2023 SAE Aero Design Competition Micro Class

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NAU NORTHERN ARIZONA UNIVERSITY

Meet the Team

Project Lead
Iain Pettit

Logistics Manager
Alexander Vierhout

Financial Manager
Gabriela Liquidano

CAD Engineer
Jacob Cabanyog

Testing Engineer
Devin Rossi duBois

Manufacturing Engineer
Alec Zodrow

Project Client - David Willy

Project Sponsors:
W.L. Gore
NAU College of Engineering, Informatics, and Applied Sciences
Terrance Hall Research Award

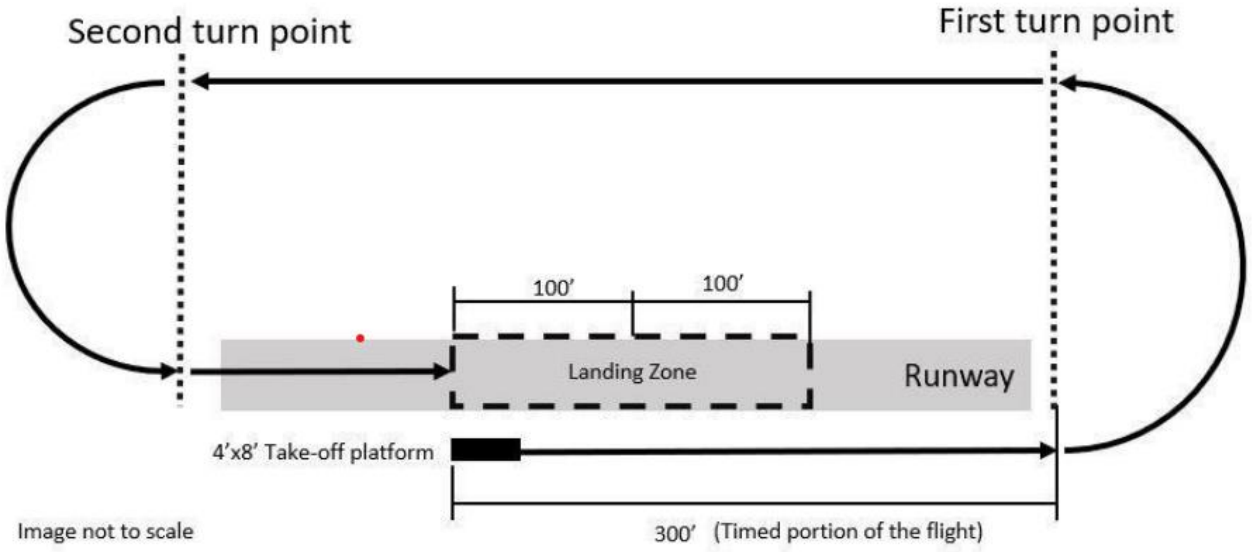
Project Description

Problem Statement

- Design a battery powered R.C aircraft to model real-world cargo planes
- Maximize Flight Speed
- Maximize Weight/Volume Cargo Capacity

Competition Design Constraints:

- 450 W maximum power consumption
- 3’ maximum wingspan
- 8’ takeoff distance
- 200’ landing Distance



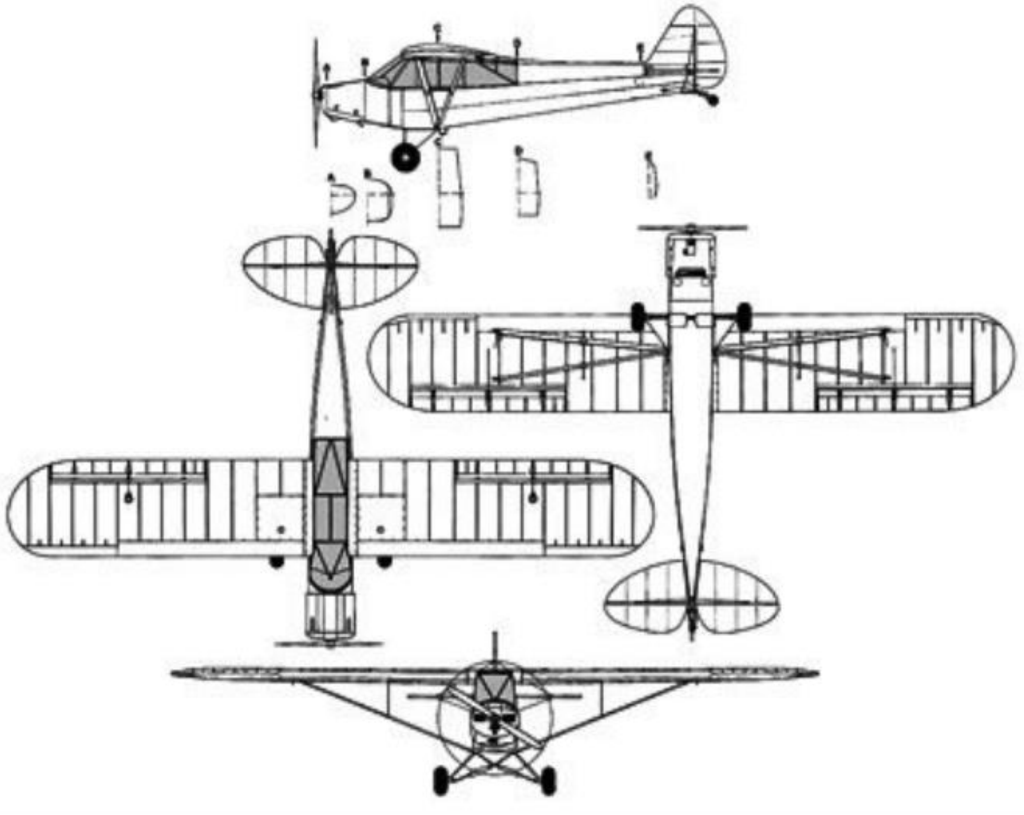
Project Requirements: CRs

Customer Requirements ranked from most important to least important:

1. Competition Ready
2. High Speed
3. Cost Effective
4. Stable Flight
5. Lightweight
6. Ability to Land
7. High Maneuverability
8. Short Takeoff Distance
9. Payload Capacity
10. Repairable
11. Durable

Project Requirements: ERs

1. Minimize Weight
2. High Thrust to Weight Ratio
3. High Lift to Drag Ratio
4. Maximize Power Consumption
5. Maximize Stress Tolerance
6. Minimize Total Cost



