CDR - Rise of the Phoenix

2023 Speedfest Orange Team

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TEAM STRUCTURE

- **Chief Engineer** – Jonah Weltzheimer

- **Aerodynamics S&C Lead** – Payton Simmons
  - Aero Engineer I – Kyler Bridenstine
  - Aero Engineer I – Caleb Todd
  - Aero Engineer I – Jared Goldman
- **Propulsion Lead** – Carson Rutherford
  - Propulsion Engineer I – Omar Abouzahr
  - Propulsion Engineer I – Zac Hallman
  - Propulsion Engineer I – Madison Morton
  - Propulsion Engineer I – Erasmo Dominguez
  - Propulsion Engineer I – Mirijan Hovsepain
  - Propulsion Engineer I – Kohl Schuler
- **Structures Lead** – Ethaniel Tobar
  - Structure Engineer I – Andrew Cottingham
  - Structure Engineer I – Benjamin Fishback
  - Structure Engineer I – Hunter Riley
  - Structure Engineer I – Britney Dunlap
  - Structure Engineer I – Garrett Martin
  - Structure Engineer I – Hayden Spillars
  - Structure Engineer I – William Watson
- **CAD/Design Lead** – Jack Buss
  - Design Engineer I – Patrick Cheatham
- **Marketing** – Jared Goldman
  - Social Media Designer – Britney Dunlap
  - Website Designer – Madison Morton
  - Music Producer – Caleb Todd

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SCHEDULE

Gantt Chart

CDR Overall Tasks

CDR Sub-team Tasks

USE TO SCROLL BY WEEKS!

ACTIVITY:	PROGRESS	START DATE	END DATE
Milestones			
Preliminary Design Review	100%	2-Feb	2-Feb
Critical Design Review	0%	23-Feb	23-Feb
Prototype Rollout	0%	27-Mar	27-Mar
Final Design Freeze	0%	5-Apr	5-Apr
Aircraft Grounded	0%	24-Apr	24-Apr
Speedfest	0%	28-Apr	30-Apr
Critical Design Review			
Optimization/Analysis Propulsion	75%	6-Feb	8-Feb
Optimization/Analysis Aerodynamics	75%	6-Feb	8-Feb
PDR - Rocket Testing Confirmation	100%	7-Feb	7-Feb
Complete Avionic Layout/Configuration	100%	8-Feb	10-Feb
Completion in Overall Configuration - CAD/Sizing	100%	10-Feb	13-Feb
Complete Internal/External/Ground Support Structural Layout	100%	12-Feb	15-Feb
Complete Updated CAD	100%	12-Feb	14-Feb
Construction Plans	50%	15-Feb	18-Feb
Finalized Gantt Chart for Construction and Testing	90%	20-Feb	22-Feb
Completed Drawings and Plans	0%	20-Feb	22-Feb
Detailed Bill of Materials	50%	20-Feb	22-Feb
Selection of Primary Propulsion Systems	95%	15-Feb	17-Feb
Structures/CAD			
Research/Benchmark - Materials	100%	6-Feb	16-Feb
RATO Implementation - Launch Stand, configuration, integration	30%	6-Feb	20-Feb
Testing Preparation - Coupons, 3D Printing, CAD, Construction Plans	100%	8-Feb	15-Feb
Testing - Rocket Thermal Signatures, Loadings	100%	15-Feb	21-Feb
Construction Build Plan	50%	14-Feb	21-Feb
OML Intiation	100%	6-Feb	10-Feb
Preliminary Plug/Mold (Practice)	100%	10-Feb	13-Feb
Endplate Integration	90%	12-Feb	13-Feb
Finalizing Testing Development	80%	12-Feb	14-Feb
Finalization of Material Selection	100%	13-Feb	16-Feb
Finalization of Internal Structure	100%	15-Feb	17-Feb
Final RATO Development	60%	13-Feb	15-Feb

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BUDGET

Projected Budget

(B.O.M) for Prototypes

Orange Team

Oklahoma State Universtiy

date: 2-Feb-23

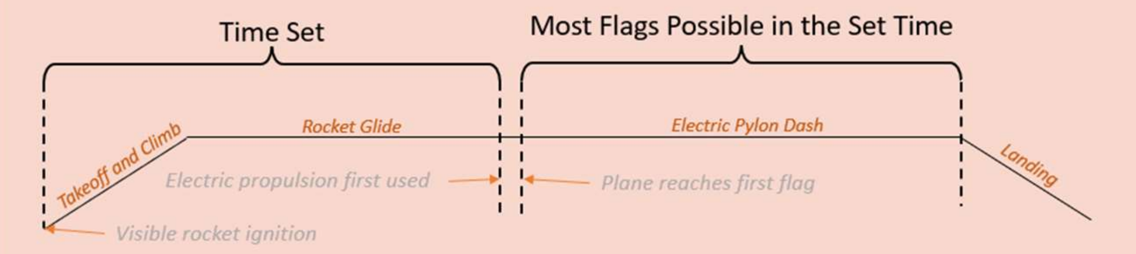
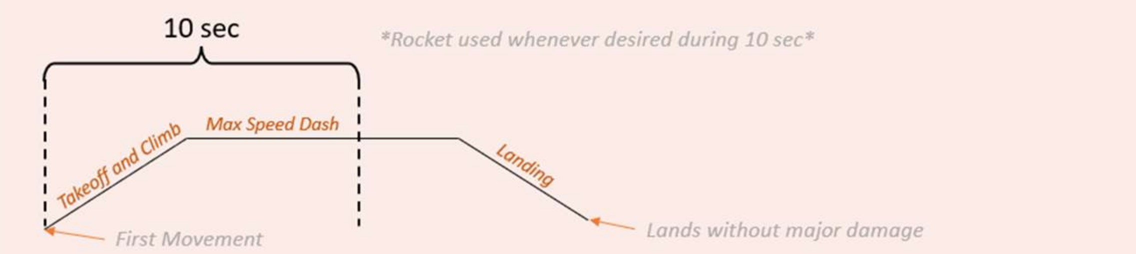
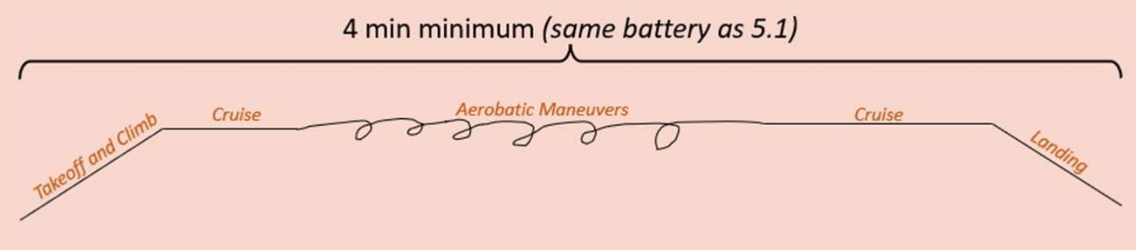
Customer: Speedfest

Total Budget	$ 2,645.55	Labor Costs:	$ -
Actual Cost	$ 2,587.94	Avionics Costs:	$ 1,184.76
		Material Costs:	$ 178.39
		Hardware Costs:	$ 311.53
		Testing Costs	$ 913.26

Item Name	Item Type	description	link	Unit (budget)	Qty	Total (budget)	Unit (actual)	Qty	Total (actual)
motor	avionics	2814-1560Kv Brushless Motor	BadAss 2814-1560Kv Brushless Motor (badasspower.com)						
Main Battery	avionics	Tattu R-Line 1550 mAh 18.5V 120C	Tattu R-Line Version 3.0 1550mAh 18.5V 120C 5S1P with XT60 Plug (genstattu.com)						
ESC	avionics								
Receiver	avionics	Jeti Duplex EX R9 2.4GHz Rec. w/Telemetry	Jeti Duplex EX R9 2.4GHz Receiver w/Telemetry (espritmodel.com)						
Aux Battery	avionics	Jeti Receiver Batt Pack 1300mAh 7.4V LiPo	Jeti Receiver Battery Pack 1300mAh 7.4V Li-Poly (espritmodel.com)						
Rocket	avionics	F50-4T Standard Single Use Motor	F50-4T Standard Single Use Motor (rocketryworks.com)						
servo	avionics		KST X08 V6.0 HV Servo | HeliDirect						
Rocket	avionics	Apogee Medalist Motor - F10-4 (1pk)							
Rocket	avionics	Aerotech 29mm Propellant Kit - F40W-4							
Rocket	avionics	Aerotech 29mm Motor - F25-6W							
Rocket	avionics	Aerotech 29mm Motor - F50T-4							
Rocket	avionics	Cesaroni - P24-3G White - Longburn (F30)							
Rocket	avionics	Firewire Mini Initiator (6/pk)							
Rocket	avionics	RC Switch with Small Low-Side Mosfet							
battery	avionics	TATTU 1300mah 5S 75C 18.5V LiPo Battery and Freestyle							
wood	testing	2inX 10in X 8 ft (southern yellow pine)	pickup order / lowes						
wood	testing	2in x 4 in X 92-5/8 Whitewood	pickup order / lowes						
wood	testing	Power Pro 2-1/2in Epoxy Wood Screws	pickup order / lowes						
keeney	testing	Keeney 1-1/4in Brass Threaded Both Ends	pickup order / lowes						
rocket	testing	ProCast Pyrogen mix	https://www.apogeerockets.com/Rocket-Motors/Motor-Starters/ProCast-Mix						
CNC Molds	Labor	-							
Main Battery	avionics	Graphene LiPo 1050 5S 18.5v Battery Pack	https://maxamps.com/collections/5s-lipo-battery-18-5v/products/graphene-lipo-1050-5s-batte						
ESC	avionics	PHOENIX EDGE LITE 100 AMP ESC	https://www.castlecreations.com/en/phoenix-edge-lite/phoenix-edge-lite-100-esc-010-0111-						
ESC	avionics	PHOENIX EDGE LITE 75 AMP ESC	https://www.amazon.com/Castle-Creations-Electronic-Speed-Controller/dp/B00CSXSELY/ref=s						
	hardware	MTM ACR7-18 Ammo Crate	https://www.amazon.com/MTM-ACR7-18-Ammo-Crate-Utility/dp/B01CNP4HOY/ref=zg_bs_196						
	hardware	Super Lube Synthetic Multi-Purpose Grease	https://www.amazon.com/Super-Lube-21030-Synthetic-Grease/dp/B000XBH9HI/ref=sr_1_2?cri						
	hardware	Castle Link V3 USB Programming Kit	https://www.amazon.com/Castle-Creations-CSE011-0119-00-Link-Programming/dp/B0716SH9V						
Motor	avionics	BadAss	https://innov8tivedesigns.com/badass-2814-1950kv-brushless-motor.html						
	avionics	RC Switch with Small Low-Side Mosfet	https://www.servocity.com/rc-switch-with-small-low-side-mosfet/						
	hardware	RMS-29/40-120 MOTOR HARDWARE	RMS-29/40-120 Motor Hardware (apogeerockets.com)						
rocket case	hardware	Cesaroni 24mm 3-Grain Case	https://www.apogeerockets.com/Rocket_Motors/Cesaroni_Casings/24mm_Casings/Cesaroni_						
	avionics	Cesaroni 24mm Standard Aft Closure	https://www.apogeerockets.com/Rocket_Motors/Cesaroni_Casings/24mm_Casings/Cesaroni_						
rocket	testing	AEROTECH 29MM MOTOR - F50T-6	Aerotech 29mm Motor - F50T-6 (apogeerockets.com)	$42.36	16	$ 677.76	$42.36	16	$ 677.76
rocket	testing	CESARONI - P24-3G SMOKY SAM (F79)	Cesaroni - P24-3G Smoky Sam (F79) (apogeerockets.com)	$28.38	7	$ 198.66	$28.38	7	$ 198.66
matches	hardware	First Fire Jr. Starters	https://www.apogeerockets.com/Rocket_Motors/AeroTech_Accessories/First_Fire_Jr_Starter?cPath=7_160&#description	$17.67	2	$ 35.34	$17.67	2	$ 35.34
propeller	avionics	Aeronaut White Turbo Spinners for Folding Propellers	https://www.espritmodel.com/aeronaut-white-turbo-spinners-for-folding-propellers.aspx	$22.00	2	$ 44.00	$22.00	2	$ 44.00

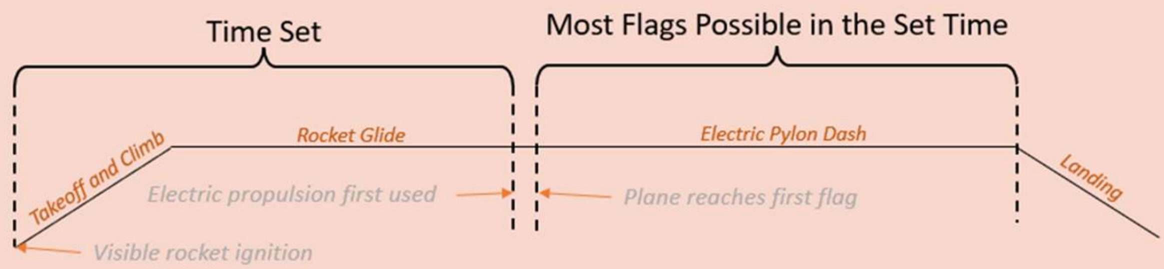
Total budget:		$ 2,645.55	Total Actual:		$2,587.94
55	1	$ 55.00	$ 56.99	1	$ 56.99
30	1	$ 30.00	$ 37.09	1	$ 37.09
25				1	
50	1	$ 50.00	$ 105.00	1	$ 105.00
25	1	$ 25.00	$ 13.00	1	$ 13.00
35	3	$ 105.00	$ 29.44	1	$ 29.44
50	3	$ 150.00	$ 45.00	3	$ 135.00
$ 30.00	1	$ 30.00	34.6	1	$ 34.60
$ 20.00	1	$ 20.00	24.6	1	$ 24.60
$ 35.00	1	$ 35.00	38.51	1	$ 38.51
$ 40.00	1	$ 40.00	42.36	1	$ 42.36
$ 23.00	1	$ 23.00	23.03	1	$ 23.03
$ 20.00	1	$ 20.00	20.63	1	$ 20.63
$ 20.00	1	$ 20.00	19.98	1	$ 19.98
$ 30.00	1	$ 30.00	29.99	1	$ 29.99
16.26	1	$ 16.26	15.12	1	$ 15.12
2.97	1	$ 2.97	2.76	1	$ 2.76

CONOPS/MISSION

Mission Name	Mission Profile	Points Available
5.1.1 Pylons		Based on number of flags in the set time 1st: 15 2nd: 10 3rd: 5 4th: 0
5.1.2 Max Speed		Based on max speed in the 10 seconds 1st: 15 2nd: 10 3rd: 5 4th: 0
5.2 Endurance/ Flight Demonstration		Based on flying at least 4 min and doing cool maneuvers Judges: 0-5

CONOPS/MISSION

MISSION # 1

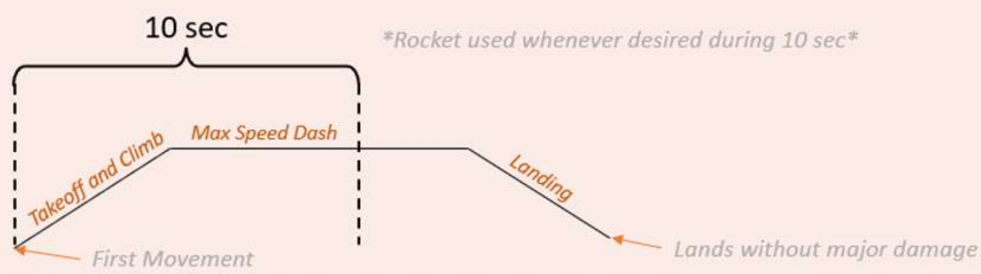
5.1.1 Pylons		Based on number of flags in the set time 1st: 15 2nd: 10 3rd: 5 4th: 0

RATO	•Maximizing T/W •Rocket through center of gravity •Minimize profile, cross-sectional drag
Glide	•High L/D •Low W/S •Minimal weight
Pylons	•Quick turns •Minimize weight •Low energy loss in turns

CONOPS/MISSION

MISSION # 2

5.1.2
Max Speed

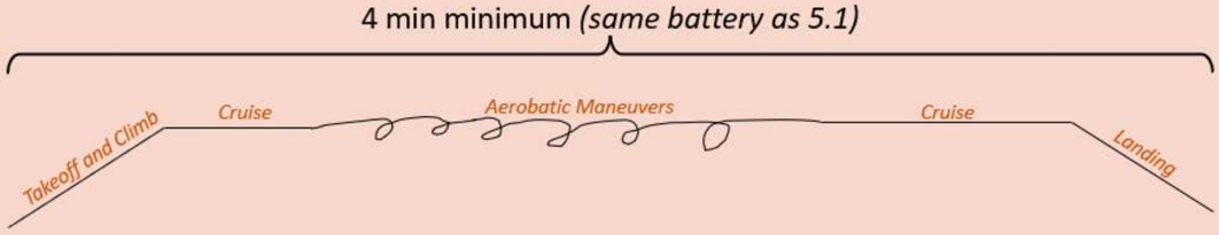


Based on max speed in the 10 seconds
1st: 15
2nd: 10
3rd: 5
4th: 0

Takeoff	•Short Takeoff •Hand-launch, Sled-Launch
Orientation	•Quick maneuvering •Efficient electric Propulsion •Fast climb
Speed	•High Acceleration •Minimal drag •Lightning speed w/Rocket boost

CONOPS/MISSION

MISSION # 3

5.2 Endurance/ Flight Demonstration		Based on flying at least 4 min and doing cool maneuvers Judges: 0-5

Aerobatics

- Demonstrate Conventional Aerobatics
- Marketing Uniqueness of aircraft (Rocket Stunts)

Endurance

- Fly for > 4min on same battery in mission # 1

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CONOPS/MISSION

MISSION # 4

Website	•Motivating/Encouraging/informative Website Design
Video	• < 2minutes •Engaging, Story-telling, Professional
Social Media	•Create a presence/influence

PDR RECAP

Concerns/Questions:
- Manufacturing Tail Boom
- Fluttering
- Material Selection
- Heat Mitigation

Answers:
- Layup Practice
- Material Strength Tests
- Increase Benchmarking
- Rocket Tests

