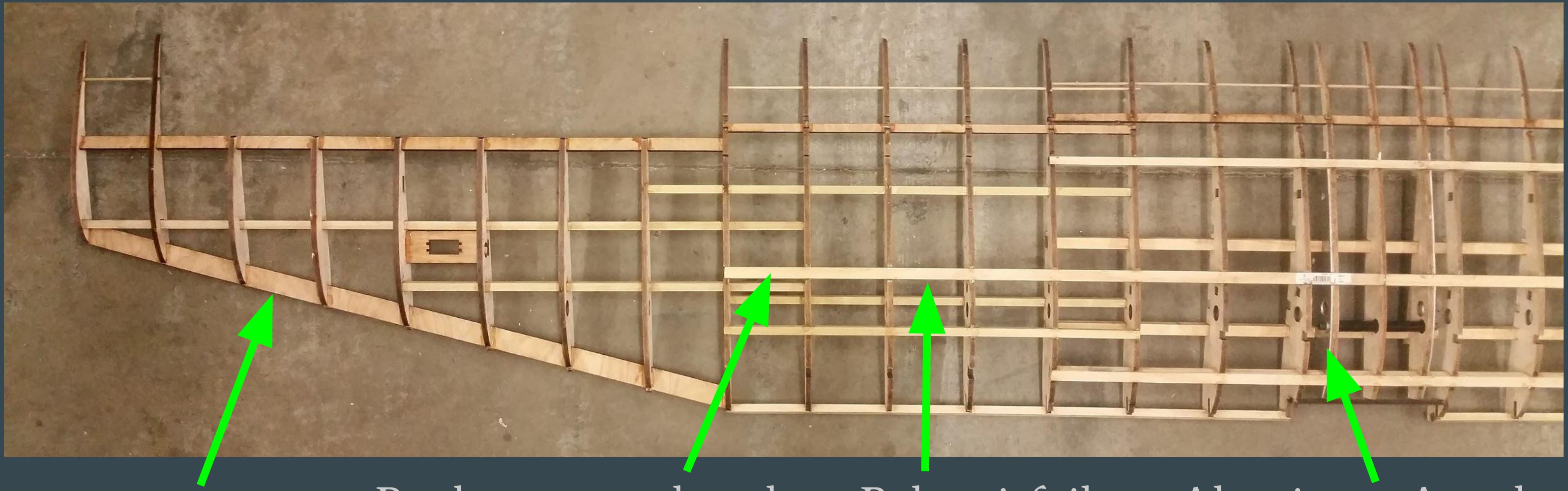
Bottom View

Cargo Storage



Structure +Materials

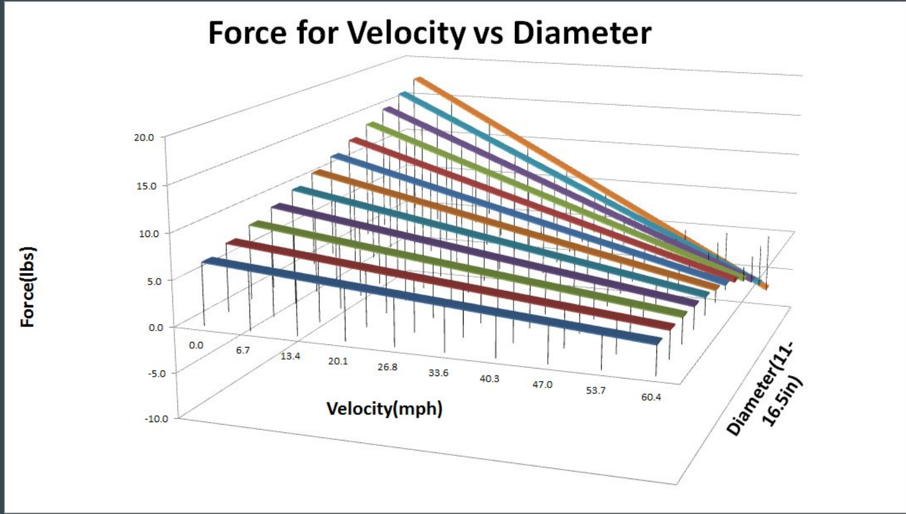
- Balsa ribs and airfoils (cut with laser)
- Pine sheet spars for attachment/fitting together + strength (cut with laser)
- Poplar square and round dowels for structure+ strength (cut by hand)
- Aluminum attachment plates to fuselage (cut by plasma cutter)