Design Decision Matrix

NAU SAE Aero 2023
9/21/2022

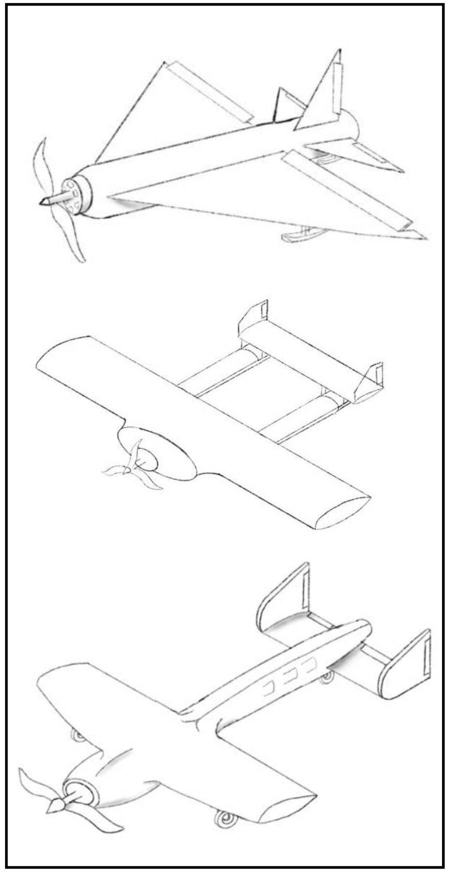
#	Technical Requirement	1	2	3	4	5	6
1	Reduce Total Cost						
2	Reduce Total Weight	+					
3	Increase Max Stress	-	-				
4	High Thrust to Weight Ratio	+	+	-			
5	High Lift to Drag Ratio			+			
6	Increase Total Part Count	+	-	-	-		
7	Maximize Power Consumption	-	-		+	+	

#	Customer Needs	Customer Weights	Reduce Total Cost	Reduce Total Weight	Increase Max Stress	High Thrust to Weight Ratio	High Lift to Drag Ratio	Increase Total Part Count	Maximize Power Consumption	1 Poor	2	3 Acceptable	4	5 Excellent
			Technical Requirements							**Customer Opinion Survey**				
1	High Maneuverability	4	3	9	0	9	9	0	1			C	A	B
2	Stable Flight	13	9	3	3	9	9	0	3				B	A
3	Lightweight	17	9	9	3	9	0	9	3		C	B		A
4	Durability	10	9	9	9	1	3	3	1		C	A	B	
5	Cost Effective	10	9	9	3	3	3	0	9		A	B	C	
6	Ability to Land	7	1	3	3	9	9	3	0		C	B		A
7	Competition Ready	19	3	9	9	9	9	9	9			C		A B
8	Short Takeoff	12	1	9	1	9	9	0	9			B C	A	
9	Payload Capacity	3	3	9	9	3	3	1	9	A		C	B	
10	Repairability	5	9	1	9	1	1	9	0		C	A B		
11	High Speed	2	1	9	3	9	9	0	9	C		A	B	
	Technical Requirement Units		**$**	**Lbs**	**PSI**	**Lbs/Lbs**	**Lbs/Lbs**	**#**	**W**					
	Technical Requirement Targets		600	4	200	1:1.6	4:5	5	450					
	Absolute Technical Importance		594	749	531	655	608	318	483					
	Relative Technical Importance		4	1	5	2	3	7	6					

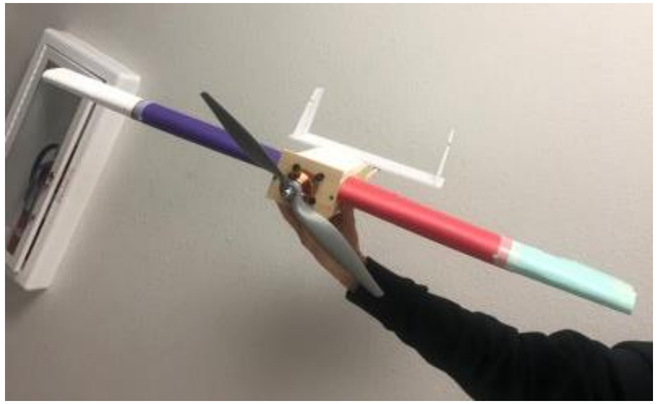
Key	Project
A	Georgia Tech 2021
B	Texas A&M 2020
C	NAU 2020

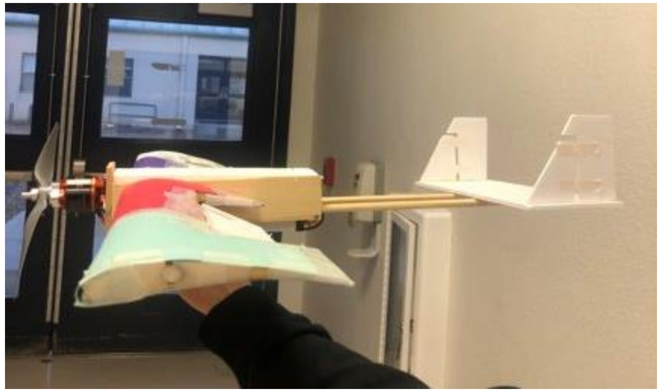
Project Starting Point

Conception Generation



Proof of Concept (First Iteration)

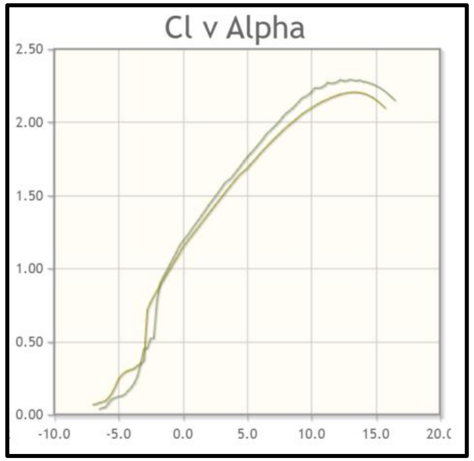




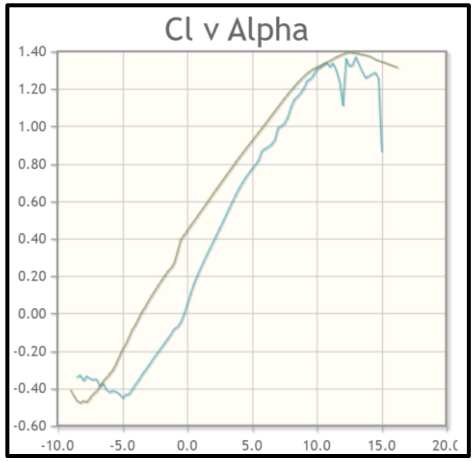
First Flight Test

Airfoil Analysis

Selig S-1223



Clark-Y



- High Camber
- High C_L for low speed aircrafts

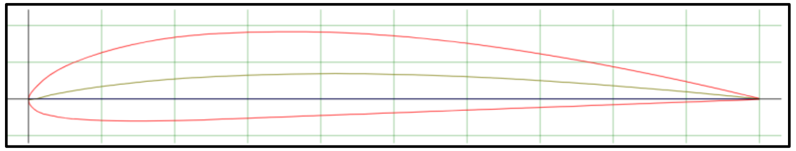
- Low Camber
- Allowed room for internals
- Easily Manufactured