PROPULSION

Testing

Rockets/Connections/Transmitter

PROPULSION

Testing

Rockets/Connections/Transmitter

Aerotech F25
Max thrust: 47 N
Burn time: 3.1 s

TC#4 – 1984°F
TC#3 – 1719°F
TC#2 – 1222°F
TC#1 – 540°F

PROPULSION

Testing Results

Carbon Tube

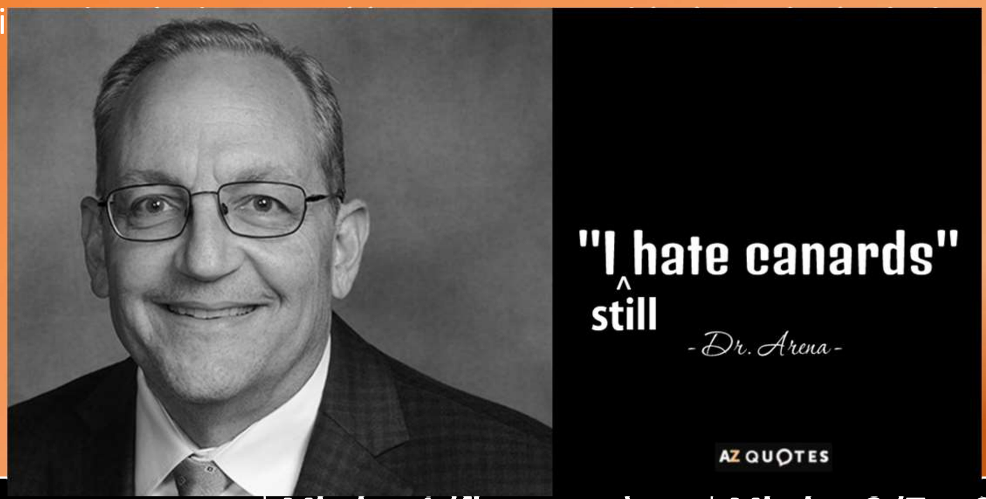
Degradation after firing
- Severe damage to tail boom
- Multiple layers burned through

Heat Mitigation
- Ceramic paint
- Aluminum foil top layer
- Different boom material selection

AERO RESULTS

Conceptual Check

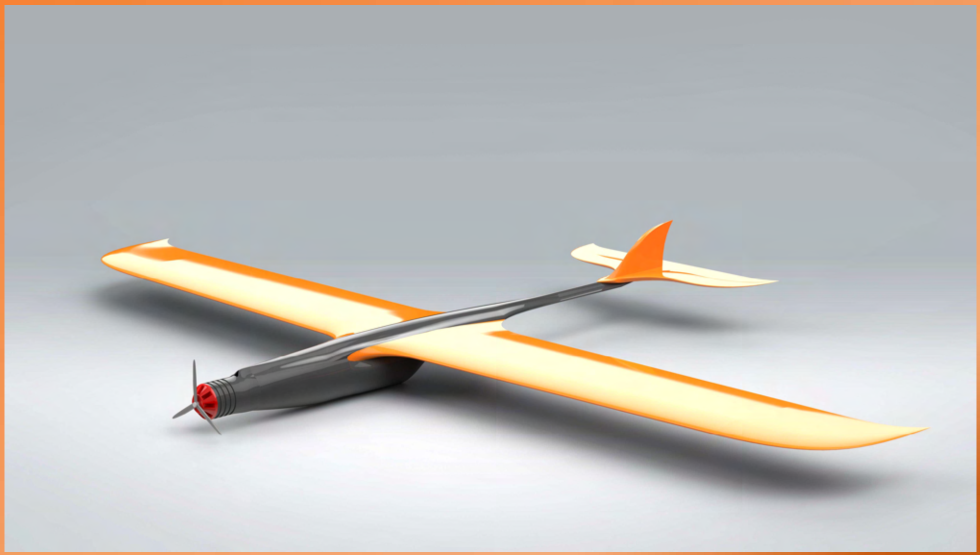
Checked to make sure the flyi



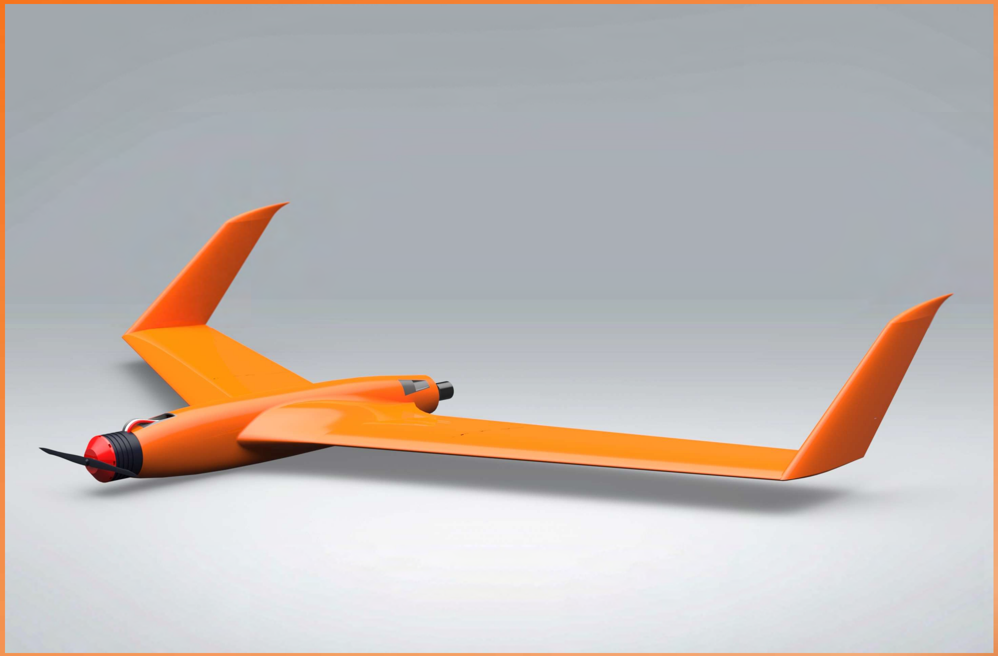
Constants:
- S
- Reynolds Number
- AR
- Motor
- Propeller
- Launch Angle
- Rocket Burn Offset

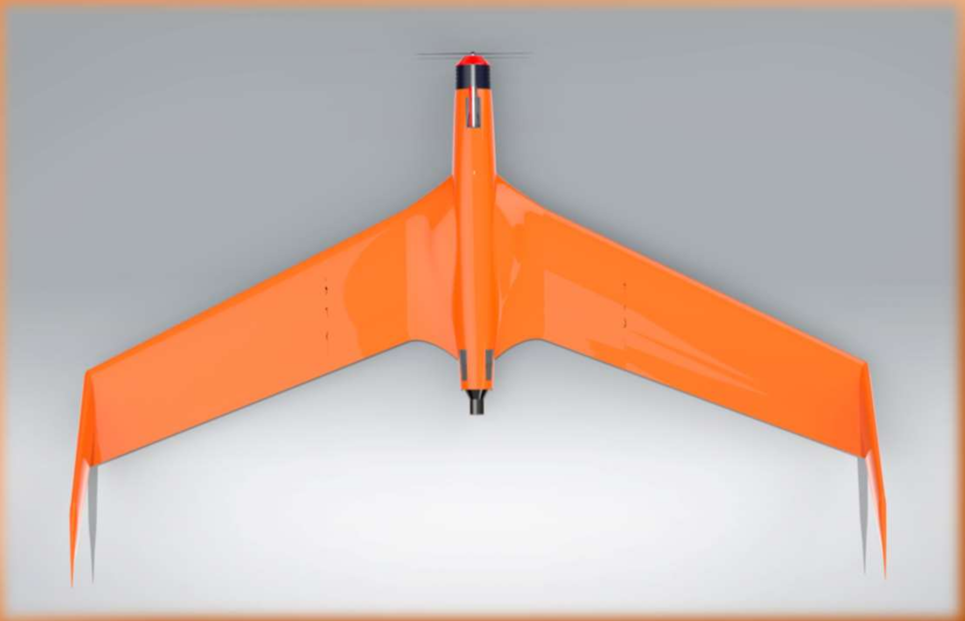
Plane Type	Mission 1 (flag count)	Mission 2 (Top Speed (mph))
Tadpole	23.5	284.05
Flying Wing	25.1	267.11

BEFORE

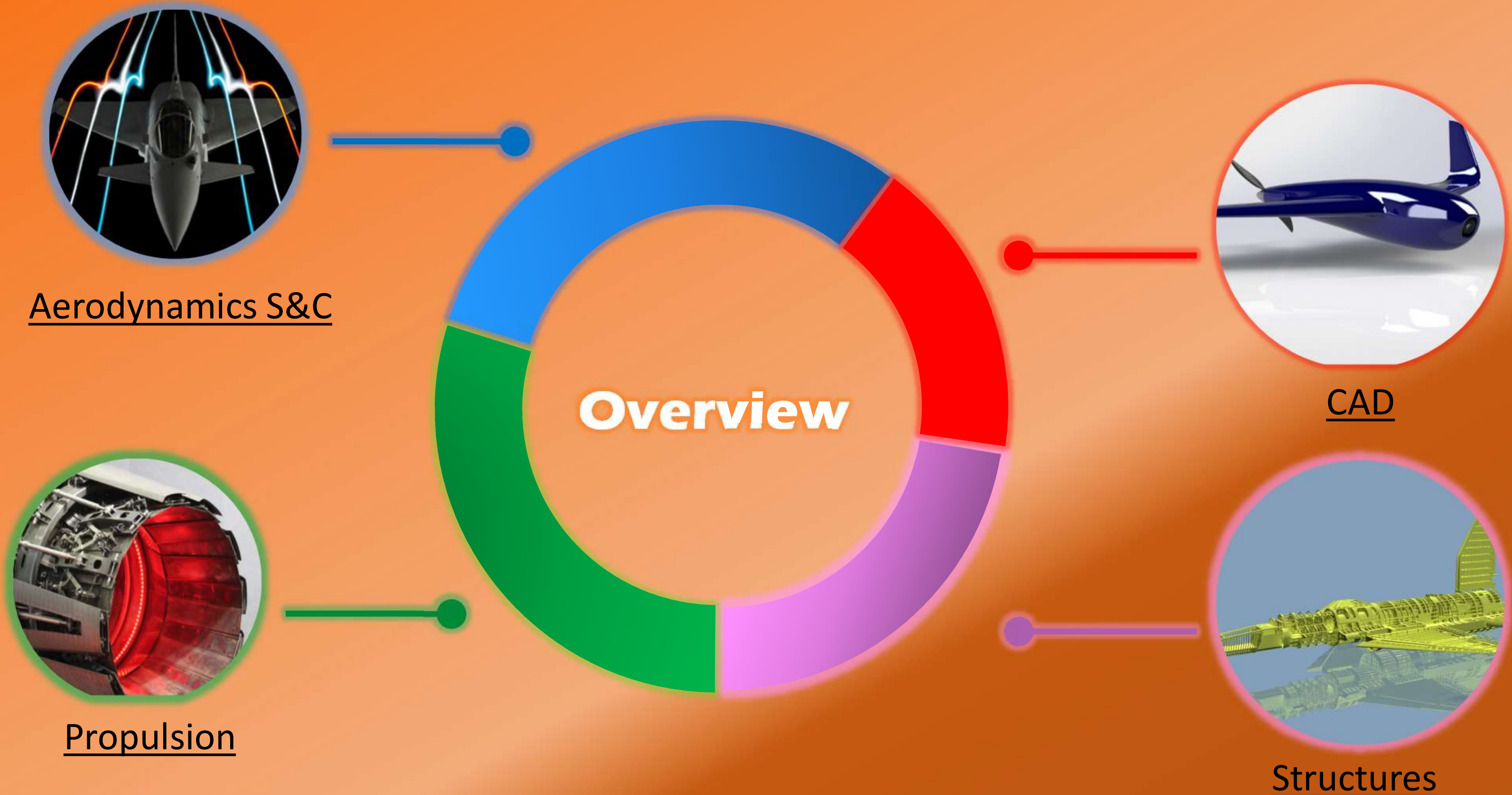


AFTER





DESIGN OVERVIEW



DESIGN OVERVIEW

Aerodynamics S&C

- Optimization
- Airfoil Selection
- Stability & Control
- Sizing
- Refinement

CAD

Propulsion

Structures

DESIGN OVERVIEW

Propulsion

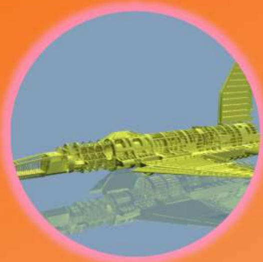
- Testing
- Power Train Config
- Selection
- Optimization
- Cost

Structures

CAD

Aerodynamics S&C

DESIGN OVERVIEW



Structures

CAD

- Benchmarking Materials
- Training
- RATO Integration
- Internal Structure Integration
- CAD/Build Plan

Aerodynamics S&C

Propulsion

CAD

CAD Team

Introduction

CAD/Design Lead

Jack Buss

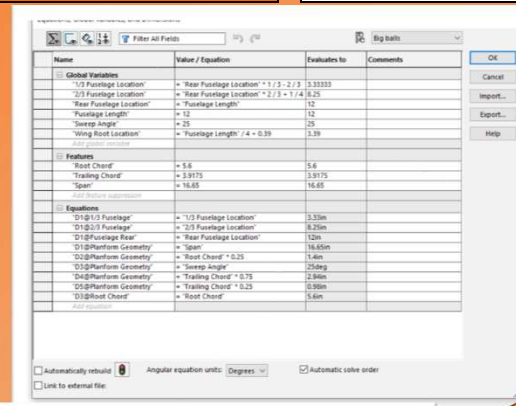
Design Engineer I

Patrick Cheatham

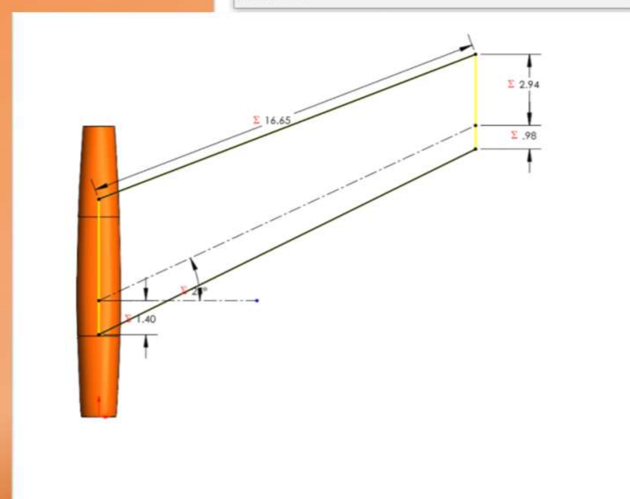
CAD

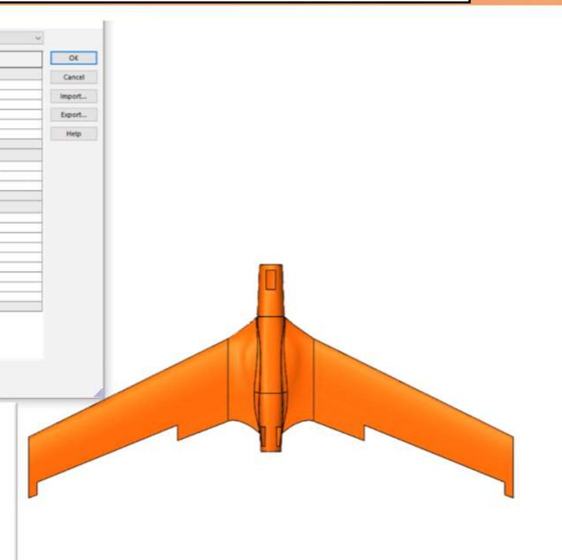
Design Model

Parameterization



Name	Value / Equation	Evaluates to	Comments
Global Variables			
"1/3 Fuselage Location"	= "Rear Fuselage Location" * 1 / 3 - 2 / 3	3.33333	
"2/3 Fuselage Location"	= "Rear Fuselage Location" * 2 / 3 + 1 / 4	8.25	
"Rear Fuselage Location"	= "Fuselage Length"	12	
"Fuselage Length"	= 12	12	
"Sweep Angle"	= 25	25	
"Wing Root Location"	= "Fuselage Length" / 4 + 0.39	3.39	
Add global variable			
Features			
"Root Chord"	= 5.6	5.6	
"Trailing Chord"	= 3.9175	3.9175	
"Span"	= 16.65	16.65	
Add feature suppression			
Equations			
"D1@1/3 Fuselage"	= "1/3 Fuselage Location"	3.33in	
"D1@2/3 Fuselage"	= "2/3 Fuselage Location"	8.25in	
"D1@Fuselage Rear"	= "Rear Fuselage Location"	12in	
"D1@Planform Geometry"	= "Span"	16.65in	
"D2@Planform Geometry"	= "Root Chord" * 0.25	1.4in	
"D3@Planform Geometry"	= "Sweep Angle"	25deg	
"D4@Planform Geometry"	= "Trailing Chord" * 0.75	2.94in	
"D5@Planform Geometry"	= "Trailing Chord" * 0.25	0.98in	
"D3@Root Chord"	= "Root Chord"	5.6in	
Add equation			