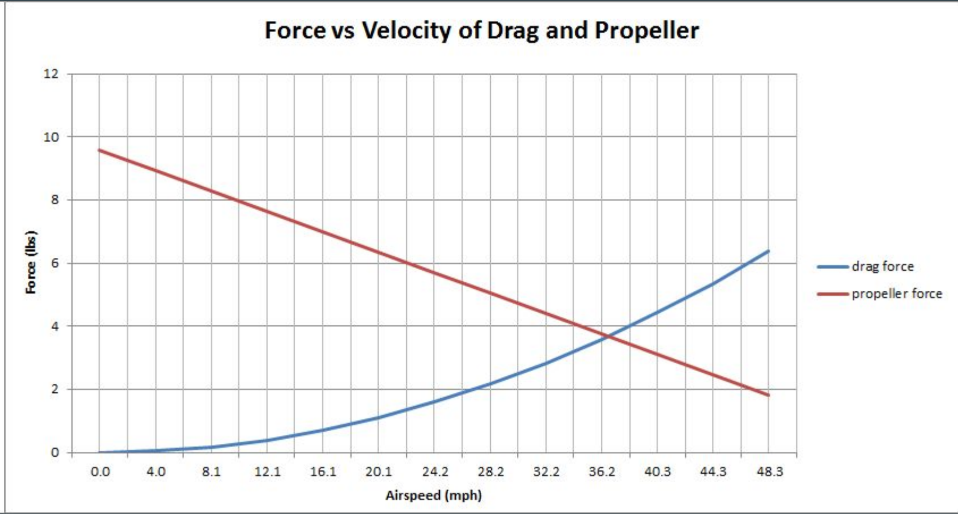


Weight

Component	Weight (lb)
Wing	4.4
Fuselage	5.2
Tail section	2
Motor	1
Landing gear	1
Hardware/glue	1
Total:	**14.6**

Propeller Calculations





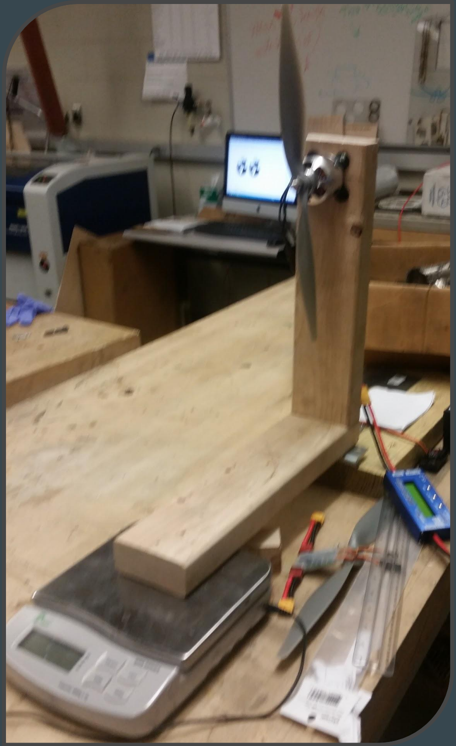
- Max 1000W set for Pitch + Diameter combinations at V=0
- Larger diameter = smaller pitch
- Propeller choice: 14x7E

- Max Airspeed: intersection of propeller force function and drag force curve
- Max Airspeed =~ 37mph