*Design Utilizes an interpolation between the above airfoils geometries to construct the frame

<u>Critical Reynolds Numbers:</u>

Takeoff ~ 20,000

Cruising ~ 190,000



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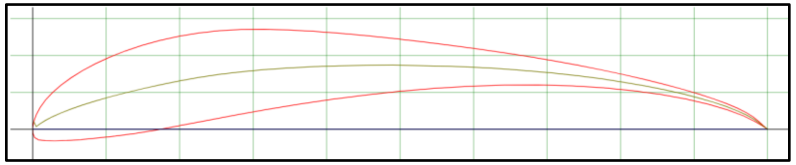
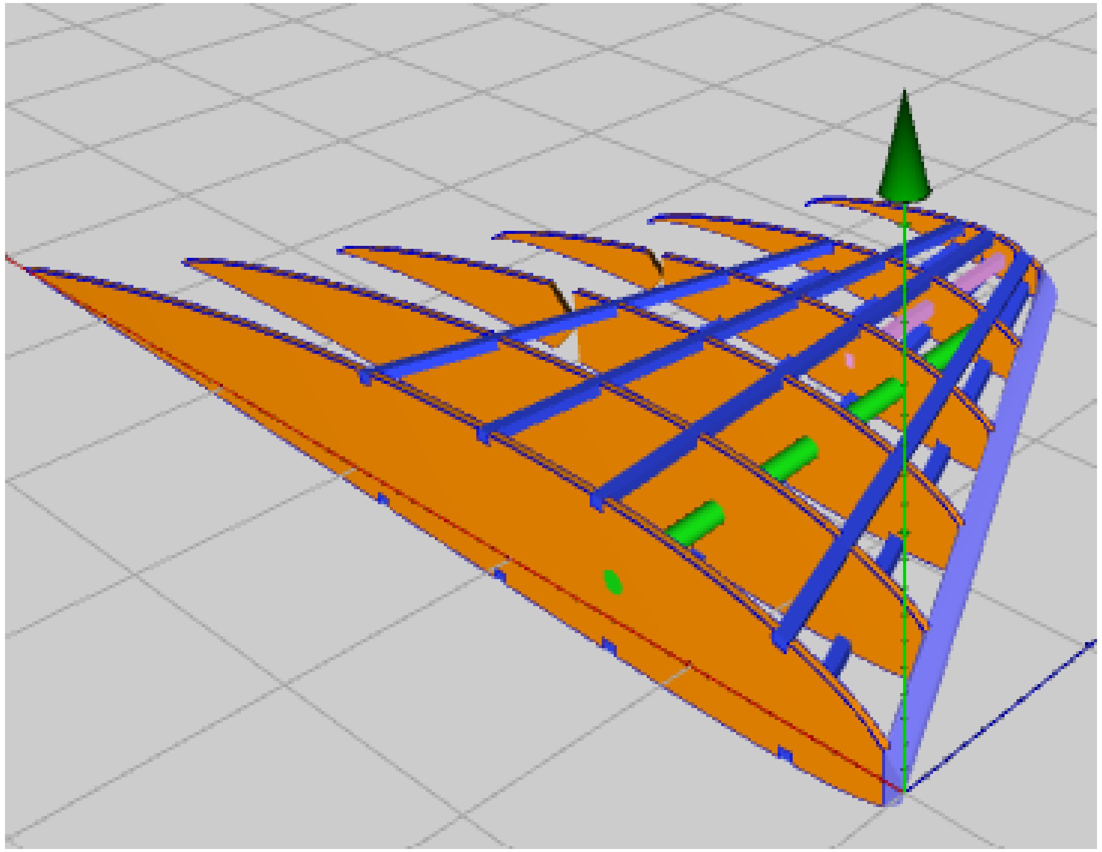


Selig S-1223

Wing Dimension Summary

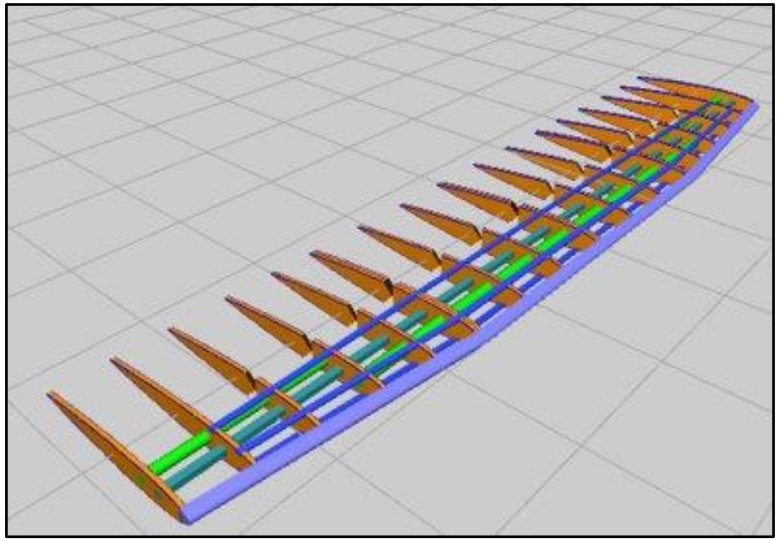
Initial Dimensions

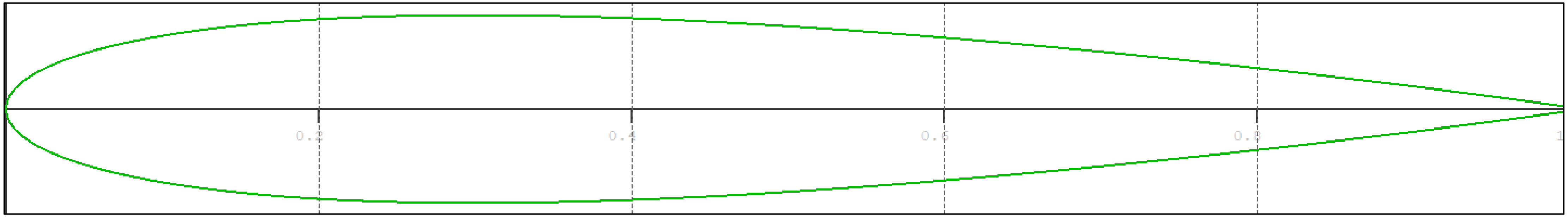
- Wingspan = 33 inches
- Average Wing Chord = 17.6 in
- Planform Area = $580.2\ in^2$
- Aspect Ratio = $\frac{span^2}{area}$ = 2.23