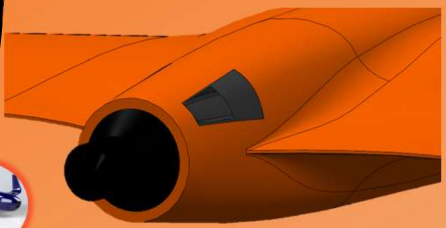


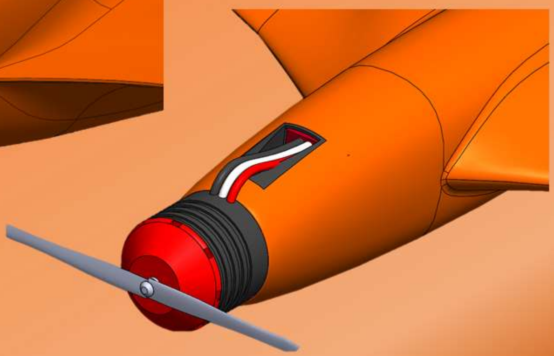


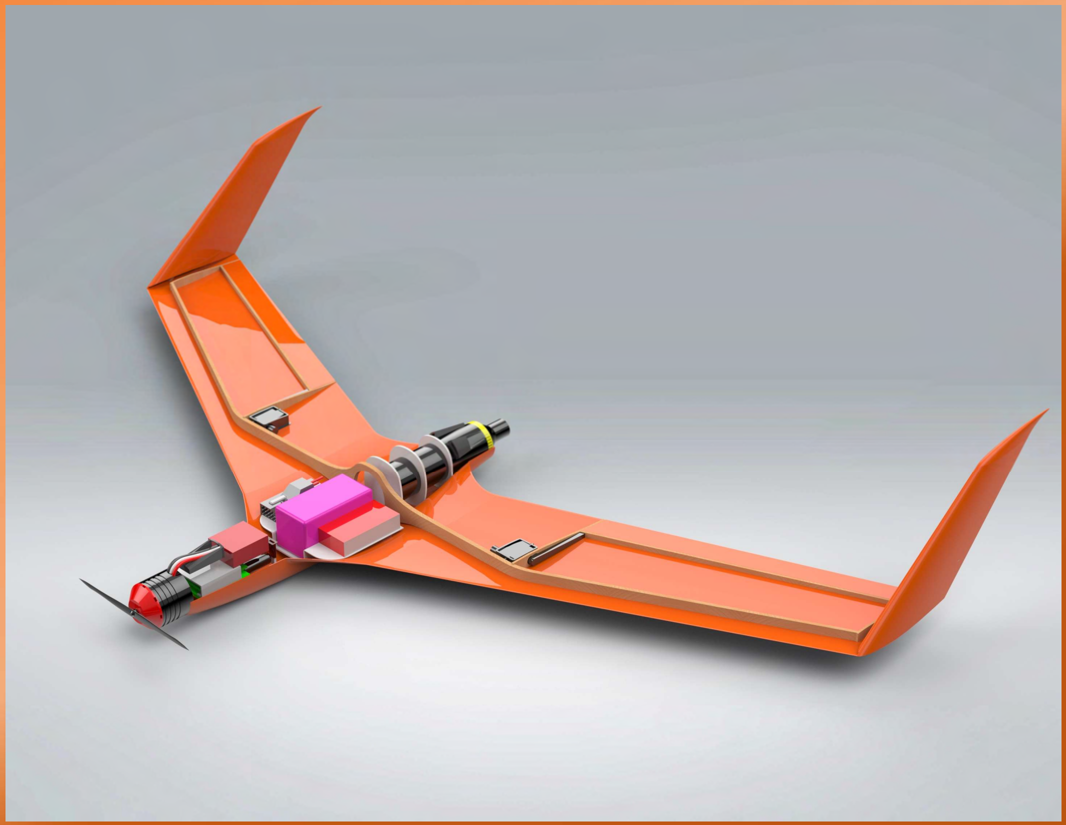
CAD

Design Model

Design Features



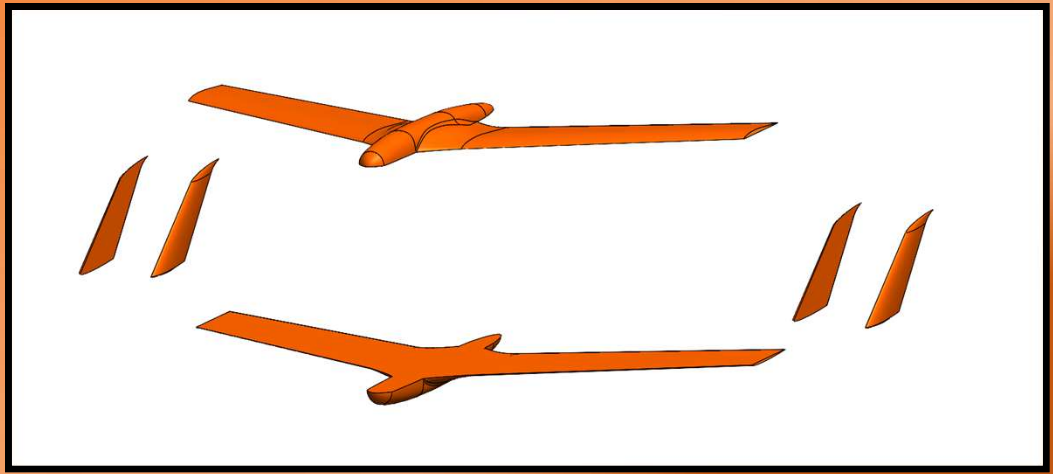


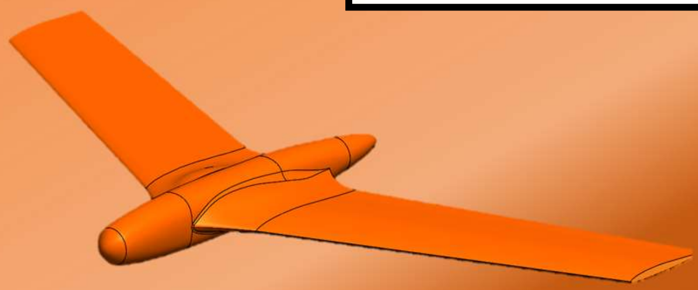


CAD

Design Model

Mold line, Plug, Manufacturing

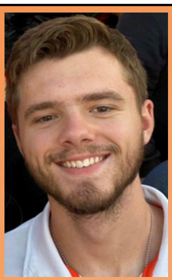




AERODYNAMICS

Aero Team

Introduction



Aerodynamics S&C Lead

Payton Simmons

Aero Engineer I

Kyler Bridenstine

Aero Engineer I

Caleb Todd

Aero Engineer I

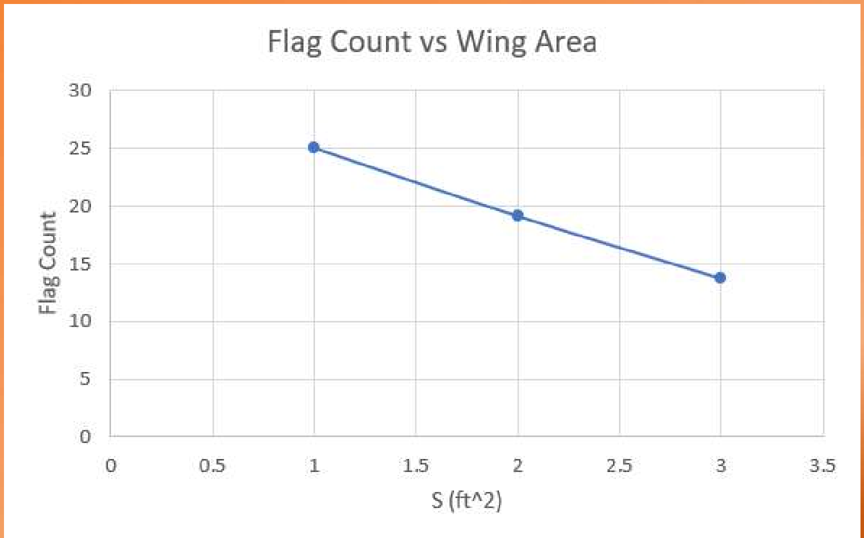
Jared Goldman

AERODYNAMICS

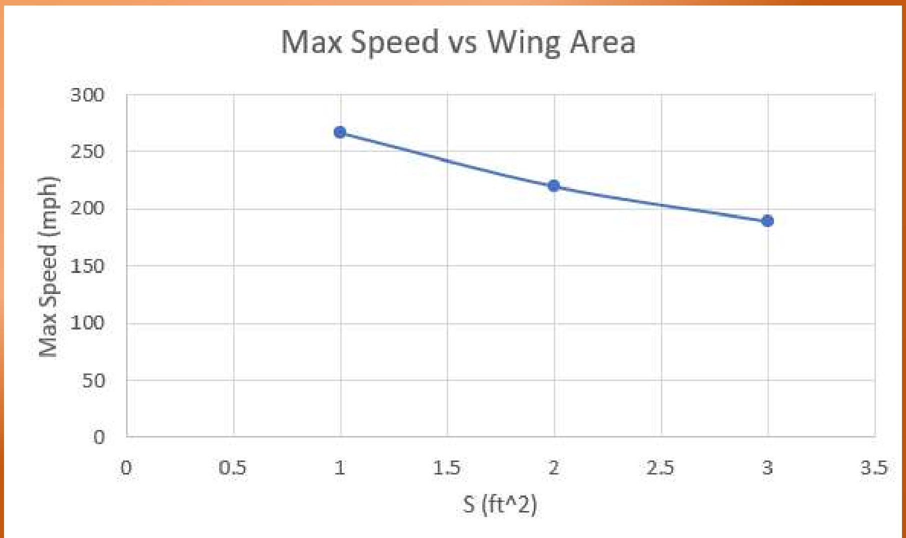
Wing Area Effects

Airfoil	Eppler 325
AR	8
Reynolds	150K
Prop	APC_6x6_25k
Motor	Badass 2814-1950KV
Rocket	F50T
Launch Angle (degrees)	60

Mission 1



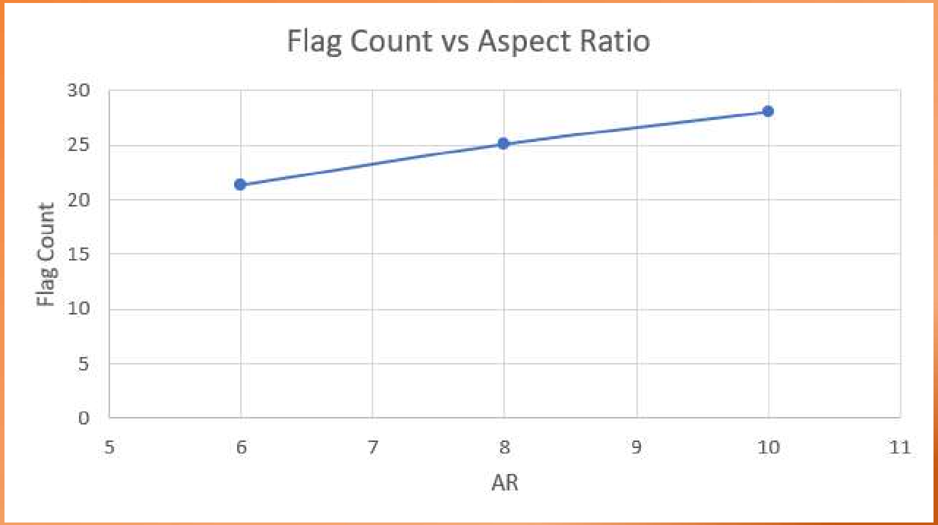
Mission 2



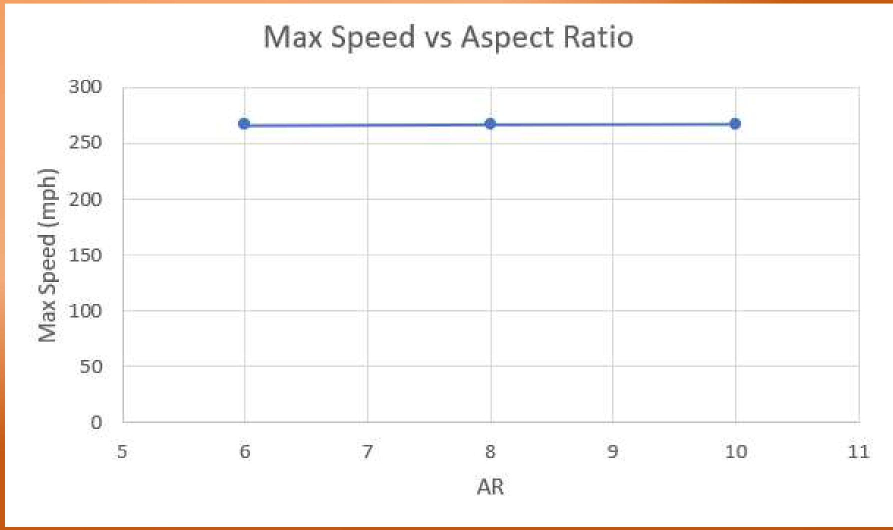
Aspect Ratio Effects

Airfoil	Eppler 325
S (ft^2)	1
Prop	APC_6x6_25k
Motor	Badass 2814-1950KV
Rocket	F50T
Launch Angle (degrees)	60
Reynolds	150K

Mission 1



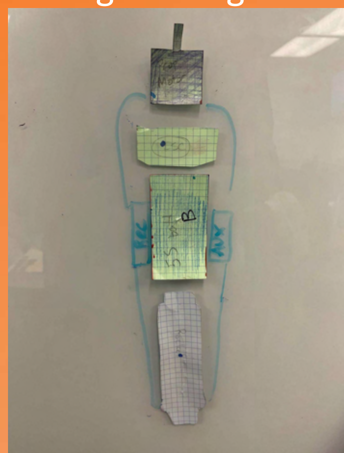
Mission 2



AERODYNAMICS

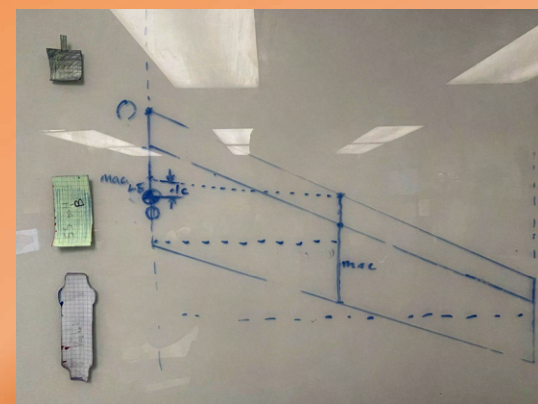
Stability Analysis

Fuselage Configuration



Inputs → **Outputs**

Wing Configuration



Baseline Sizing:

S – 1.25 ft^2 AR – 7 Sweep - 20° Taper Ratio – 0.7

Chosen CG Location – 0.1c

SM approximately 5 – 10%

Wing Sizing/Configuration

S/AR down selection:

- Highest Score
- Stability Sensitivity

Aspect Ratio	Mission 1 (Flag Count)	Mission 2 (Top Speed (mph))
6	24.6	270.76
6.5	25.9	270.84
7	26.2	269.32
7.5	26.9	269.38

Wing Area (ft^2)	Mission 1 (Flag Count)	Mission 2 (Top Speed (mph))
0.8	27	295.64
1	27.2	283.71
1.1	26.8	277.36
1.2	27	273
1.25	26.2	269.32
1.5	25.4	258.13

Final Selection:

- S – 1.1 ft^2
- AR – 7
- Sweep = 25°
- Taper ratio = 0.7

Vertical Stabilizer Sizing

- Goals:
  - S_T as small as possible
  - $C_{n\beta} \geq 0.05$
- Processes to decrease stabilizer size
  - Sweep Vertical Stabilizer
  - Taper Vertical Stabilizer
    - Decreases $C_{n\beta}$ and also Decreases Area
- Final Specifications
  - $S_T = 12.1\ in^2$
  - $b = 3.85$ in
  - $\Lambda = 40°$
  - $\lambda = 0.6$
- Airfoil as needed with or without rudder

Final Wing Design

Wing:

- S – 1.1 ft^2
- AR – 7
- b – 2.774 ft
- Taper Ratio – 0.7
- Root Chord – 5.6 in
- Tip Chord – 3.92 in
- Sweep - 25°

Vertical Stabs:

- V_v – 0.04
- AR – 1.23
- b – 3.85 in
- Root Chord – 3.91 in
- Tip Chord – 2.35 in
- S – 12.1 in^2

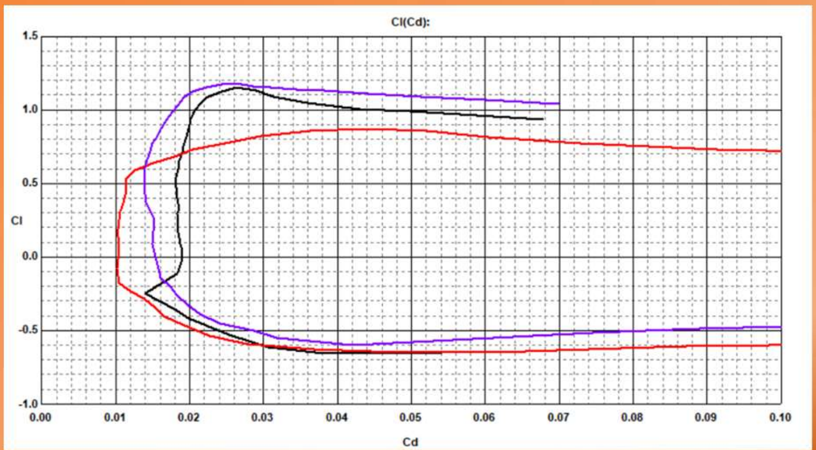
Stability:

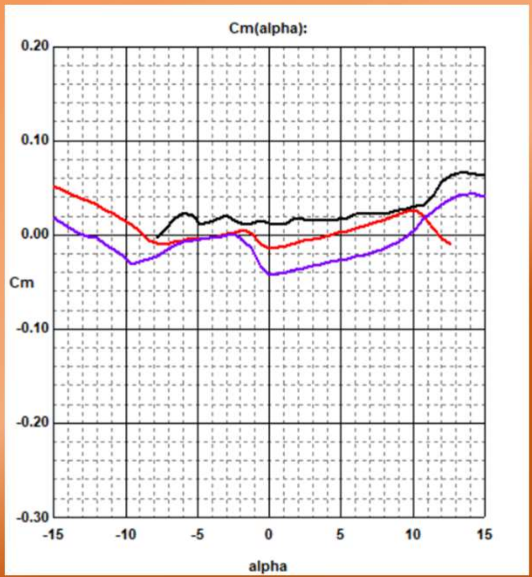
- Pitch SM – 14%
- $C_{n\beta}$ – 0.055

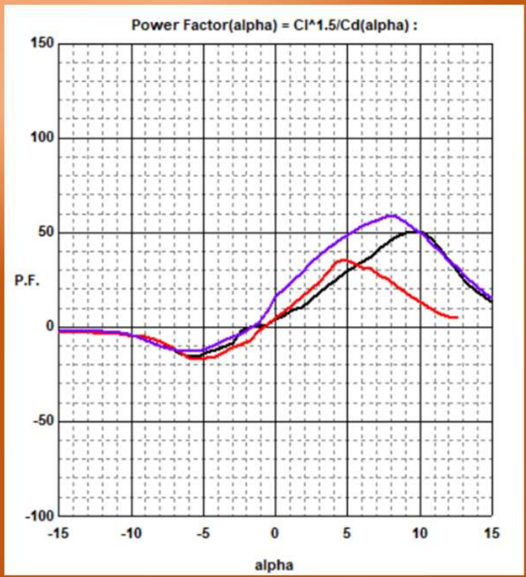
AERODYNAMICS

Airfoil Design

Re = 150000
Mach = 0.0000
NCrit = 6.00







@speedfestorange

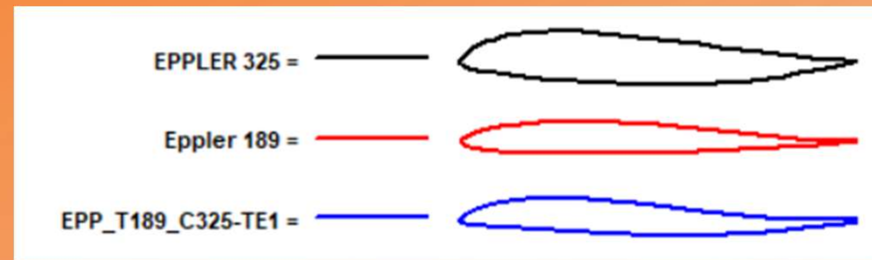
AERODYNAMICS

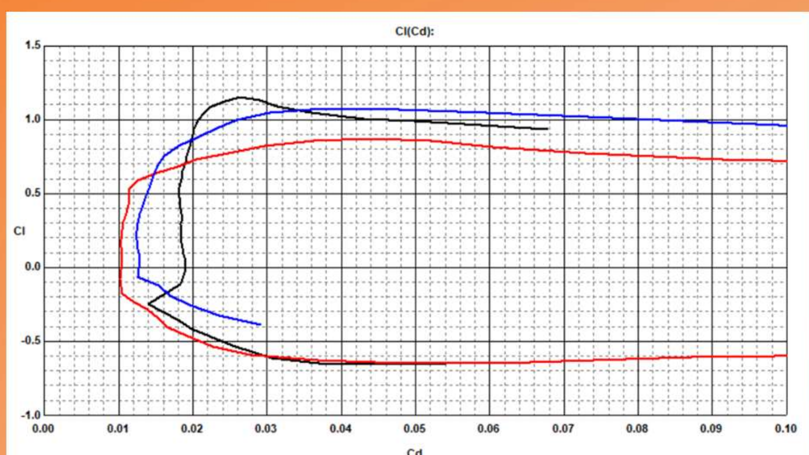
Airfoil Design

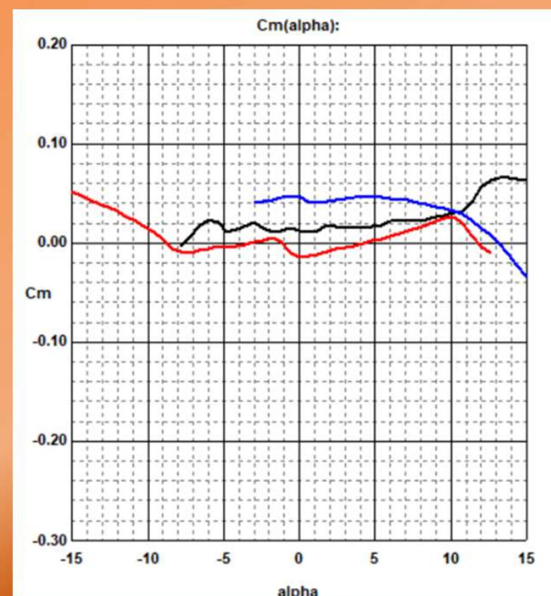
EPP_T189_C325_TE (AKA The Arena Special)