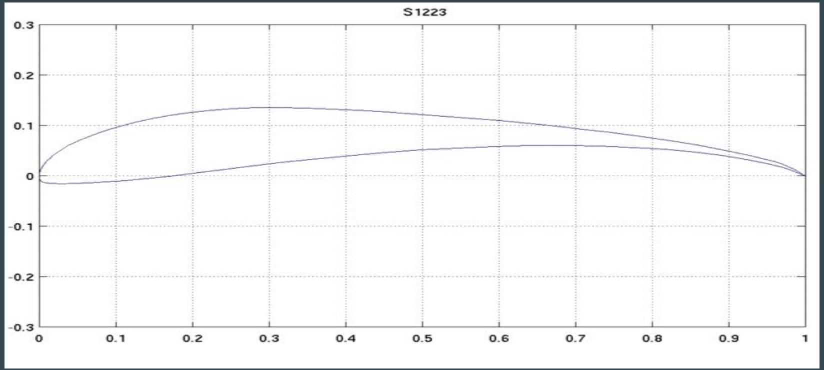
Measuring Static Thrust

- 450Kv, 14x7E-> 655W 6.90lbs
- 450Kv, 15x8E-> 850W 8.45lbs
- 450Kv, 16x8E-> 1190W 11.1lbs
- 500Kv, 14x7E-> 970W 8.70lbs
- 500Kv, 15x8E-> 1450W 12.3lbs