Horizontal Tail Selection

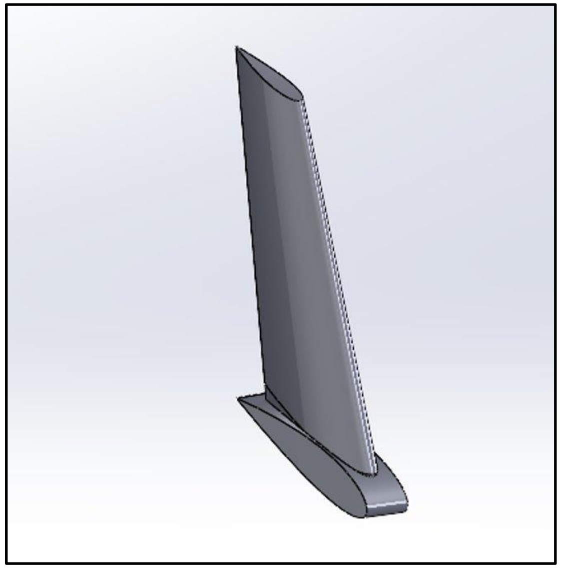
- NACA 0012 Airfoil
- Aspect Ratio: 1.6
- Planform Area: 157.5 in^2
- Flap Chord: 62%
- Flap Span: 90%
- TVC: 0.38