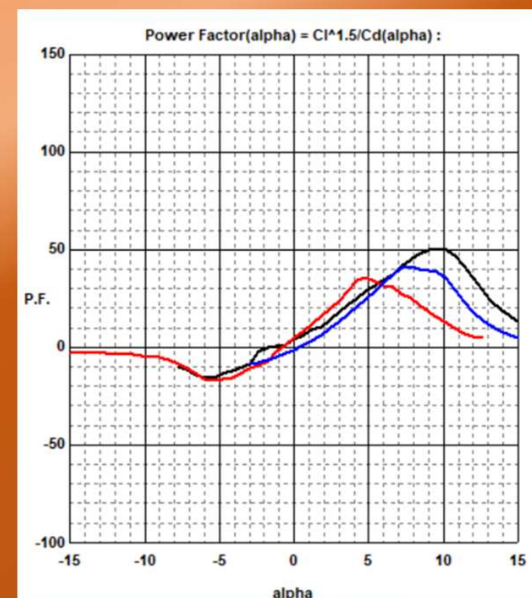
- Thickness of Eppler 189
- Camber of Eppler 325
- 8.28% thickness @ 30.1%
- 1.78% camber @ 18.1%

Re = 150000
Mach = 0.0000
NCrit = 6.00



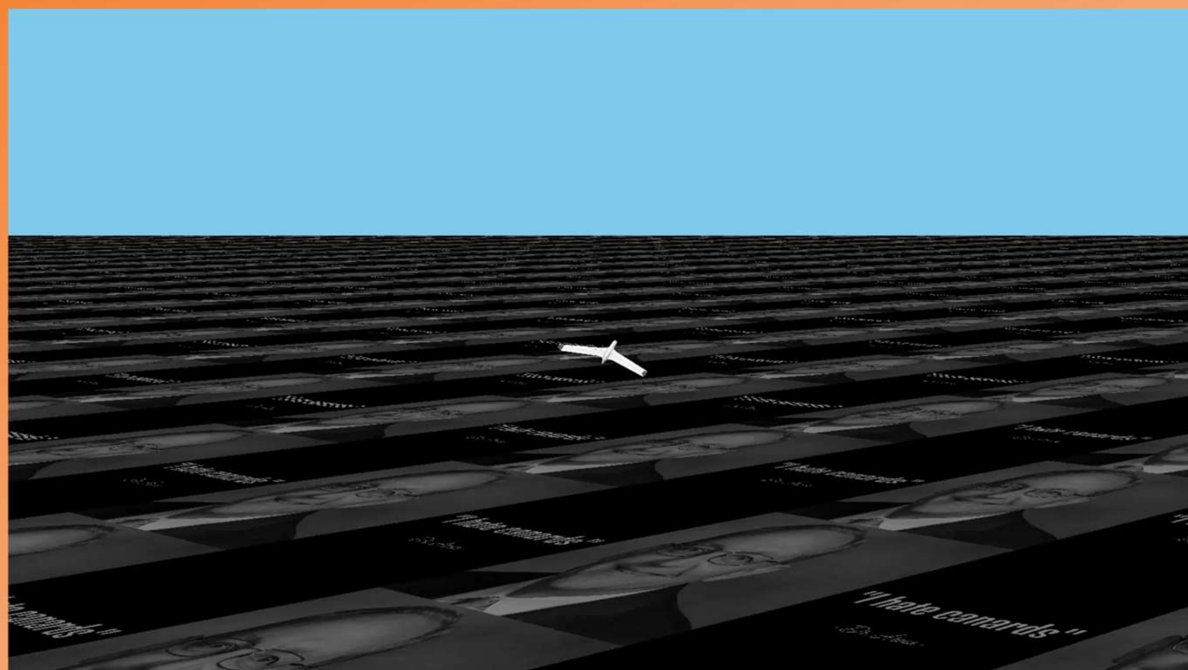






Flight Simulator Refinements

"The Arena Special" Max Speed Flight SIM Test

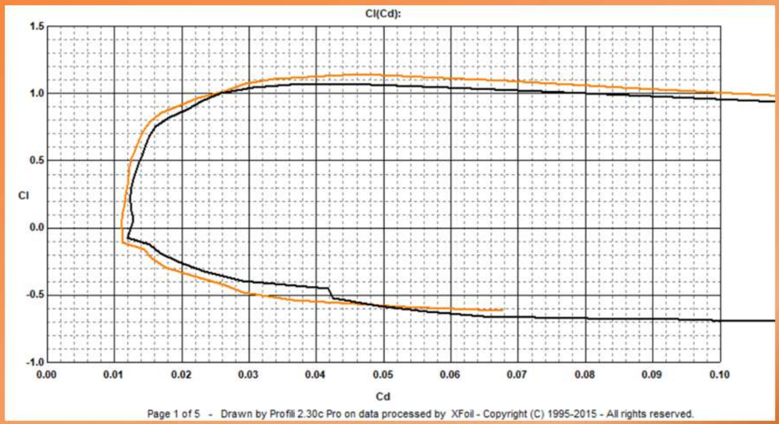


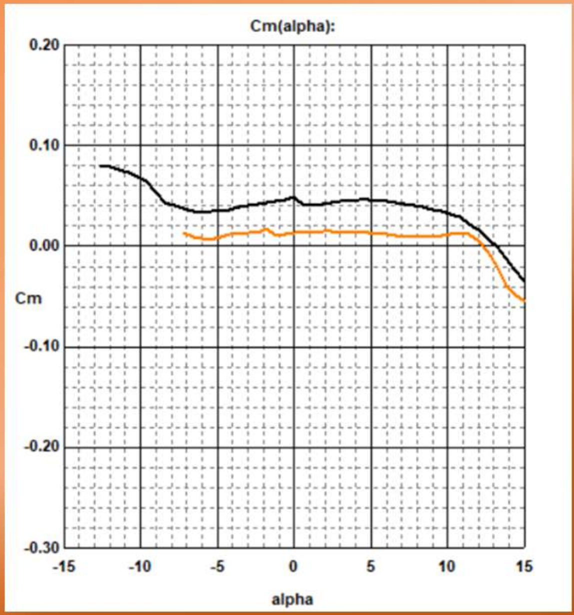
AERODYNAMICS

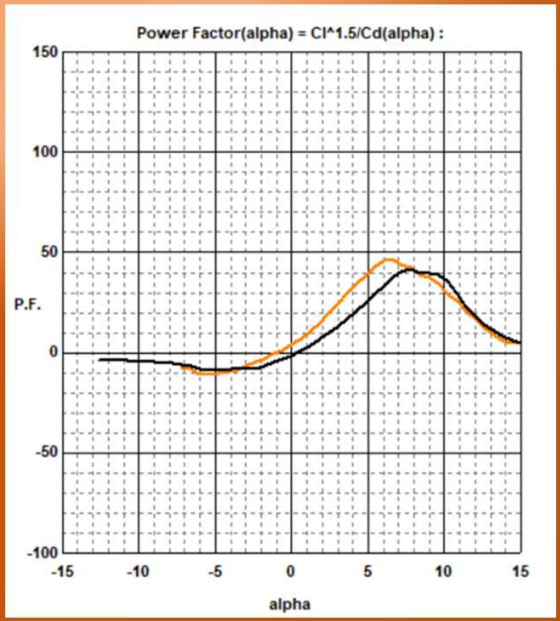
Airfoil Design

Re = 150000
Mach = 0.0000
NCrit = 6.00

Tadpole22 (aka SR-22)





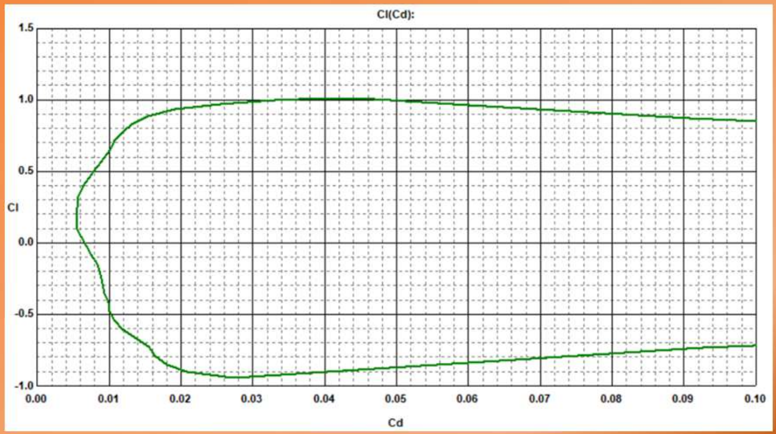


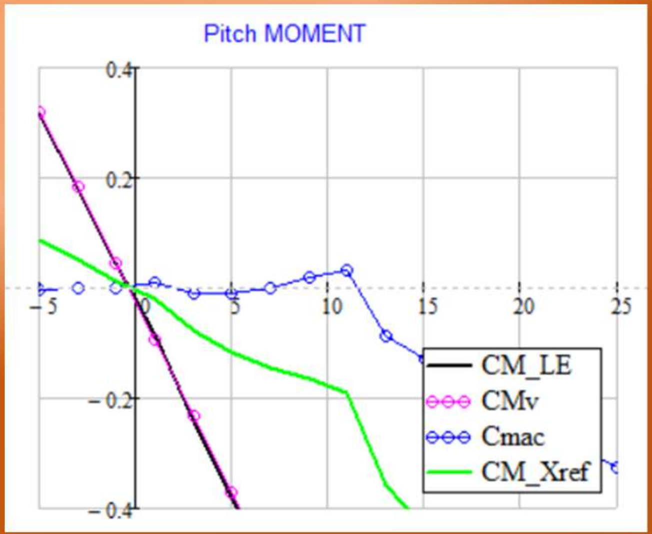
AERODYNAMICS

Flight Simulator Refinements

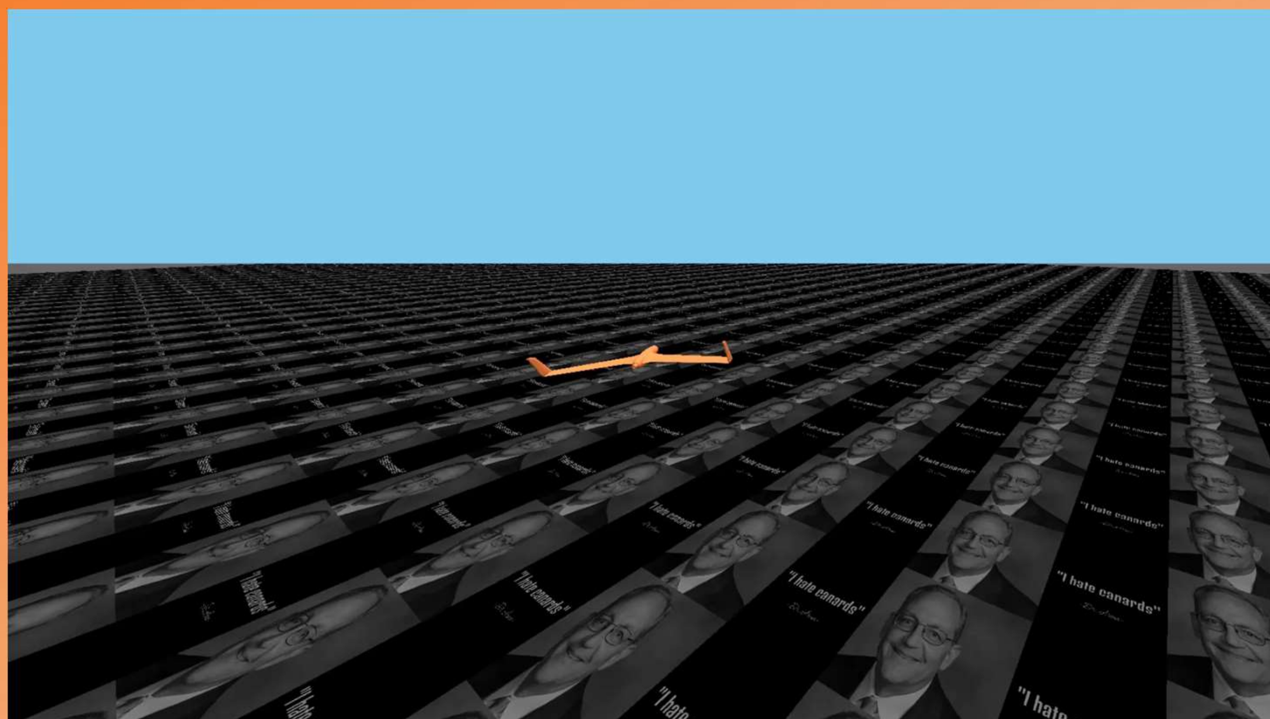
SR-23

- Front 100% Eppler 189
- Rear 50% NACA 1109
- 8.32% thickness @ 30.9%
- 1.13% camber @ 35.2%



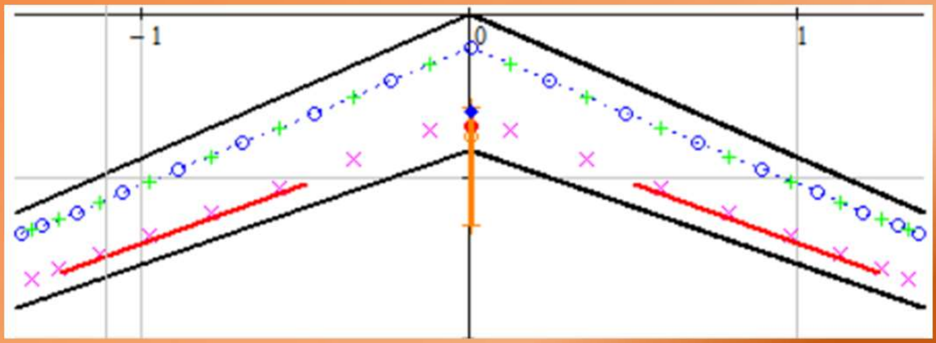


Flight Simulator Refinements

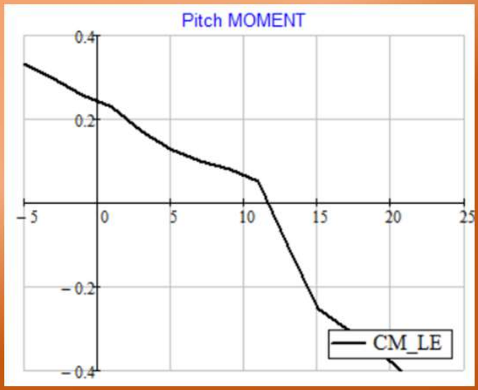


Control Surface Sizing

- Initial sizing done using VLaM code
- Goals for elevator deflection:
    - Trim close to stall AOA
    - Trim below 0 AOA
- Handling qualities observed in flight SIM
- Aileron deflection was decided using SIM
- 20% chord with a 9” span each
- Deflection Range:
    - Elevator -20° ~ 10°
    - Aileron -10° ~ 10°



Elevator -20° deflection



Elevator 10° deflection

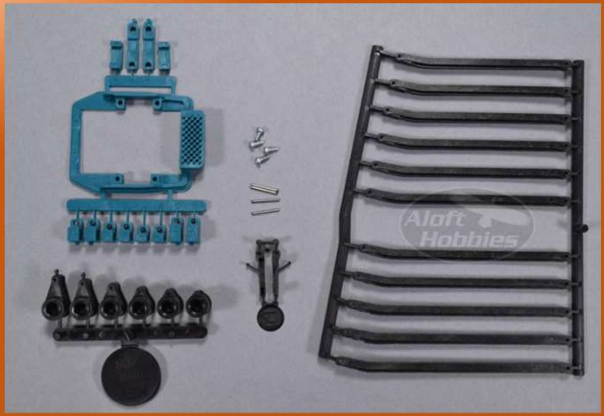
Servo Sizing

Servo	KST X08 Plus
Manufacturer	KST Technology
Applications	DLG/Airplanes 3.8V/8.4V (1S/2S)
Type	LV/HV Coreless Micro
Torque 3.8V	33.3 oz/in (2.4 kg/cm)
Torque 6V	53.4 oz/in (3.85 kg/cm)
Torque 8.4V	73.5 oz/in (5.3 kg/cm)
Speed 3.8V	0.18 sec/60 degrees
Speed 6V	0.12 sec/60 degrees
Speed 8.4V	0.09 sec/60 degrees

Tested for worst case for each mission:

- Mission 1
  - 20° deflection at 156 knots
  - Hinge moment with 1.5 FOS = 21.25 oz/in
- Mission 2
  - 10° deflection at 240 knots for max speed
  - Hinge moment with 1.5 FOS = 31.84 oz/in