- Final -> 500Kv, 14x7E

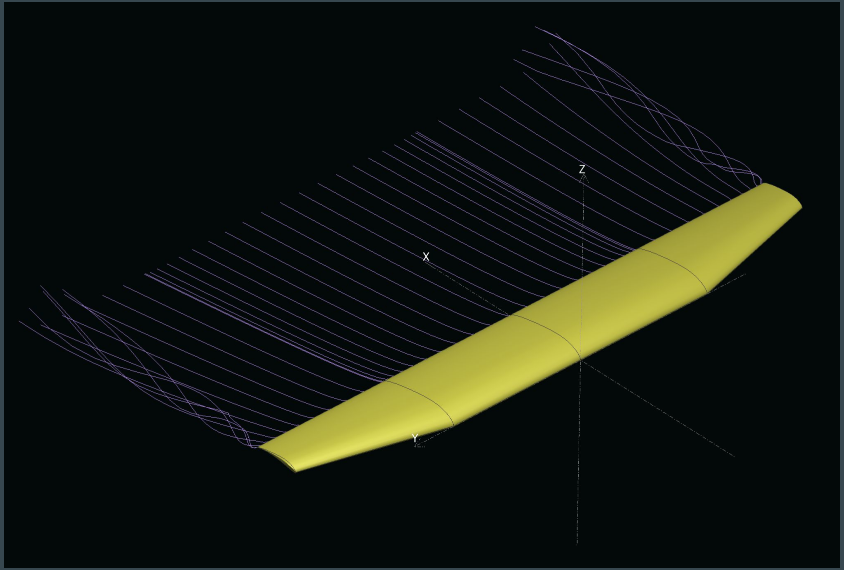


Airfoil



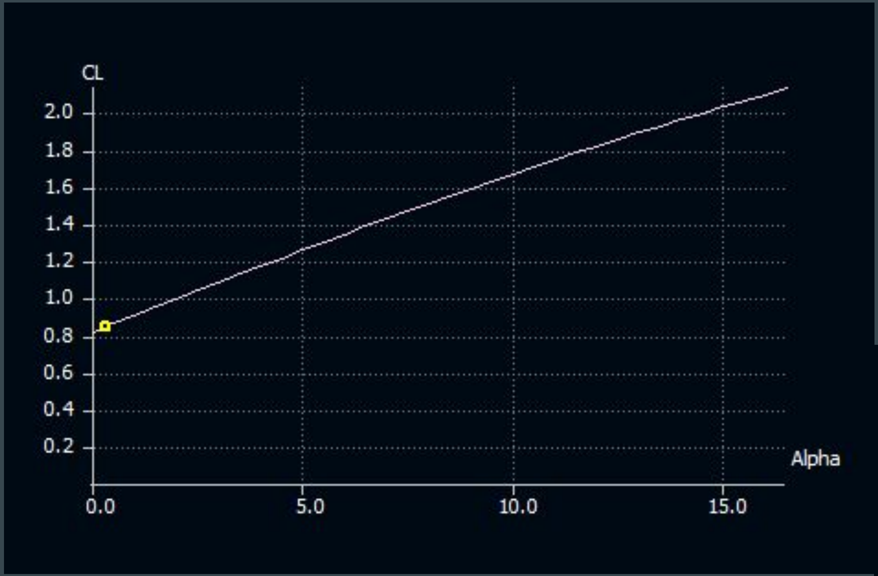
Airfoil	C_L at 0°	C_D at 0°	C_L/C_D at 0°	Max C_L
NACA 9312	0.844	0.019	44.6	1.5
FX74 CL5	1.09	0.025	41.8	1.62
CH10	0.93	0.024	39.5	1.62
S1210	0.99	0.018	55.7	1.77
S1223	1.11	0.02	55.3	1.84

Wing Section



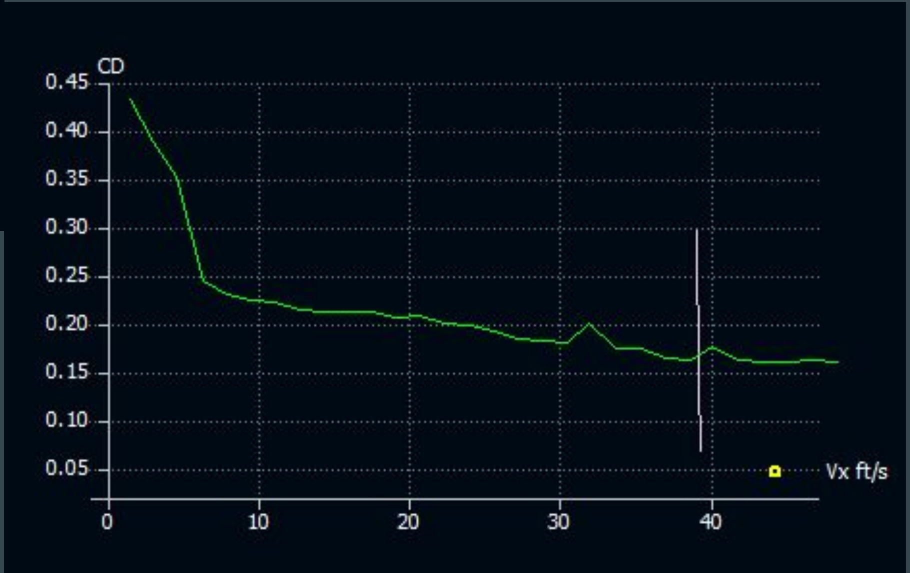
Wing Span	120 in
Root Chord Length	18 in
Taper Start	30 in
Tip Chord Length	10 in
Wing Area	13.34 ft^2

- Maintains large wing area with high lift coefficient
- Tapering reduces drag
- Easy to manufacture