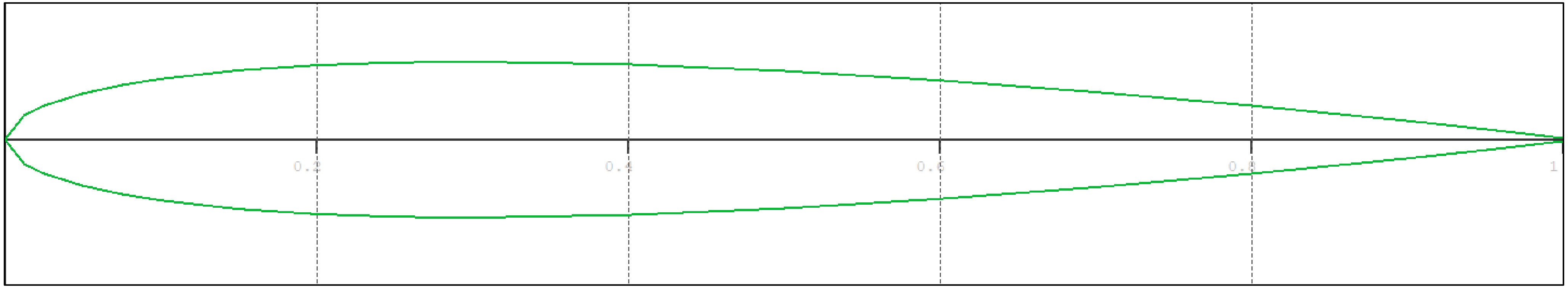




Vertical Tail Selection

- NACA 0010 Airfoil
- Planform Area: 22.5 in^2
- Double Fin Geometry
- TVC: 0.05





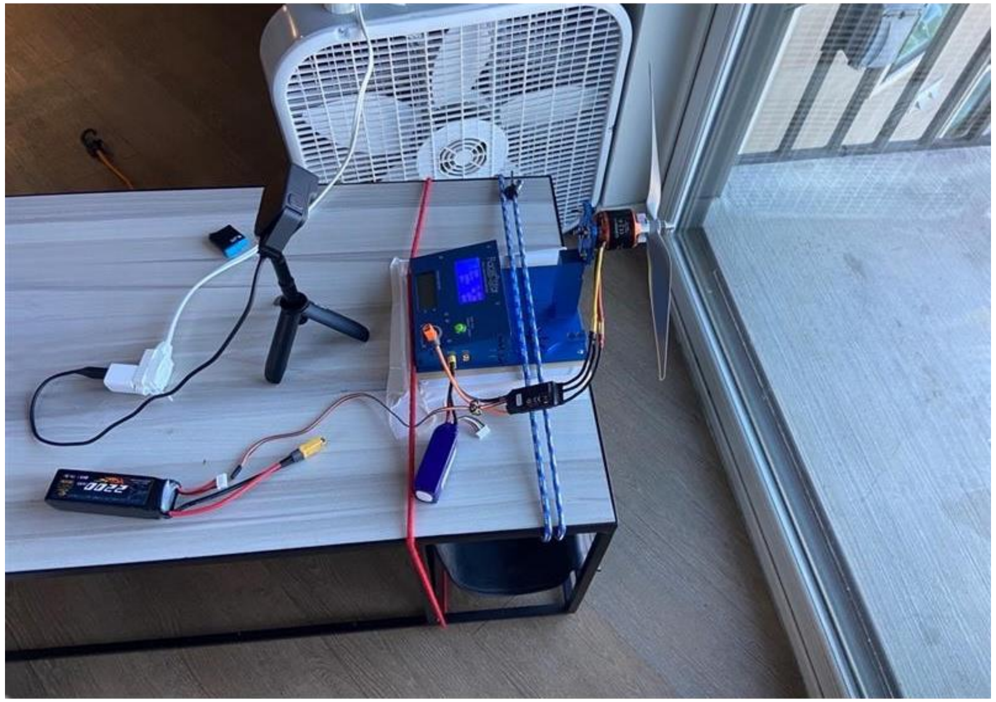
Propulsion Testing

<u>Static Propulsion Testing Results</u>

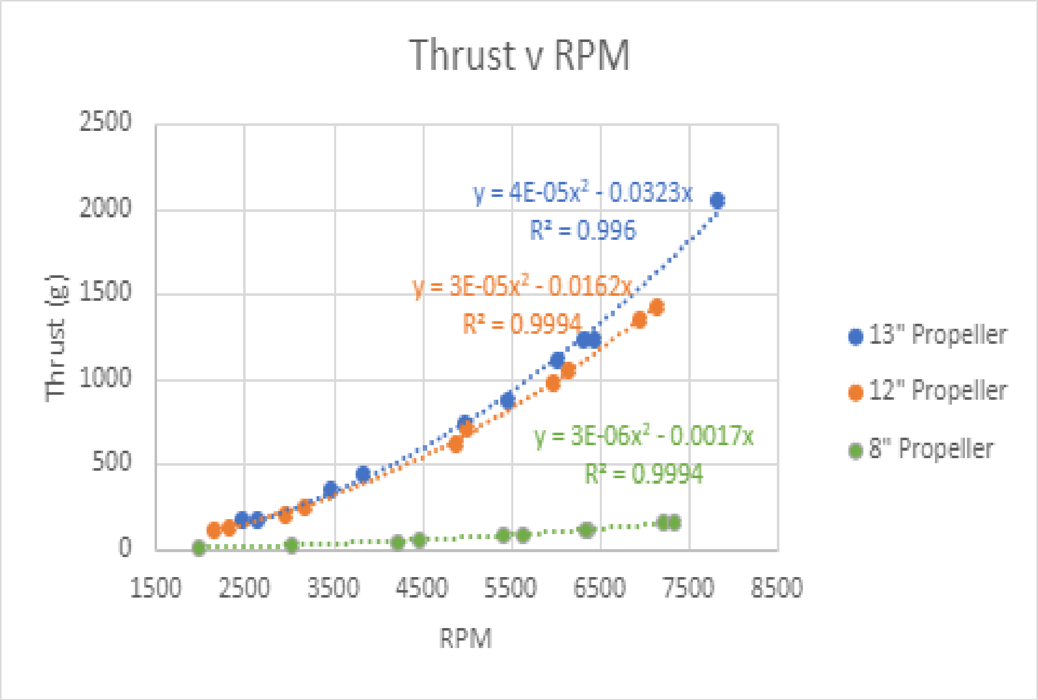
- From Three different sized propellers
- Thrust vs. RPM
- Thrust vs. Power
- Power vs. RPM
- COT and COP