Integrated drive System (IDS) used for mounting



PROPULSION

Propulsion Team

Introduction

Propulsion Lead
Carson Rutherford

- Propulsion Engineer I — Omar Abouzahr
- Propulsion Engineer I — Erasmo Dominguez
- Propulsion Engineer I — Zac Hallman
- Propulsion Engineer I — Mirijan Hovsepain
- Propulsion Engineer I — Madison Morton
- Propulsion Engineer I — Kohl Schuler

PROPULSION

Optimization Analysis Method

- Change one variable at a time while keep the rest constants
- Variables & Values:

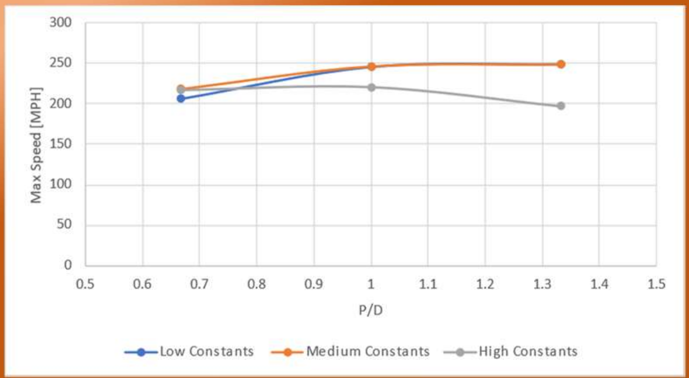
	Kv	AF	S	Prop	Rocket	Launch ang
High	4700	4406	1.5	6x8	F85	60
Medium	1950	2406	1	6x6	F40	40
Low	1350	"0006"	0.5	6x4	F25	20

- Outputs : Max Speed and Flags Captured

Mission 2

	P/D Low	P/D Medium	P/D High		P/D Low	P/D Medium	P/D High		P/D Low	P/D Medium	P/D High
Low				med				high			
AF											
S											
kv	206.58	245.8	263.47		218.27	246.62	249.09		217	220.48	197.28
Rocket											
Launch an											

P/D Iterations For Mission 2



P/D Iterations Graphed

PROPULSION

Rocket Down Select

- Aerotech F50T
  - Base Rocket: Lowest Power, Single Use, Easiest Control
- Cesaroni F51
  - Best RATO: Most possible flags due to launch height, reloadable
- Cesaroni F79
  - Best Speed: Highest Top Speed, reloadable

Mission 1			
Rocket	Flags	Height [ft]	Glide Time [s]
F50	31	612	183
F51	36.6	721	216.2
F79	31.8	625.8	187.6

Mission 2	
Rocket	Top Speed [MPH]
F50	311.3
F51	315.8
F79	320.6

Motor Down Select

- BadAss 2814-1950
  - High Kv Outrunner, lightweight, low cost
- BadAss 2820-1350
  - Outrunner, medium weight, low cost
- Hacker - 10108993
  - High Kv In-runner, heavy with gearbox, and high cost.

Mission 1	
Motor	Flags
BadAss 2814	36.6
BadAss 2820	35.4
Hacker	30.9

Mission 2	
Motor	Top Speed [MPH]
BadAss 2814	320.6
BadAss 2820	300.1
Hacker	263.8

PROPULSION

Battery Down Select

- MaxAmps 1050
  - High C-rating, smallest size and lowest weight, low capacity
- MaxAmps 1300
  - High C-rating, small size and low weight, high capacity
- Tattu
  - Lower C-rating, larger size and weight, high capacity

PROPULSION

Other Avionics

- Aux Battery: Jeti Receiver Battery Pack 650mAh
- ESC: PHOENIX EDGE LITE 75 AMP
- Receiver: Jeti Duplex EX R6 Light US
- Rocket Switch: RC Switch with Small Low-Side Mosfet
- Speed Sensor: JETI MSPEED EX 450
- Flight Control Stabilizer: FT Aura 5 Lite

Propeller Selection

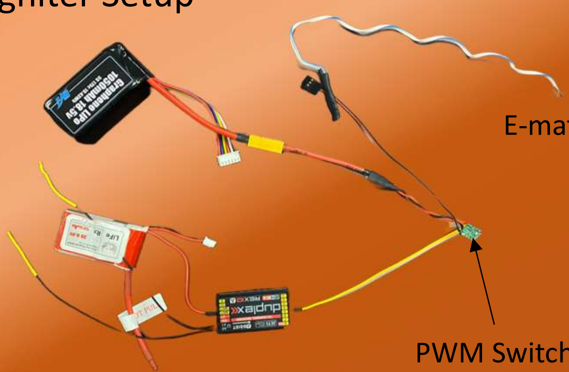
- Graupner Cam Slim
  - $\frac{P}{D} = 1.33$
- APC Thin Electric
  - $\frac{P}{D} = 1.17$
- APC with 20% Trim
  - $\frac{P}{D} = 1.33$

Mission 1	
Motor	Flags
Graupner	38.3
APC	34.9
APC 20% Trim	34.9

Mission 2	
Motor	Top Speed [MPH]
Graupner	320.6
APC	317
APC 20% Trim	320.3

Testing

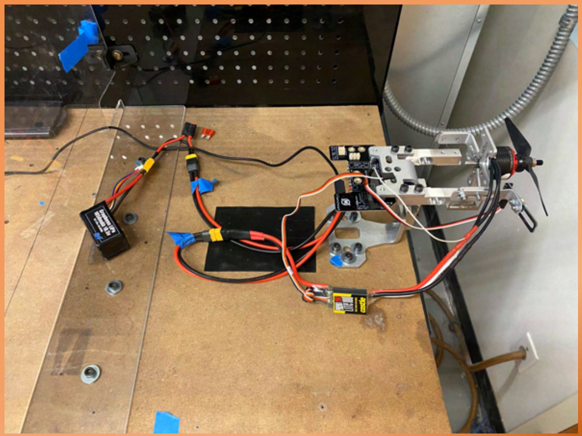
- Igniter Function: How does igniter function with rocket and receiver/transmitter
- ESC to Motor: Compatibility and programming
- Static Performance: How well does it correlate to predicted performance



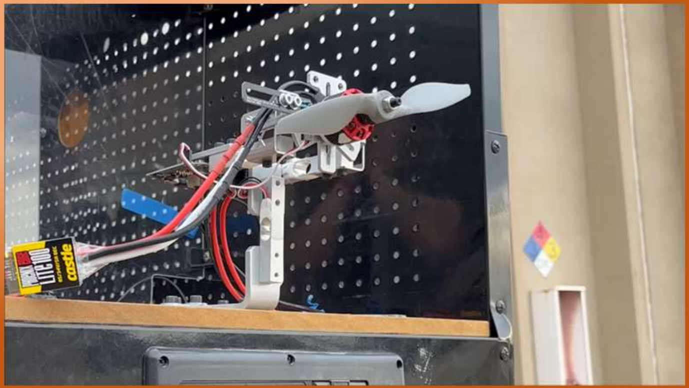
PROPULSION

Testing

F50T Test



Dino Setup



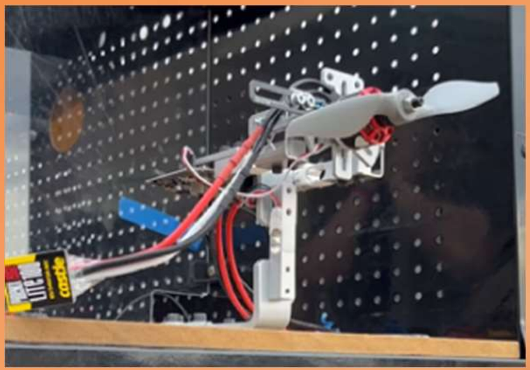
Dino Test

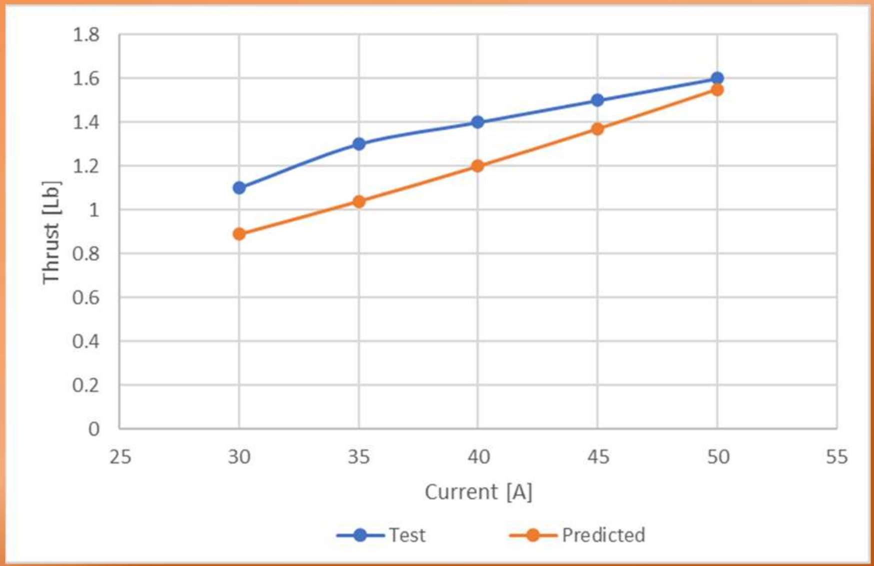
PROPULSION

Testing Results

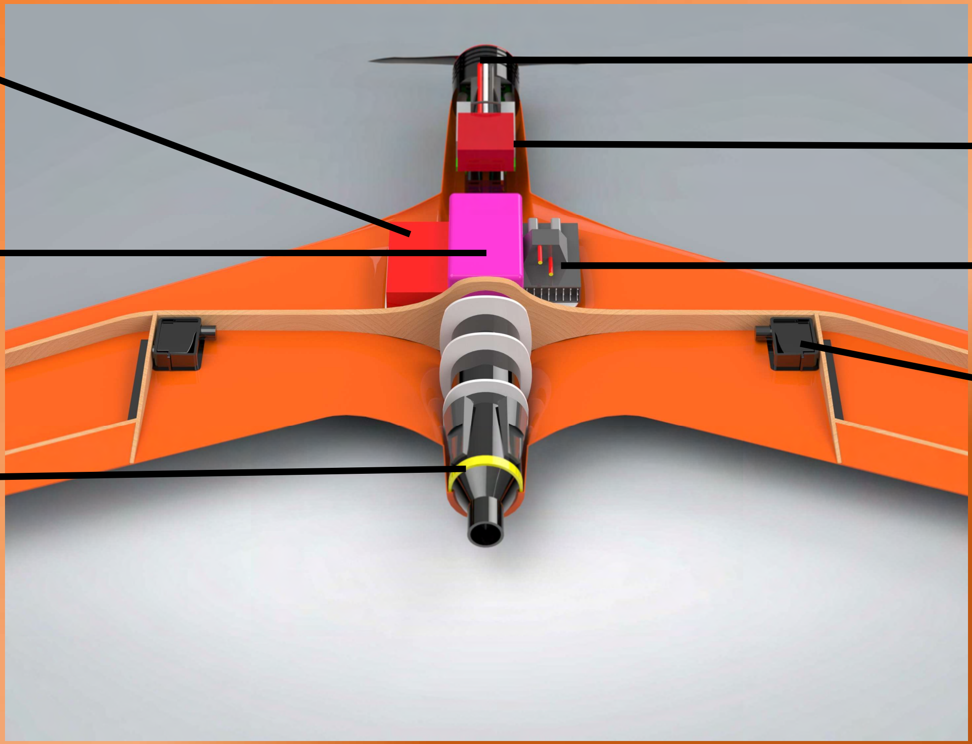
Static Performance

- Test data was performed on the static Dino Stand
- Predicted data from MathCad programs