Coefficient of lift vs angle of attack

Coefficient of drag vs velocity

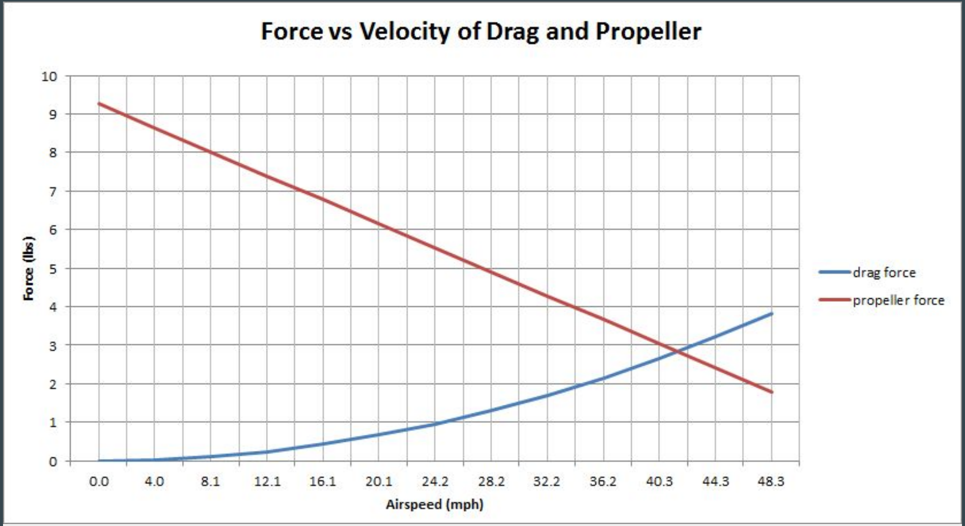


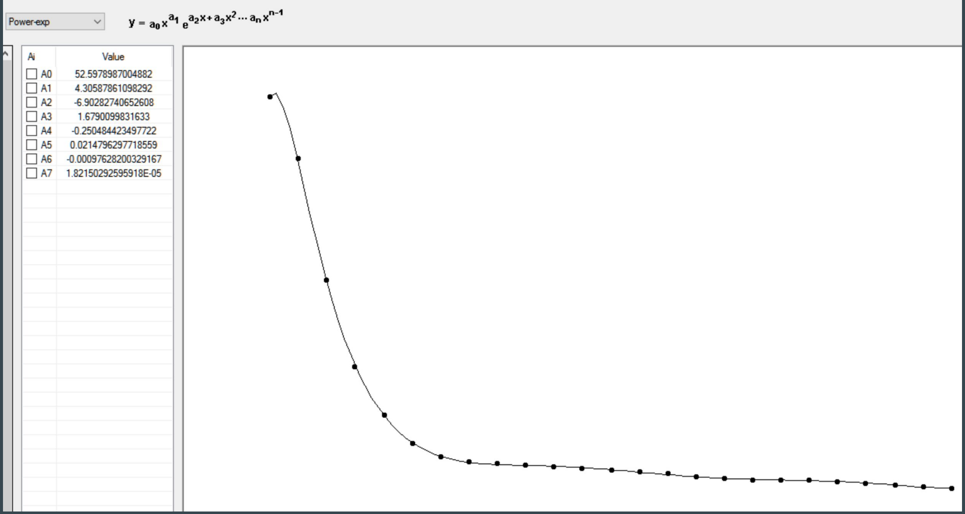
Mathematical Model

$$T_{net}(v) = T(v) - D(v) - f(v)$$

$$V(v) = v + a\Delta t$$

$$\Delta X(v) = x + v\Delta t + 0.5a\Delta t^2$$



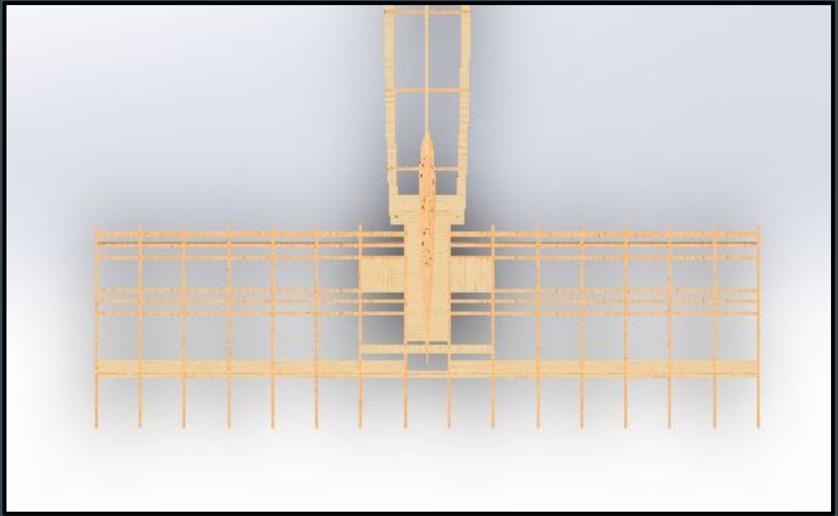


Score Prediction

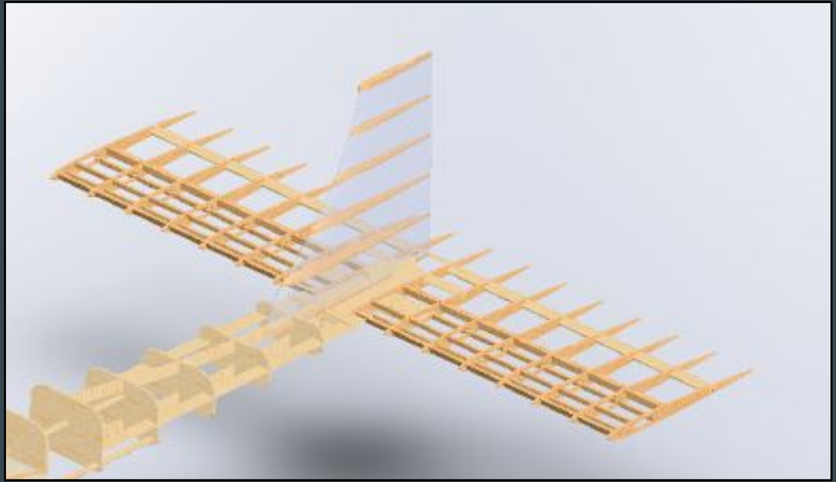
- Passengers: 24 (3 lbs)
- Luggage: 12 lbs
- Total Payload: 15 lbs