<u>Measurement Devices</u>

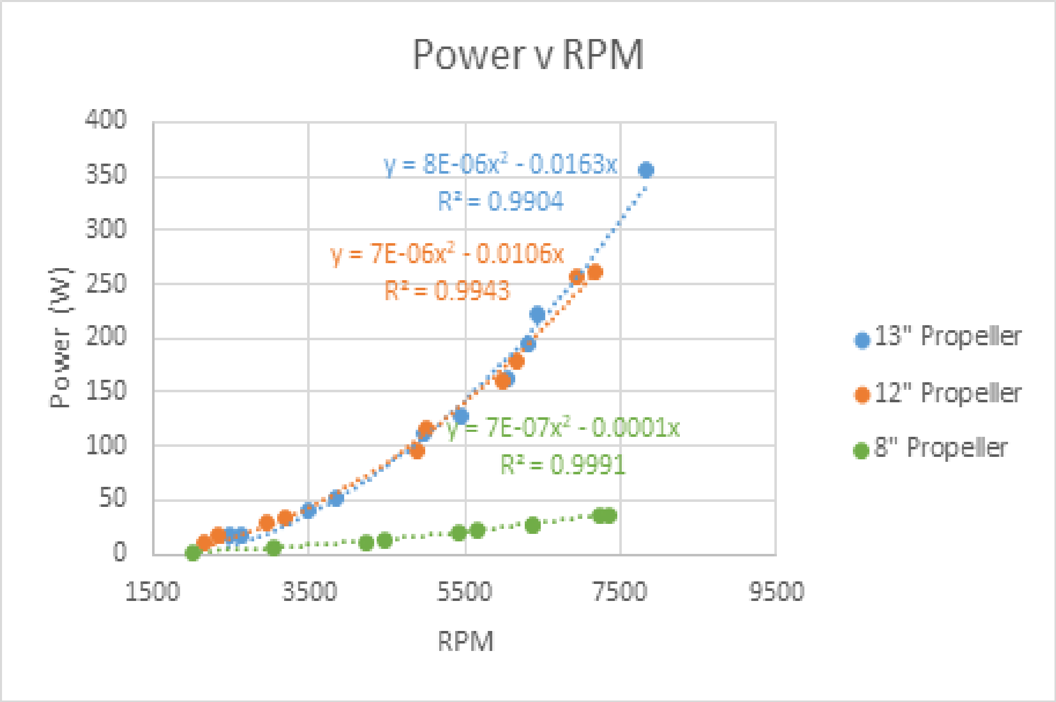
- Dynamometer
- Tachometer
- GoPro



Propulsion Testing Results

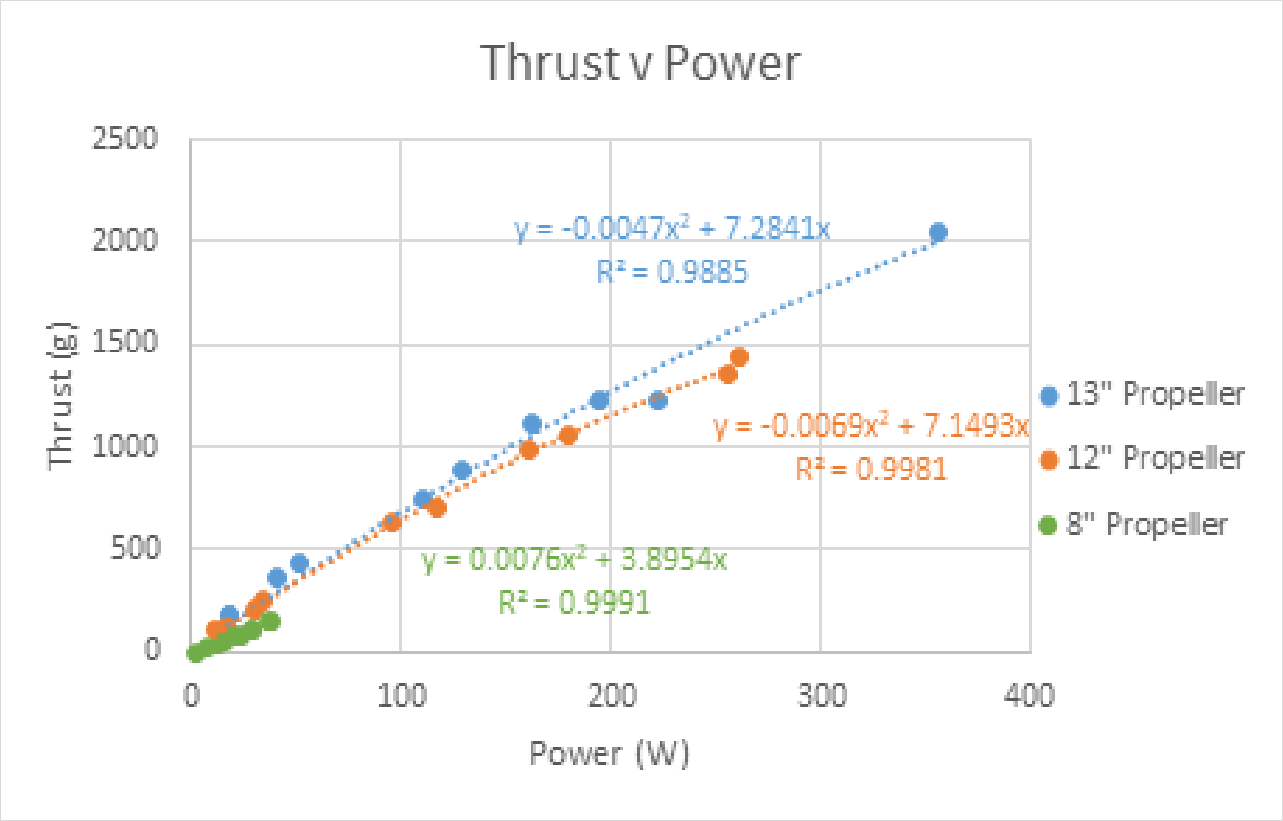


Thrust vs RPM



Power vs RPM

Propulsion Testing Results Cont.



Thrust vs Power

Propulsion Final Results Cont.

Propeller	Avg Coefficient of Thrust (C_T)	Avg Coefficient of Power (C_P)
8” Propeller	0.0456	0.0722
12” Propeller	0.0853	0.0607
13” Propeller	0.0703	0.0385