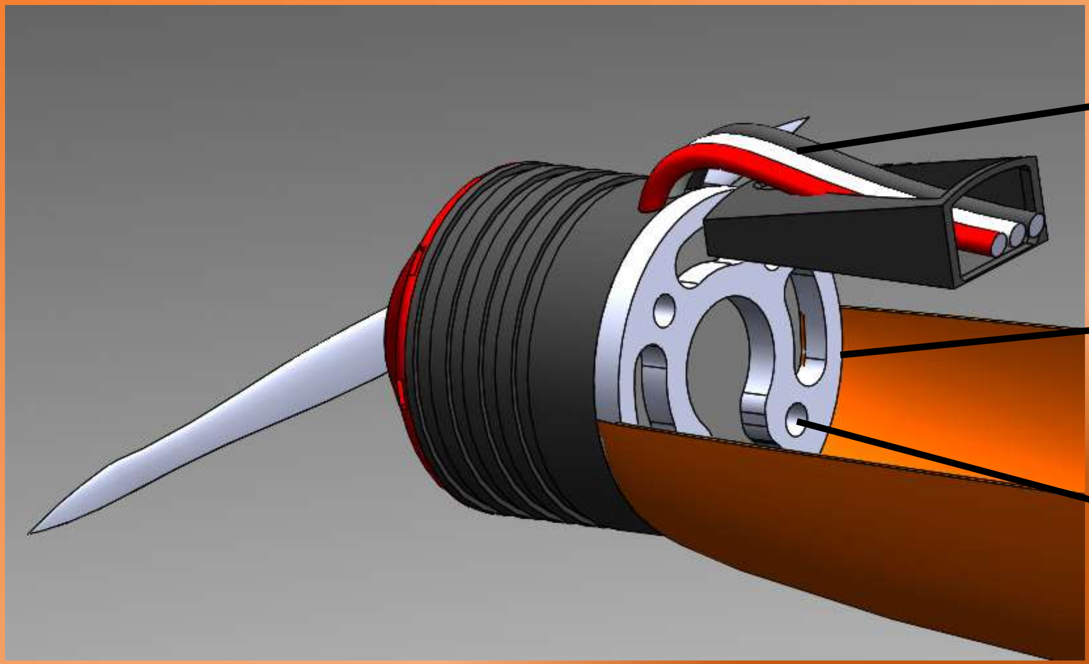




Internal Layout



Motor Integration

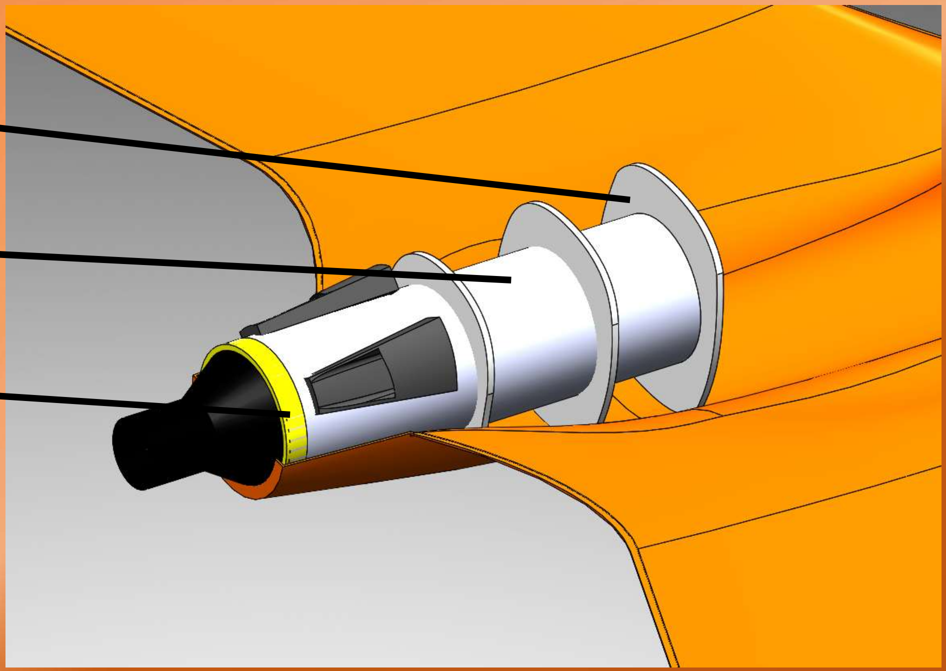


Motor wiring into the fuselage

Firewall bonded into the nose of the aircraft

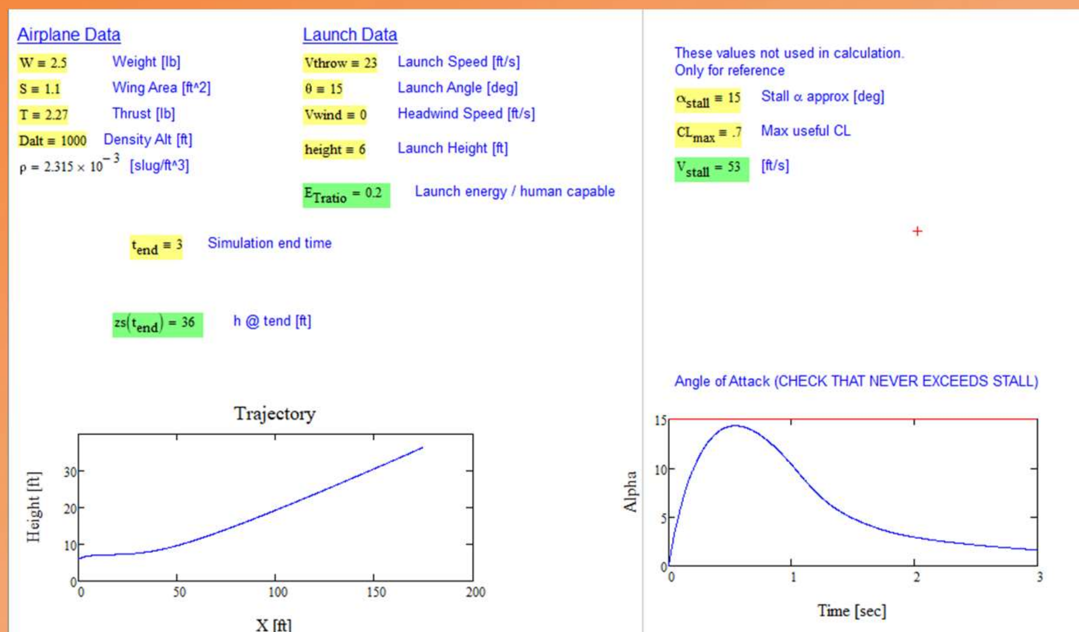
Motor screws into the firewall

Rocket Integration



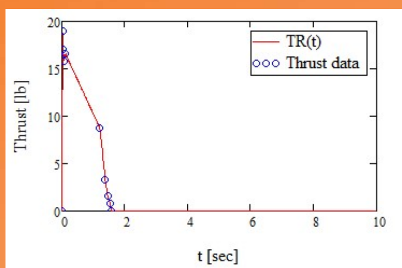
Hand Takeoff Requirements

- To perform mission 2 with a mid-air rocket we must hand launch

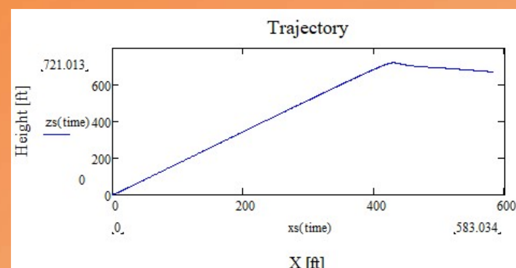


Estimated Performance Maps

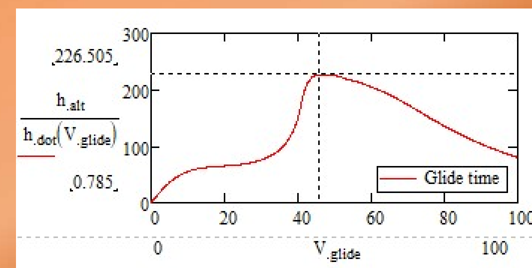
- Mission 1 using F51 Rocket



Rocket Thrust vs Time



Height of rocket



Glide Time From RATO

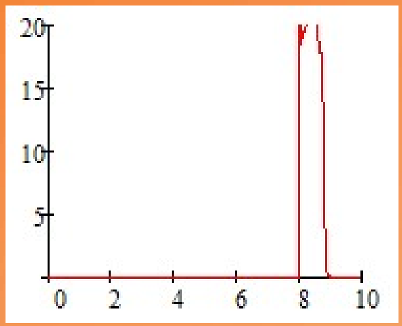
$t_{total} := 6.8 + 2 + 2.5 = 11.3$

$Flags := 2\frac{t_{glide}}{t_{total}} = 38.3$ Number of flags possible

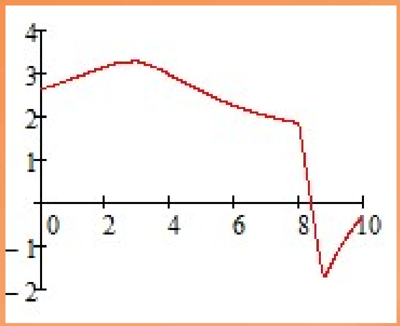
Expected Flag Count

Estimated Performance Maps

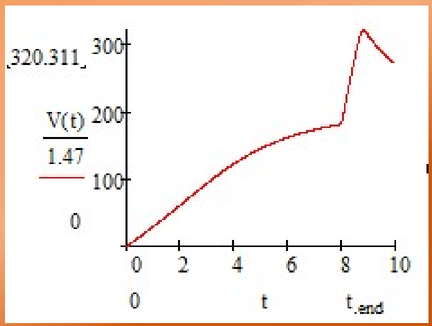
- Mission 2 using F79 rocket



Rocket Thrust vs Time



Propellor Thrust vs Time



Velocity vs Time

Top Speed – 320.3 MPH

Estimated Performance Maps

Mission 3

- To achieve a 4-minute endurance flight, the airplane will need to throttle to 60%
- 60% throttle gives a cruise speed of 127 mph

$Throttle \equiv .6$

$ng \equiv 1$ G-load in turn

$$\frac{E_{batt}}{60Vpack \cdot Ibatt(I_{sc\_cruise})} = 4.2$$ Cruise Endurance [min]

$$V_{cruise} \frac{3600}{5280} = 127$$ cruise in mph

Structures Team

Introduction



Structures Lead
Ethaniel Tobar

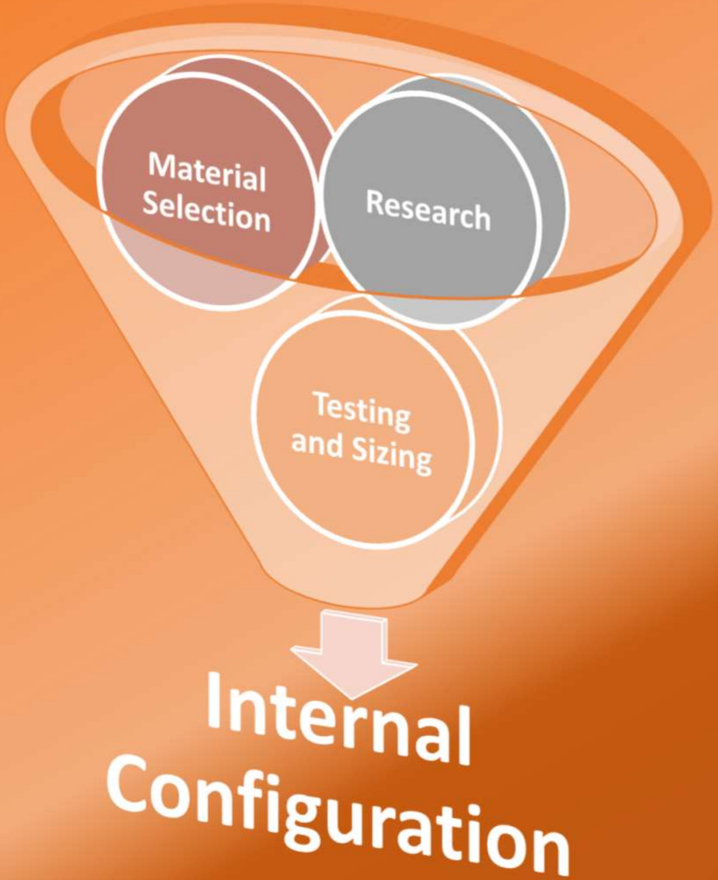
- Structure Engineer I – Andrew Cottingham
- Structure Engineer I – Britney Dunlap
- Structure Engineer I – Benjamin Fishback
- Structure Engineer I – Garrett Martin
- Structure Engineer I – Hunter Riley
- Structure Engineer I – Hayden Spillars
- Structure Engineer I – William Watson





Review of Topics

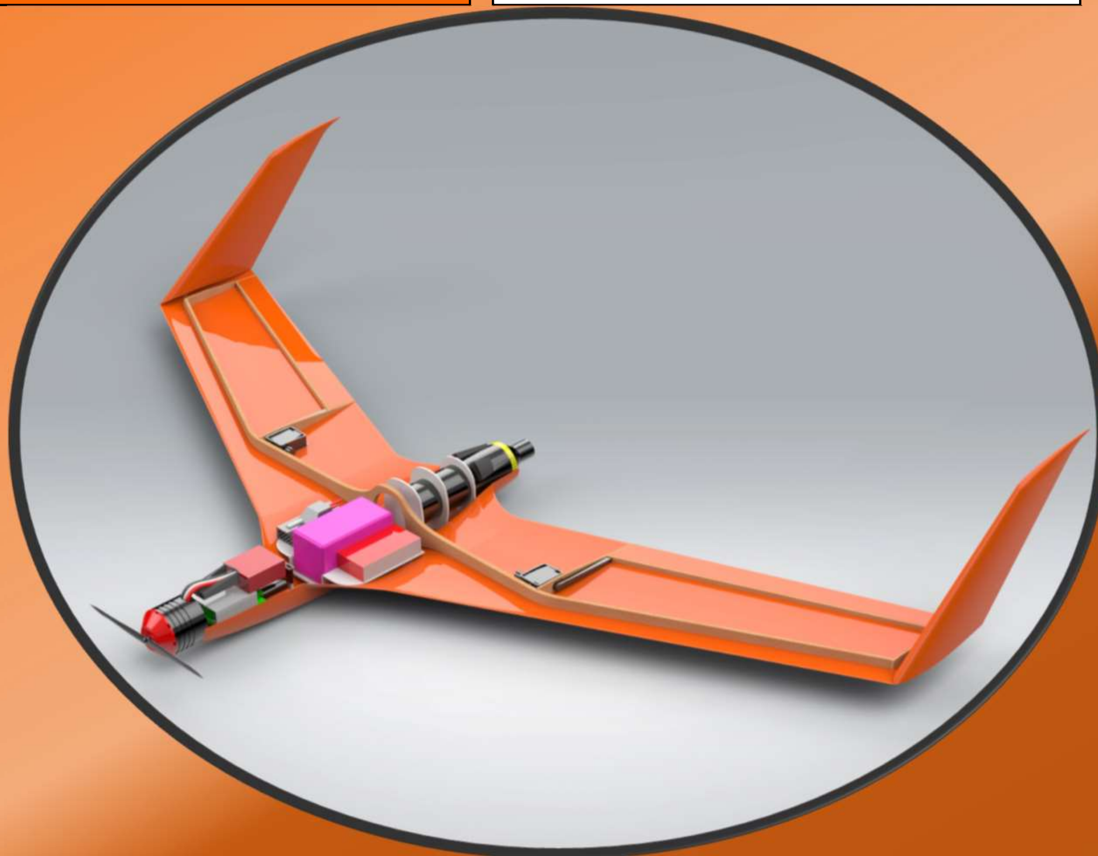
A Process of development



STRUCTURES

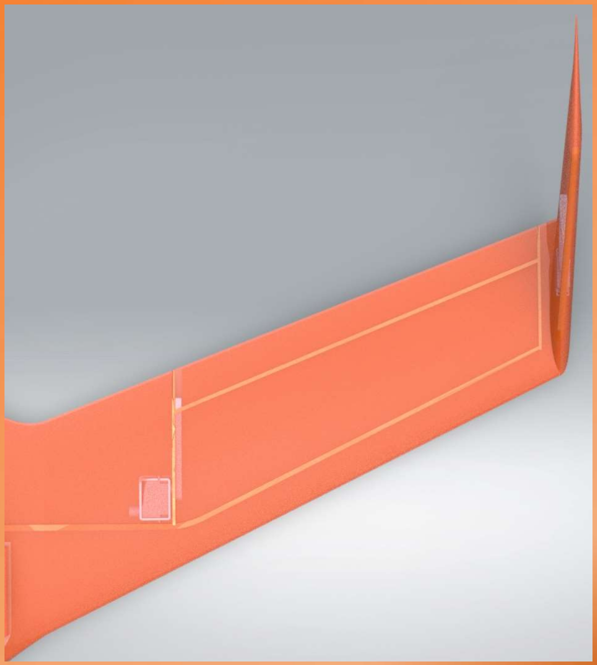
Internal Configuration

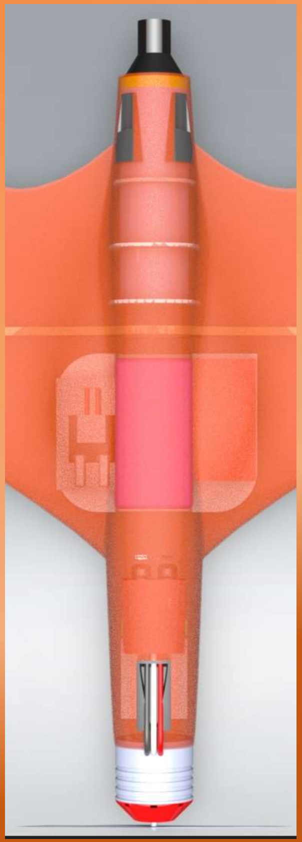
Component Considerations



Internal Configuration

Fuselage Wing: List of Materials





Inboard Section

- Inboard Skin
- Motor Mount
- Main Component Housing
- Main Hatch
- Rocket Housing

Outboard Section

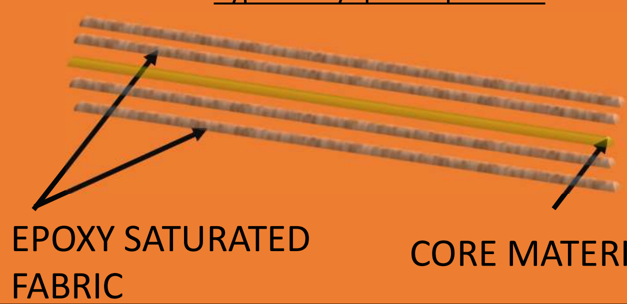
- Outboard Skin
- Main Spar
- Ribs
- Aft Shear Web
- Servo Bay
- Servo Hatches
- Elevon Shear Web
- Wiper
- Endplate Connection Points

STRUCTURES

Fuselage Wing

Inboard Section: Composite Skin

Typical Layup Composition



Core Materials

- Balsa Wood (multiple thicknesses)
- 3oz 1/8”, Divinycell foam, cubed and un-cubed
- 1 mm, Rohacell Foam
- 1/8”, Honeycomb, expanded and non-expanded
- No Core, Dual Core
  - 90 and 45 degree orientations

Lamina Materials

- 3 oz Fiber Glass
- 5.7oz Carbon Fiber
- Kevlar, various weaves
- Tooling Glass
- Carbon Scrim

Fuselage Wing

Inboard Section: Composite Skin

Coupon Development

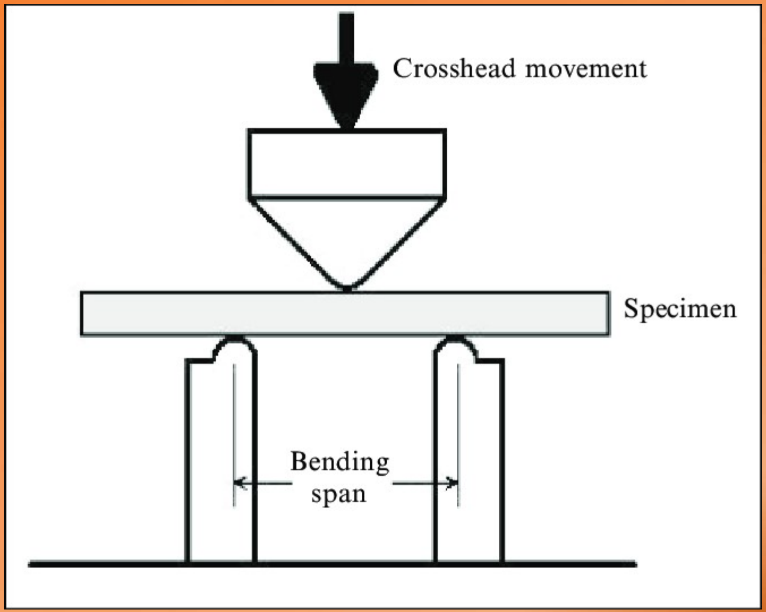
- Organized composition via excel file
- Developed 6 main core groups
- Built 40+ coupons to refine lay up techniques
- Tested 20+ coupons to generate useful data

Core Grou	Item	Connection(s)	Outer 1	Outer 2	Outer 3	Core	Inner 1	Inner 2	Inner 3
1. Balsa	1.1	basic	5.7 oz **Carbon** @90	3 oz **Glass** @45		5/64th" Balsa	3 oz **Glass** @45	3 oz **Glass** @90	
1. Balsa	1.2	1.1, replace I2 with tooling	5.7 oz **Carbon** @90	3 oz **Glass** @45		5/64th" Balsa	3 oz **Glass** @45	20 oz **Tooling** @90	
1. Balsa	1.3	1.1, thinner core	5.7 oz **Carbon** @90	3 oz **Glass** @45		1/8th" Balsa	3 oz **Glass** @45	3 oz **Glass** @90	
1. Balsa	1.4	1.1, add alum @ O1	**Aluminum** Foil	5.7 oz **Carbon** @90	3 oz **Glass** @45	5/64th" Balsa	3 oz **Glass** @45	3 oz **Glass** @90	
1. Balsa	1.5	1.1, Add Kevlar @ O3	5.7 oz **Carbon** @90	3 oz **Glass** @45		5/64th" Balsa	3 oz **Glass** @90	3 oz **Glass** @45	Kevlar @90
1. Balsa	1.6	1.1, remove I2	5.7 oz **Carbon** @90	3 oz **Glass** @45		5/64th" Balsa	3 oz **Glass** @90		

STRUCTURES

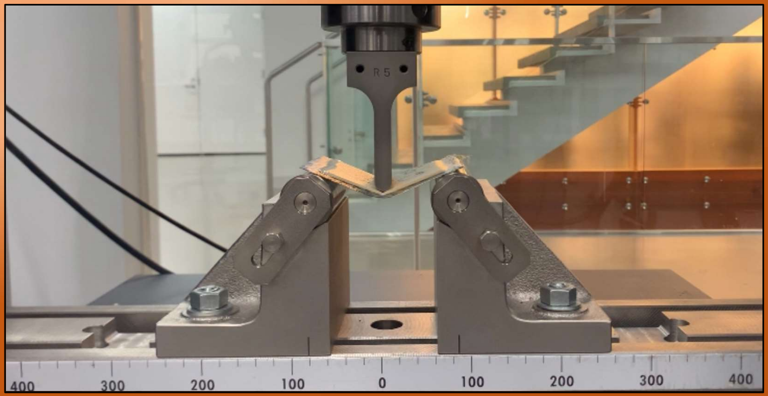
Fuselage Wing

Inboard Section: Composite Skin



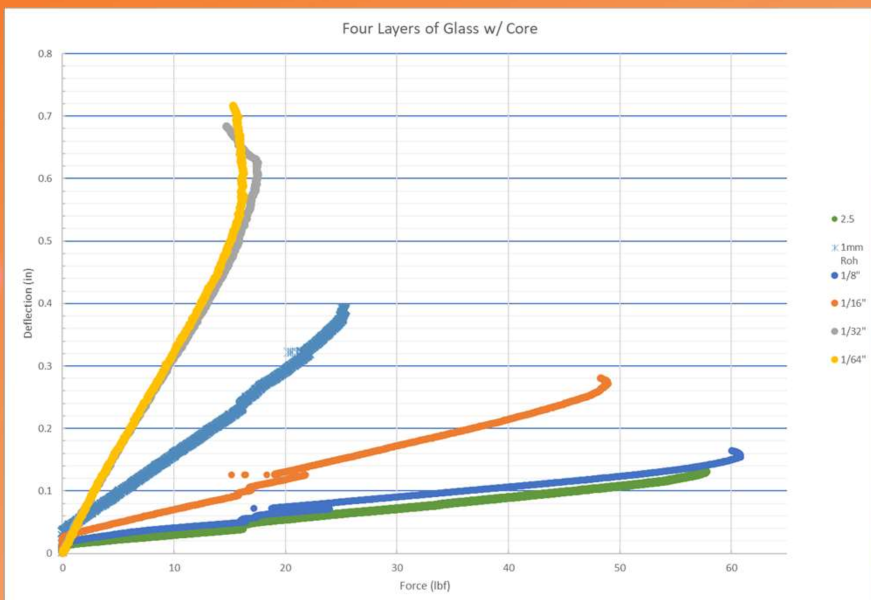
Testing 3 Point Bending

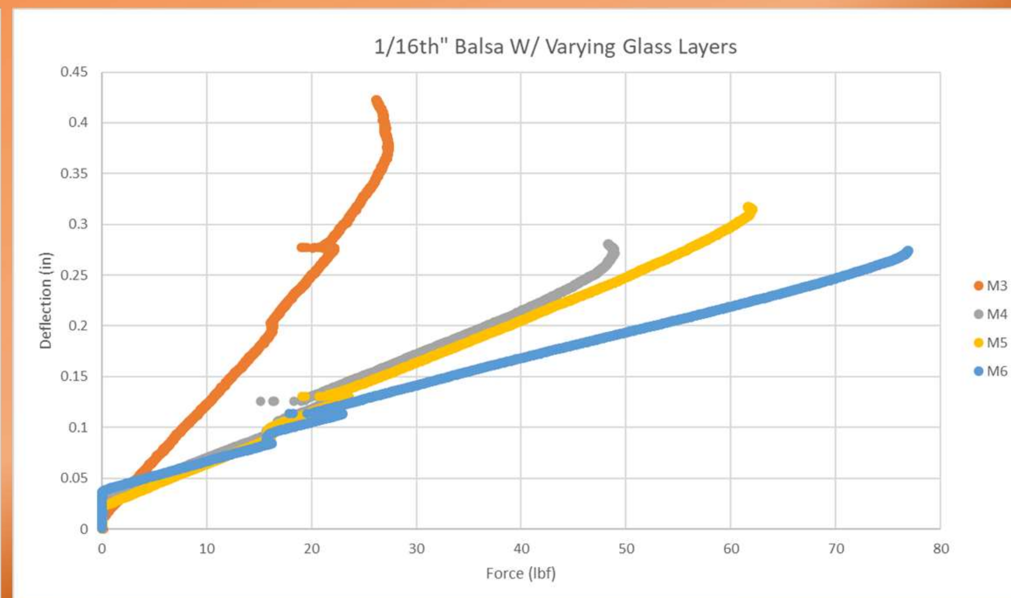
- Tested potential combinations of skin and core
- Force vs Displacement Data
- Easy to compare stiffnesses of materials from Force vs Displacement Curve