- Maximum Plane weight (Luggage + Empty + Passengers)
  - 32lbs
- $FS = \$100P + \$50C - \$100E \text{ for each flight}$
  - Flight Score per round: 3000
  - Final Flight Score: 75

$$\frac{1}{40\,N}\left[\sum_{1}^{N} FS\right] - \sum T$$

Tail Section



- Vertical stabilizer is shifted further forward than is conventional, to allow room for elevator movement.

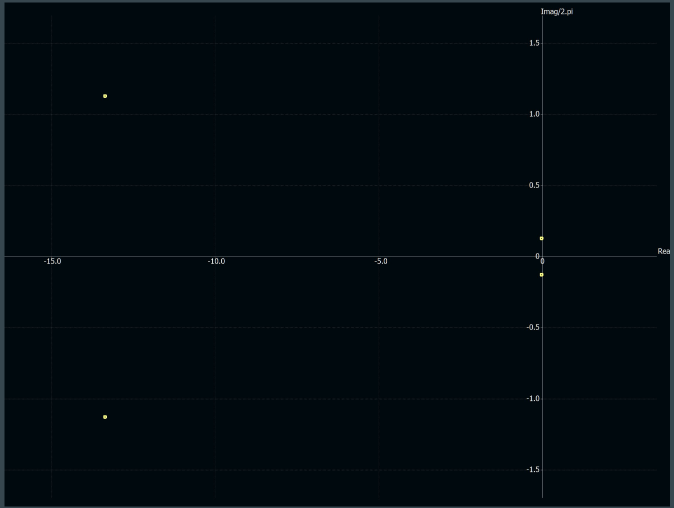


- Elevator is one uniform section, instead of split like conventional designs.