Takeoff Calculations

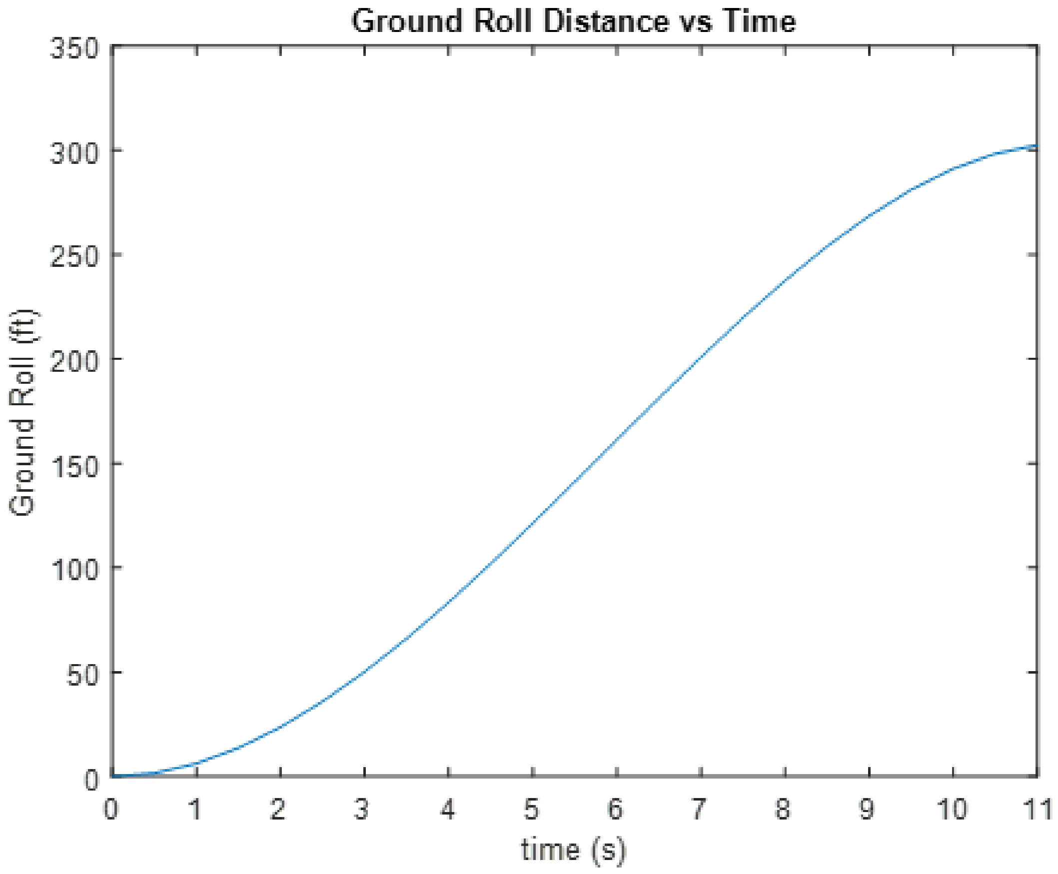
<u>Distance to Takeoff:</u>

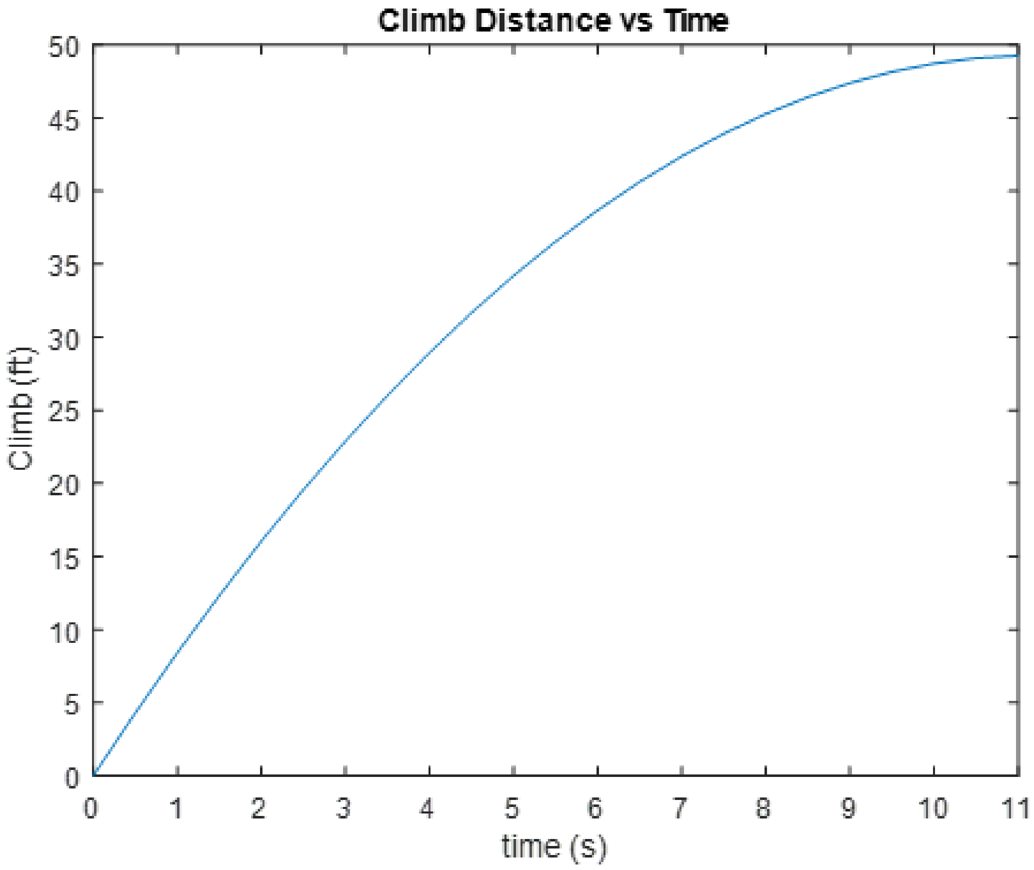
$$D_{takeoff} = \frac{1.21 * \frac{W_{empty}}{A_p}}{g * \rho * \frac{T}{W_{empty}}}$$