Fuselage Wing

Inboard Section: Composite Skin



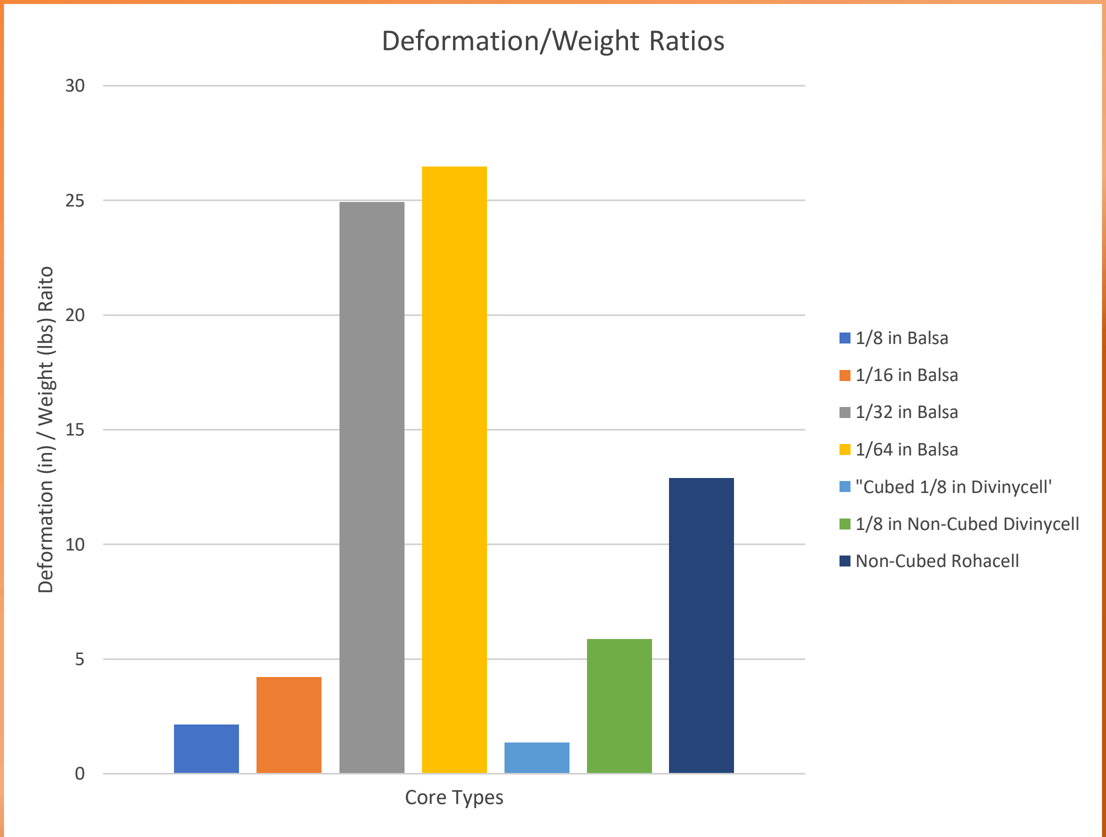


STRUCTURES

Fuselage Wing

Inboard Section: Composite Skin

Core Type	Coupon Weight (g)	Coupon Thickness (in)
1/8 in Balsa	10.2	0.14
1/16 in Balsa	**9.63**	**0.07**
1/32 in Balsa	8.47	0.045
1/64 in Balsa	8.53	0.03
Cubed 1/8 in Divinycell	**12.53**	**0.13**
Non-Cubed 1/8 in Divinycell	8.87	0.13
Non-Cubed Rohacell	7.71	0.04



STRUCTURES

Fuselage Wing

Inboard Section: Motor Mount

Motor Mount — Transfer electric motor thrust loading

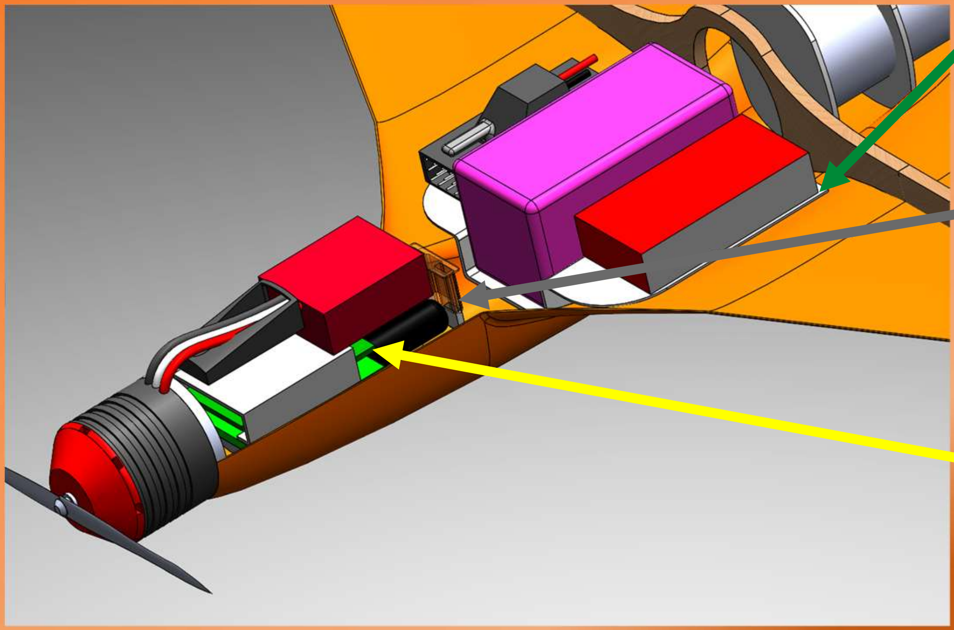
- Bonded to fuselage before the two halves are joined
- Reinforced with carbon tow connecting skin and fire wall
- Must transfer worst case scenario loading, 3 lbf of trust
- CAD provided dimensions

Testing Considered — Validating our weight cost optimization

- Carbon, aero ply, and fiberglass plates of various thicknesses to be tested
- To be put in bending test, point loads applied

Fuselage Wing

Inboard Section: Component Housing



Battery, Aux Battery, Speed Sensor	Balsa base plate for flush and flat connection, velcroed
Fuse Access	Hole in the OML per requirements
Gyro, ESC	Shelved, friction fitted

Fuselage Wing

Inboard Section: Main Hatch

Main Hatch

Access point to the fuselage avionics

- Large length with small width, tight tolerance needed
- Placed on the top of the fuselage
- Joined to skin with tape
- Composition similar to the surrounding skin
- Reinforced with extra layers of glass if needed

STRUCTURES

Fuselage Wing

Inboard Section: Rocket Integration

Rocket Wall

Transfers rocket load

- 1/8" thick Aero ply, Fiberglass Laminate, Carbon Fiber Laminate
  - Will be tested to ensure it can support largest rocket load, 22 lbf
- Bonded to fuselage before the two halves are joined

Rocket House

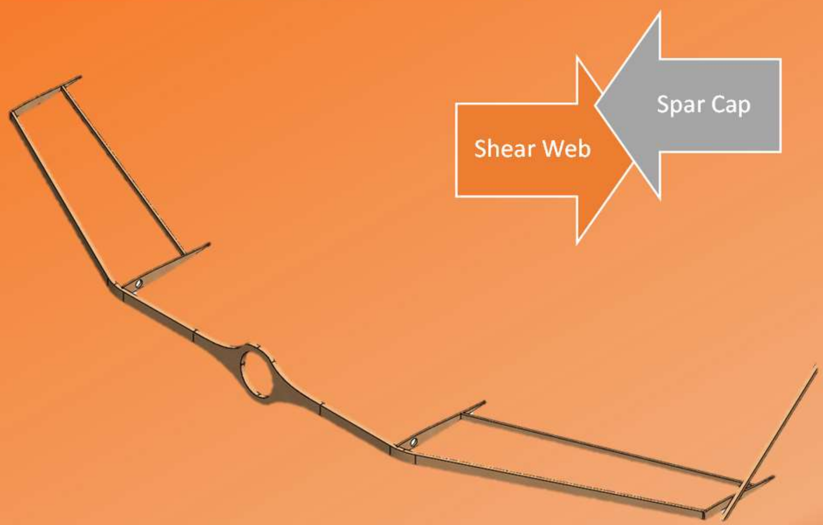
Houses rocket motor

- Traditional cardboard tube housing
- Held in place by a series of two formers
- Added to fuselage before the two halves are joined

STRUCTURES

Fuselage Wing

Outboard Section: Main Spar



Shear Web — Formed outside of the wing

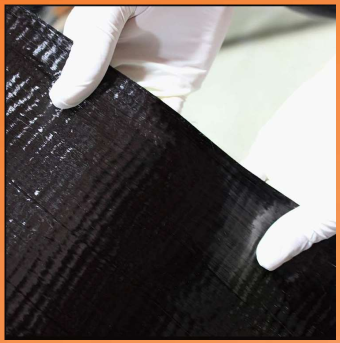
- Balsa, formed to fit sweep
- Aero Ply, reinforce straight center section
- Custom Made, epoxied wooden sheets
- Jig Developed

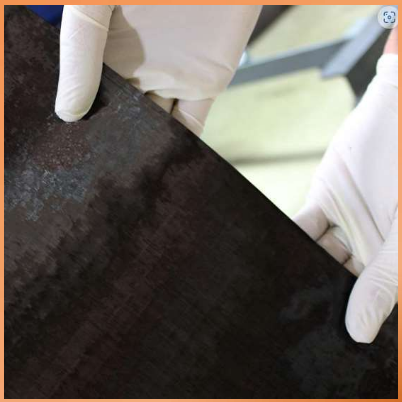
Spar Cap — Laid up in the skin

- Carbon TOW (various weights tested)
- Continuous Strip, folded over itself
- Precise location needed for proper load transferal

Fuselage Wing

Outboard Section: Main Spar





Spar Cap

Formed outside of the wing

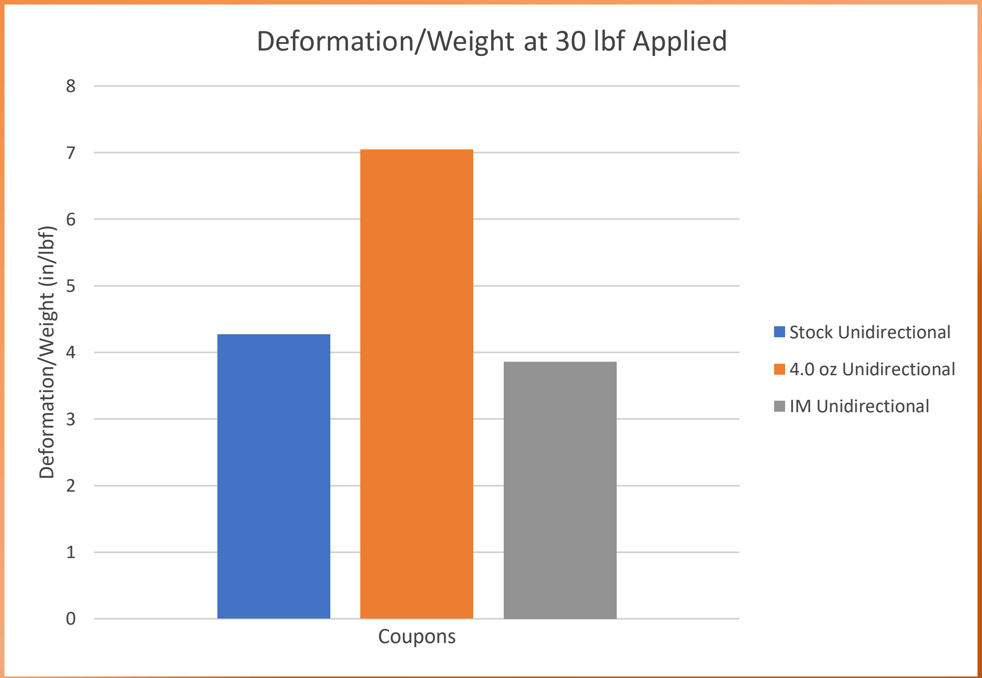
- 4.3 oz IM unidirectional carbon fabric
- 4.0 oz unidirectional carbon fabric
- Stock unidirectional carbon tow

STRUCTURES

Fuselage Wing

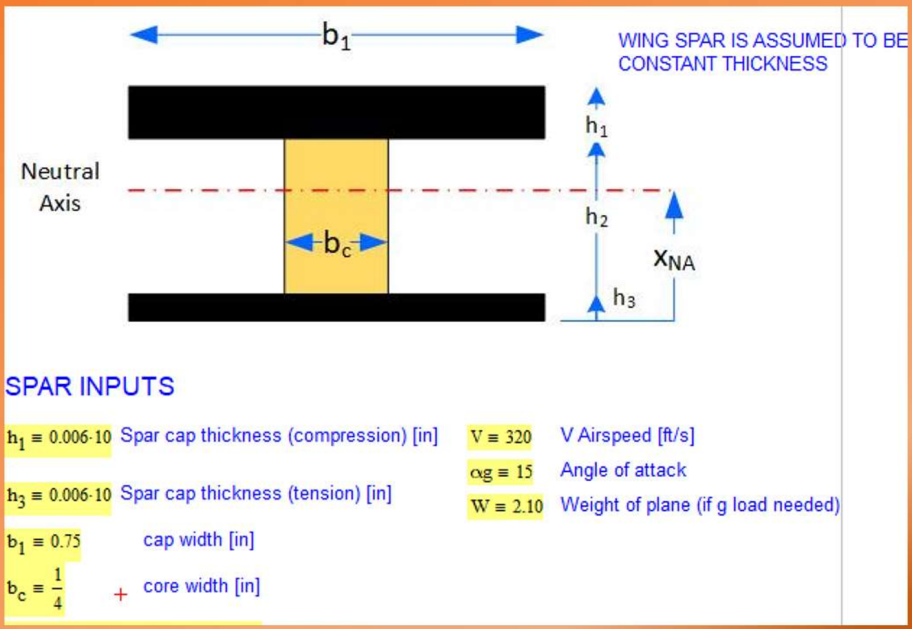
Outboard Section: Spar Caps

Fiber Type	Coupon Weight (g)	Coupon Thickness (in)
Stock Unidirectional	9.86	0.09
4.0 oz Unidirectional	12.30	0.08
IM Unidirectional	11.97	0.08



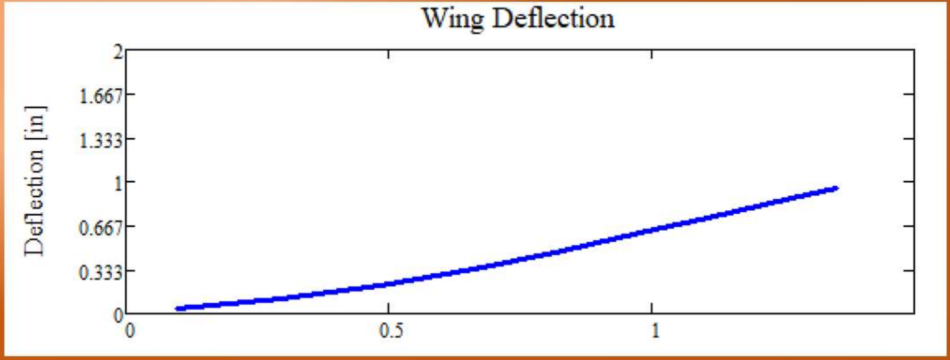
Fuselage Wing

Outboard Section: Spar Design



Point of Departure Based upon given analysis tools

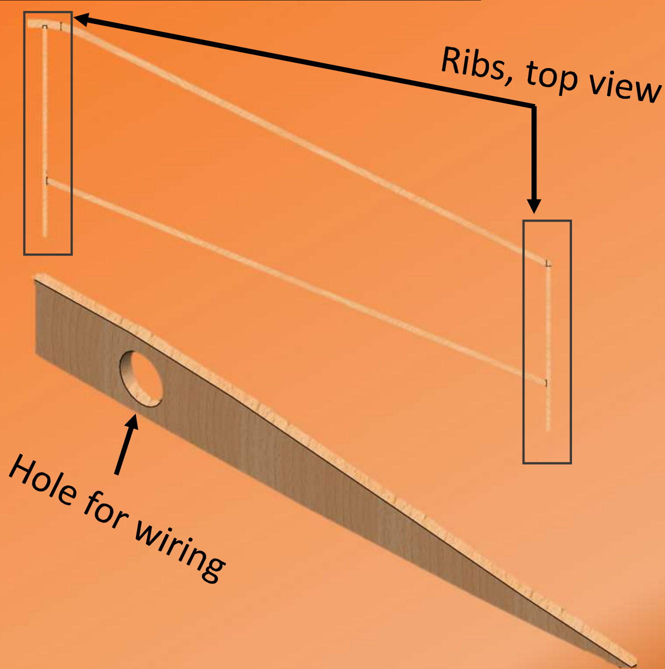
- 5 layers (folded) of IM Uni carbon Tow
- 0.25” Shear web thickness
- Wing deflection kept to ~ 1in,