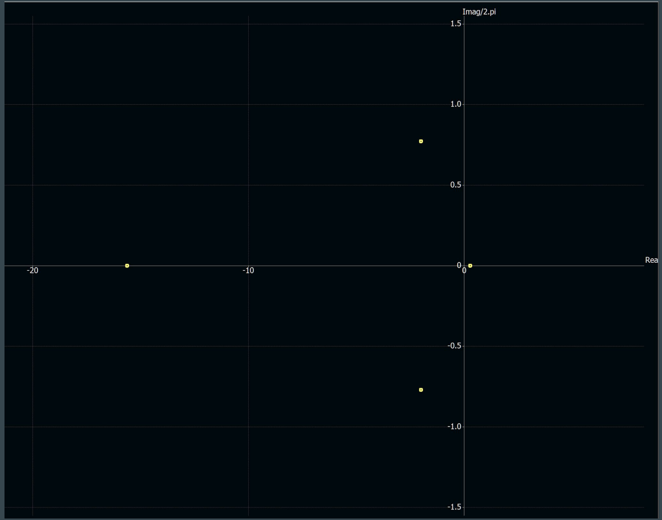
Stability

	Span (in)	Chord Length (in)	Area (ft^2)
Horizontal Stabilizer+Elevator	53	14	5.15
Elevator	53	4	1.47

	Height (in)	Base Chord L (in)	Top Chord Length (in)	Area (ft^2)
Vertical Stabilizer+Rudder	18	16	7	1.40
Rudder	18	3	3	0.375



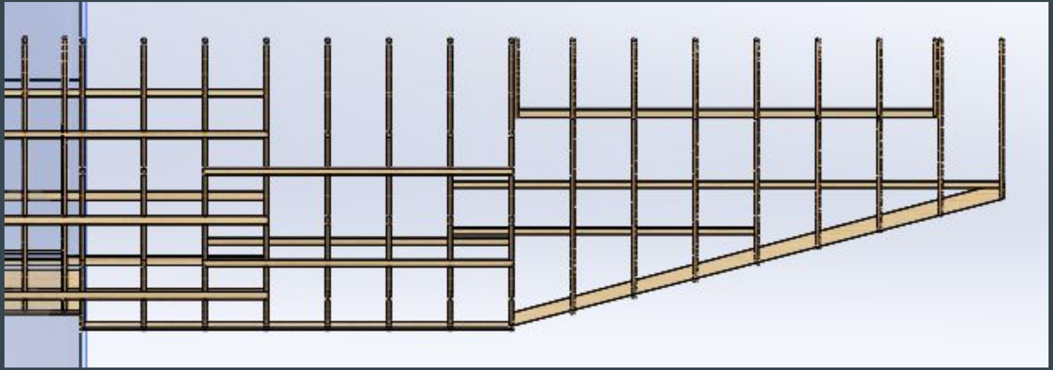
Longitudinal Root Locus Graph.



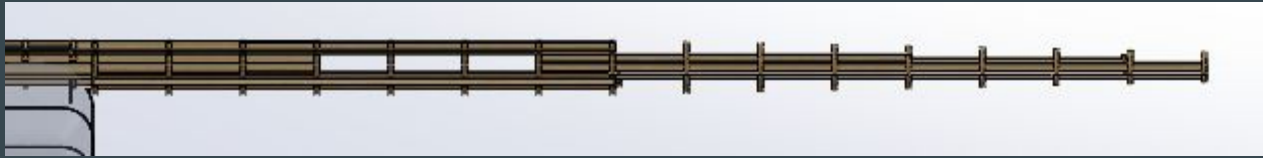
Lateral Root Locus Graph.