Weight	Thrust	Thrust-to-Weight Ratio
2.8 lbs	6.7 lbs	2.39

$D_{takeoff}$ =7.9 ft

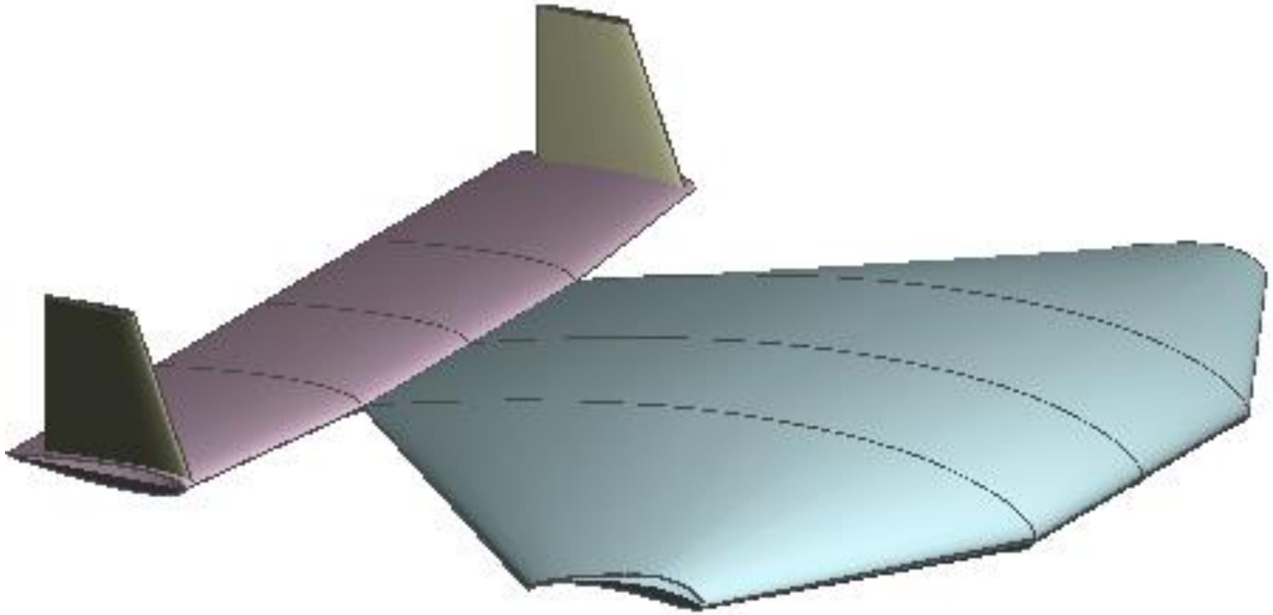
Payload Prediction Graph



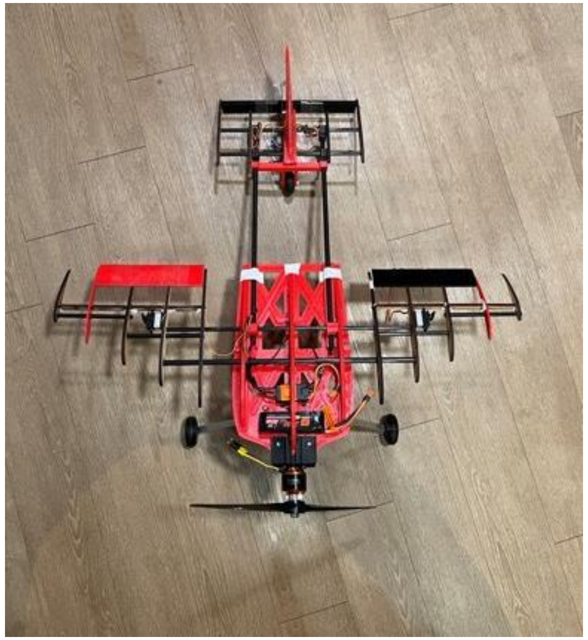


Stability and Control

- COG: 6.1 in
- NP: 7.97 in
- MAC: 19.4 in
- Static Margin: 9.6%



Construction Process



Bill of Materials

Starting Budget: $3000

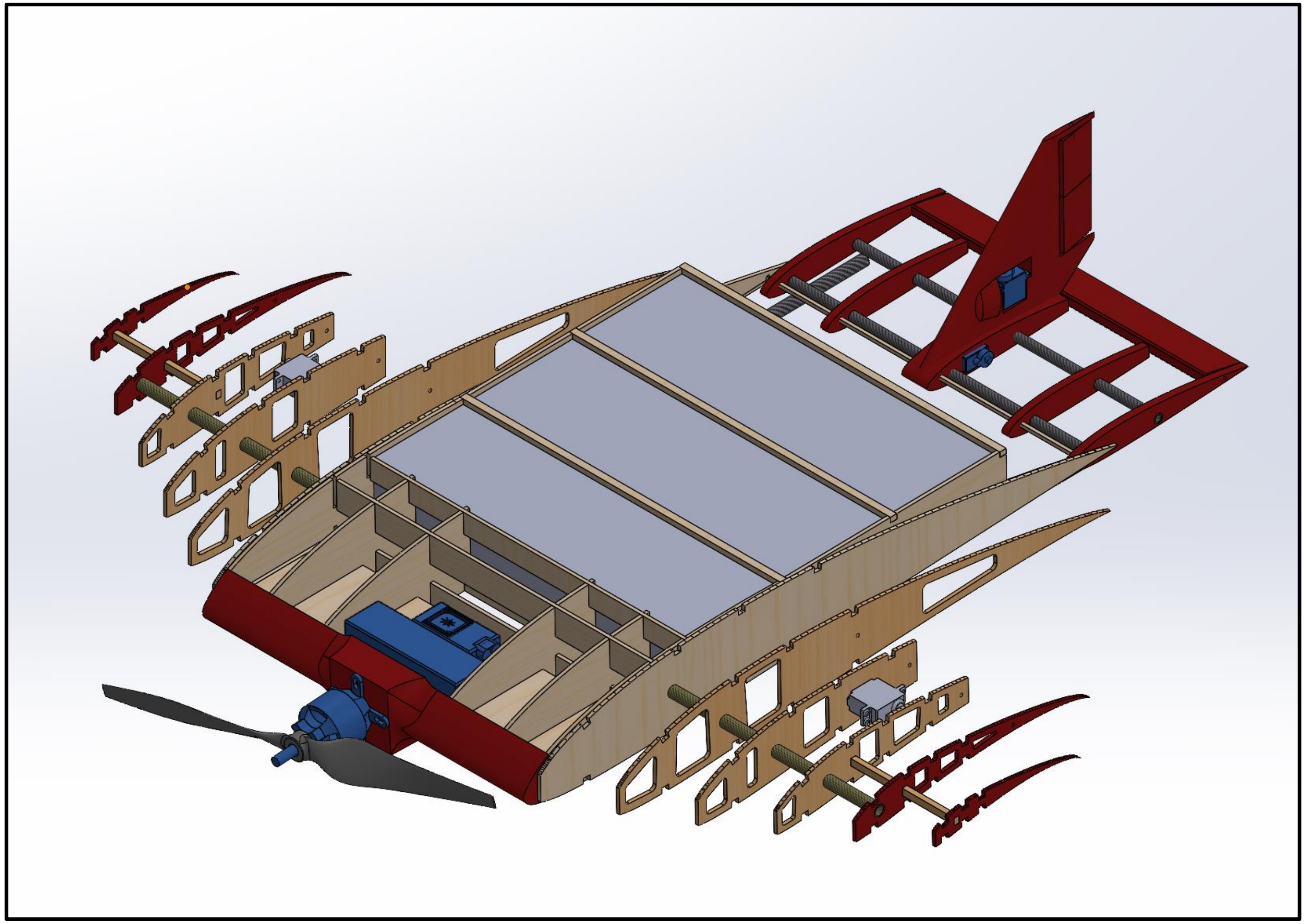
NAU CEIAS: +$1000

Terrance Hall Research Award: +$2846

Total: $6846

Item	Cost	Quantity	Total Price	Description	Primary Vendor/ Manufacturer
Sport Propeller 16x10 - 3 Blade	$5.13	1	$5.13	Main Motor Propeller	22F NAU SAE Team
Landing Gear Rear Wheel	$6.87	1	$6.87	The wheel for our rear langing gear mount	Amazon
Landing Gear Front Wheels	N/A	2	Donated	The wheels for our front langing gear mount	22F NAU SAE Team
Spektrum AR620 Receiver	N/A	1	Donated	"Motherboard" of plane	22F NAU SAE Team
Spektrum DX8E Transmitter	N/A	1	Donated	Plane Controller	22F NAU SAE Team
Avian 45 Amp Brushless Smart ESC, 3S-6S	$59.99	1	$59.99	Throttle controller for main motor	Horizon Hobby
Avian 4250-800Kv Outrunner Brushless Motor	$89.99	1	$89.99	Main Motor	Horizon Hobby
Spektrum 4 cell LiPo battery	$64.99	1	$64.99	Main Power Source	Horizon Hobby
Servo Motors	$10.20	4	$40.80	Control Surface motors	Horizon Hobby
SAE Power Limiter - Mirco	$85.00	1	$85.00	Competition required Watt Limiter	Neumotors
Red Arming Plug	$8.99	1	$8.99	Competition required "kill switch"	Gator RC
LED Kit	$2.50	1	$2.50	Indicating direction of flight	Home Depot
Fasteners	$4.16	2	$8.32	Various bots, screw, and nuts	Home Depot
Carbon Fiber Rods - 10mm x 500mm	$11.34	4	$45.37	Main Support Beams	Grainger
Carbon Fiber Rods - 8mm x 500mm	$6.15	4	$24.63	Main Support Beams	Grainger
Ultra-Coat	$20.00	2	$40.00	The wrap that will encompas the plane body	Hobby Bench
4 Pin Spinner 1-1/2", yellow	$9.00	1	$9.00	Safety cap for motor	Hobby Bench
Balsa Wood Airfoils	N/A	24	$25.00	Main Wing, Tail Wing, and Elevator ribs	NAU Idea lab
Balsa Wood Fuselage Components	N/A	6	$20.00	Balsa wood plates for housing cargo and internal components	NAU Idea lab
Control Surfaces	N/A	5	$7.50	All control surfaces for the planes (ailerons)	3D Printing
Vertical Tail Wing	N/A	1	$1.50	The Vertical Tail Wing (rudder)	3D Printing
Front Motor Mount	N/A	1	$1.00	Mounting design to hold the motor in place	3D Printing
Mounting Brackets	N/A	4	$6.50	Carbon Fiber/Nylon joints for main support beams	3D Printing
Front Landing Gear Mount	$8.97	1	$8.97	Mounting design to hold the front landing gear to the plane	Hobby Bench
Rear Landing Gear Mount	N/A	1	$5.00	Mounting design to hold the rear landing gear to the plane	3D Printing
Weight Plates	N/A	2	Donated	Weighted plates for competition scoring	Nau Machine Shop
		Total	$567.05		

Final Design



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Thank you SAE