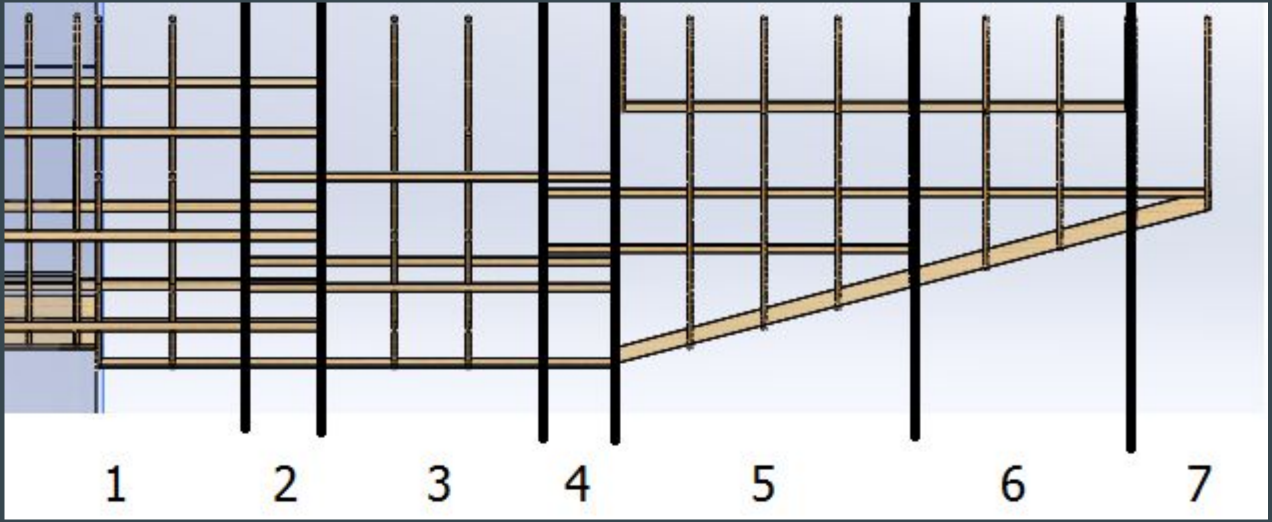
Wing Loading Analysis

- Originally treated wing as simple cantilever beam
- Due to changing area moment of inertia along wing, needed to be considered section-by-section
- Deflection and maximum stresses found for each segment, then combined for whole wing



Wing Loading Analysis - Cont’d





Wing Loading Analysis - Cont’d

Segment	Deflection (in)	Angle (degrees)	Max Stress (psi)
1	0.057438	0.574533	1683.992
2	0.003517	0.104694	789.8026
3	0.075994	0.707553	2132.878
4	0.004193	0.123328	963.3333
5	0.174623	1.100589	1638.722
6	0.140503	1.029745	2691.696
7	0.001144	0.023314	244.1406

For 0.5 lb/in distributed load:

Total deflection 0.457 in
Total angle
(wingtip angle) 3.66°
Max stress 2691 psi

For 1.5 lb/in distributed load:

Total deflection 1.37 in
Total angle 11.0°
Max stress 8075 psi

Budget

Material Cost: $755

Landing Gear	
Tube	$20.00
Wheels	$10.00

Wood	
Balsa	$150.00
Pine	$24.00
Dowels	$8.00

Electronics	
Control System DX7	$280.00
Batteries (2)	$106.00
Speed Controller	$30.00
Wires	$30.00

Hardware, etc	
Nuts and Bolts	$20.00
Glue	$45.00
Latches	$15.00
Hinges	$15.00
Control Horns	$4.00
Push Rods	$6.00

Estimated Engineering Cost:

$/Hour	Hours	Total
$50.00	700	$35,000.00

Schedule

	Week								
Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Analysis	■	■							
Design	■	■							
Writing SAE Report	■	■	■						
Design cont'd	■	■	■						
Analysis cont'd	■	■	■						
Detail Drawings		■	■						
Assembly Drawings		■	■						
Submit SAE Report			■						
Buy & Order Parts			■	■	■				
Laser cutting					■	■	■		
Fuselage assembly					■	■	■		
Assembly cont'd						■	■	■	■
Wing assembly						■	■	■	■
Tail Assembly						■	■	■	■
Electronics						■	■	■	■
Landing Gear						■	■	■	■
Analysis								■	■
Flight Testing								■	■
COMPETITION									■

Testing

- Results:
- -Plane flew with cargo
  - 6.5lbs + 16.6lb plane = 23 lbs total
  - Pilot Advice
  - Rough Landing
- Modifications:
- -Convert to Tail Dragger Landing Gear
- -Weight Reduction (2lb weight reduction)

Questions?

Solidworks CFD