STRUCTURES

Fuselage Wing

Outboard Section: Ribs

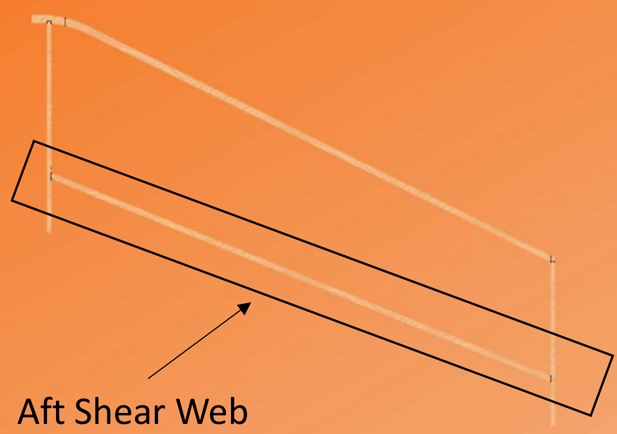


Ribs(s) Small and Precise reinforcement

- Different Balsa Thicknesses will be tested
- Sandwich elevon surface
- Sanded to fit sizing
  - Must Fit
    - Pitot Tube Room
    - Servo Wiring Room

Fuselage Wing

Outboard Section: Aft Shear Web



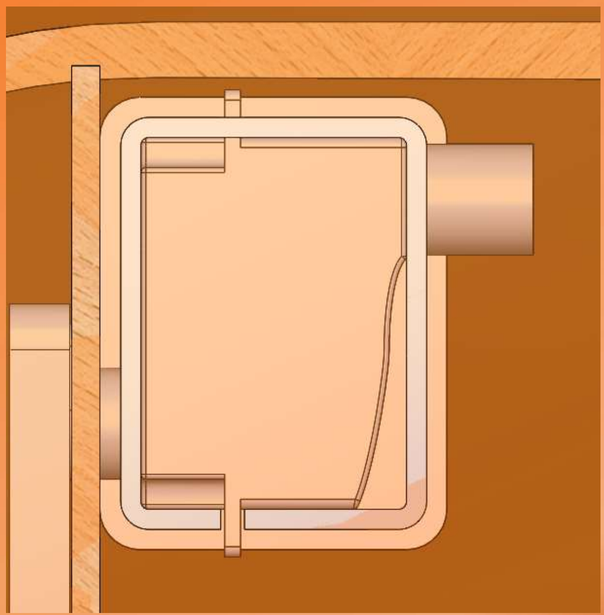
Aft Shear Web

Closes out the wing

- Doubles as connection stiffening
- Top to bottom end grain balsa
- Precision sanding required
- Square balsa cuts

Fuselage Wing

Outboard Section: Servo Bay



Servo Mount

Bonded in the Skin

- Balsa formed structure
- Adhesive for skin connection
- To be laser cut to exact dimensions
- Position driven by wing tolerances

Fuselage Wing

Outboard Section: Servo Bay Hatches

Servo Bay Hatches

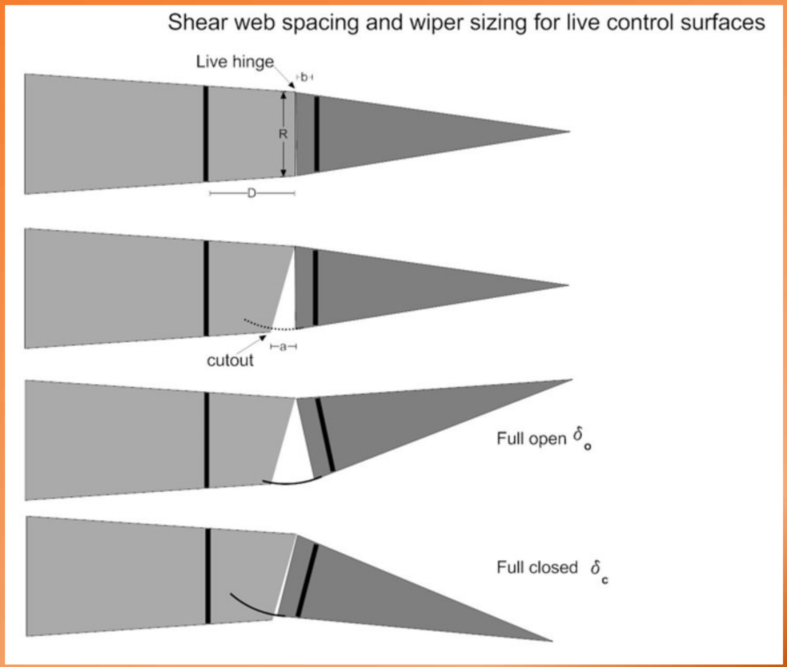
Servo Maintenance access

- Positioned under the wing
- Same composition as the surrounding skin
- Kevlar hinges
- Giles Method: In skin hatch lay up method
- Practice lay ups completed

STRUCTURES

Fuselage Wing

Outboard Section: Elevon Components



Elevon Shear Web — Closing out the aileron

- Epoxy strip to fill small section
- Strengthens elevon stiffness

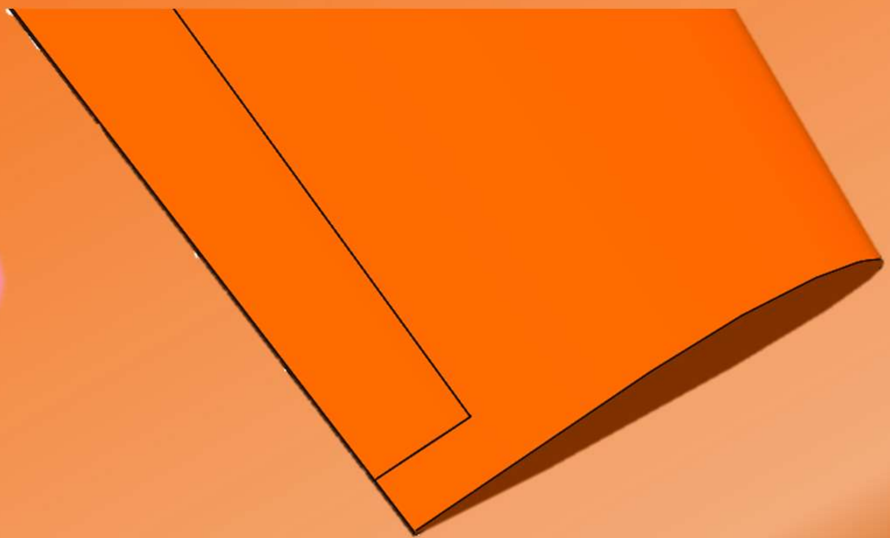
Wiper — Allowing closeout during deflection

- Developed for max deflection of 10 deg
- Formed post wing connection
- Eliminates FOD during actuation

STRUCTURES

Fuselage Wing:

Outboard Section: Endplate Attachment



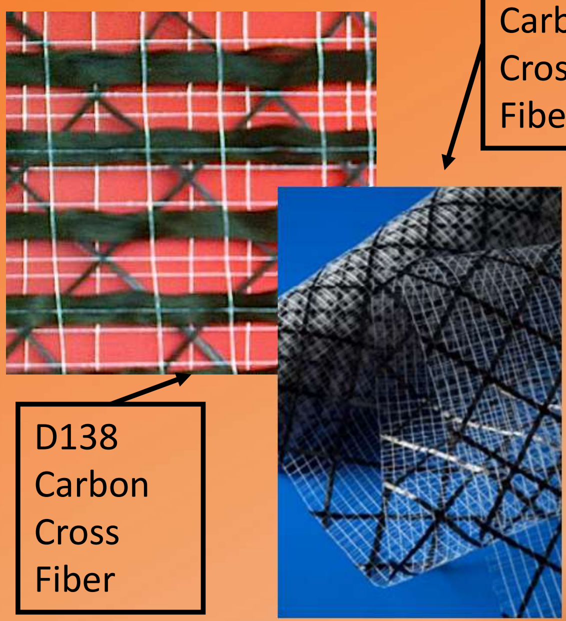
Endplate Attachment Points

Connecting wing tips to endplates

- Wing tip to be cut off
- Epoxied with a flush connection to the endplate
- Plywood Build up, for mounting screws to puncture

Fuselage Wing

Outboard Section: Composite Skin



D144 Carbon Cross Fiber

D138 Carbon Cross Fiber

Material Selection

Less layers for less loads

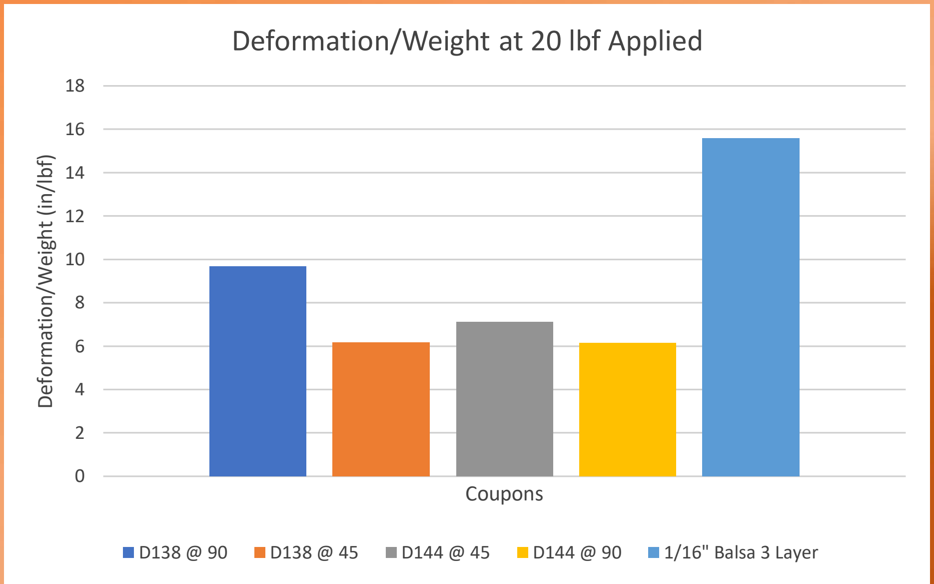
- Similar as the materials found in the inboard section
  - Primarily a Fiberglass and Balsa Construction
- Less lamina layers will be utilized than the inboard section
- A carbon scrim material is considered for reinforcements

STRUCTURES

Fuselage Wing

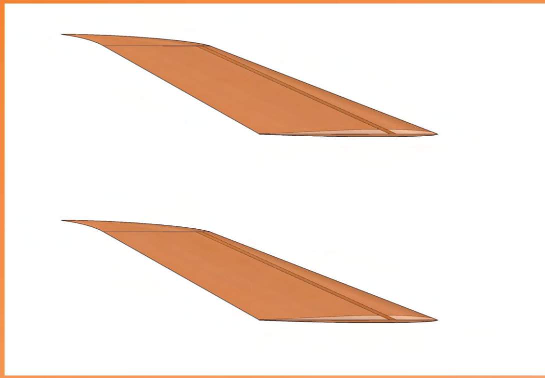
Inboard Section: Composite Skin

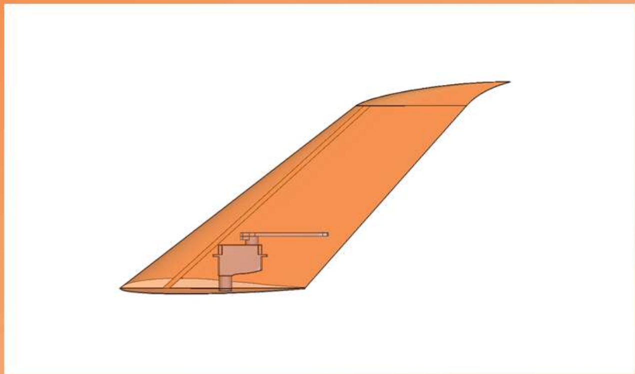
Outer Lamina	Coupon Weight (g)	Coupon Thickness (in)
D138 Cross fiber @ 90	8.94	0.07
D138 Cross fiber @ 45	9.63	0.08
D144 Cross fiber @ 45	8.20	0.08
D144 Cross fiber @ 90	8.75	0.08
Baseline Balsa	7.27	0.05



Endplates

List of Materials





Without Rudder

- Main Spar
- Attachment Points
- Composite Skin

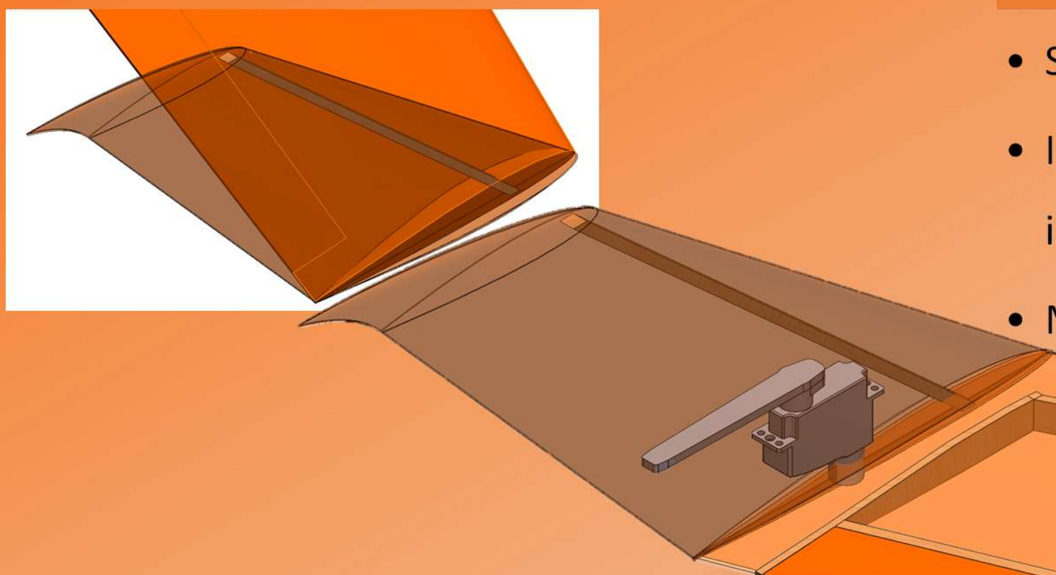
With Rudder

- Main Spar
- Servo Bay
- Servo Hatch
  - Elevon Shear Web
  - Wiper
- Composite Skin

STRUCTURES

Endplates

Main Spar



Main Spar

Reinforce endplate shear strength

- Same materials as main wing spar, custom balsa
- IM Servo placed in one endplate, reduced drag at increased weight to traditional servo and horn
- May pivot to an external actuator in future

STRUCTURES

Weight Breakdown

Overall weights

TOTAL WEIGHT		
Internals and Skin		
Internal Structure	0.130154	lbs
Avionics/Propulsion	1.18	lbs
Skin	0.72	lbs
Weight	**2.023955**	lbs

MAIN SPAR

Main Shear Web: BALSA		
length	31.06	in
heigth	1.75	in
width	0.06	in
volume	3.40	in^3
density	9.36	lbs/ft^3
Weight	**0.0184**	lbs

Spar Caps: IM UNIDIRECT. CARBON FIBER		
length	31.06	in
width	0.75	in
weight per area	0.03	lb/ft^2
area	23.30	in^2
Weight	**0.029121**	lbs

Shear Web Center Reinforce: AERO PLY		
length	10.25	in
heigth	1.75	in
width	0.125	in
volume	2.242	in^3
density	43.70	lbs/ft^3
Weight	**0.056703**	lbs

Main Spar Weight	**0.1042**	lbs

AFT SHEAR WEB

Shear Web: BALSA		
length	9.72	in
heigth	0.16	in
width	0.1	in
volume	0.15552	in^3
density	9.36	lbs/ft^3
Weight	**0.001686**	lbs

ENDPLATE SPAR

Endplate Shear Web: BALSA		
length	5.00	in
heigth	1.75	in
width	0.06	in
volume	0.55	in^3
density	9.36	lbs/ft^3
Weight	**0.0059**	lbs

SERVO BAY

Servo Mount: BALSA		
volume	0.12	in^3
density	9.36	lbs/ft^3
Weight	**0.001951**	lbs

FIREWALL

Motor Mount: assuming carbon fiber		
volume	0.11	in^3
density	0.057	lbs/in^3
Weight	**0.00627**	lbs

RIBS

Ribs: BALSA (estimated at right triangle)		
height	0.24	in
length	3.81	in
width	0.0625	in
volume	0.028575	in^3
density	9.36	lbs/ft^3
Weight	**0.00062**	lbs

COMPONENT HOUSING

Mounting Tray: BALSA		
volume	0.49	in^3
density	9.36	lbs/ft^3
Weight	**0.0080**	lbs

ROCKET HOUSING

Formers and Bulkhead: AERO PLY		
volume	0.34	in^3
density	43.70	lbs/ft^3
Weight	**0.0258**	lbs

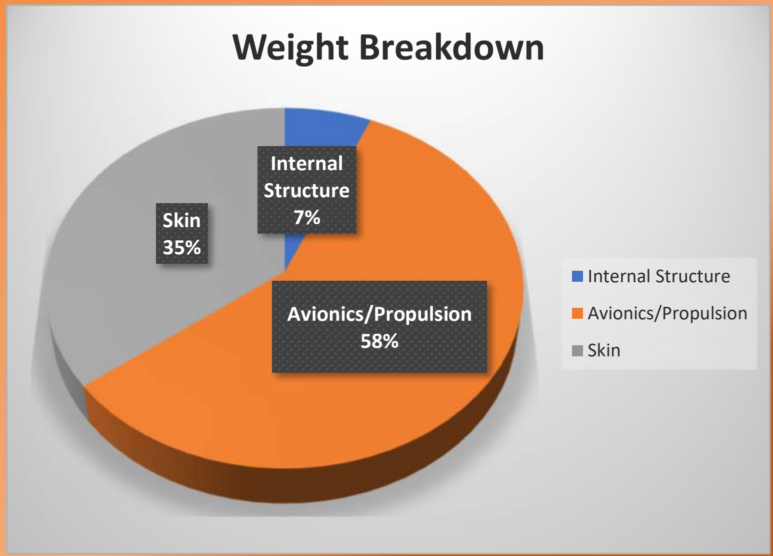
SKIN

Full Skin: Estimating full core w/ 4 layers of glass		
surface area	398	in^2
thickness	0.7	in
density	0.0026	lbs/in^3
Weight	**0.716**	lbs

Weight Breakdown

Overall weights

TOTAL WEIGHT		
Internals and Skin		
Internal Structure	0.130154	lbs
Avionics/Propulsion	1.18	lbs
Skin	0.72	lbs
Weight	**2.023955**	lbs



Key Assumptions

- Skin assumed to have full balsa core composition, four glass lamina
- Servo and housing present in endplate
- Aero Ply motor mount, Carbon Fiber rocket wall

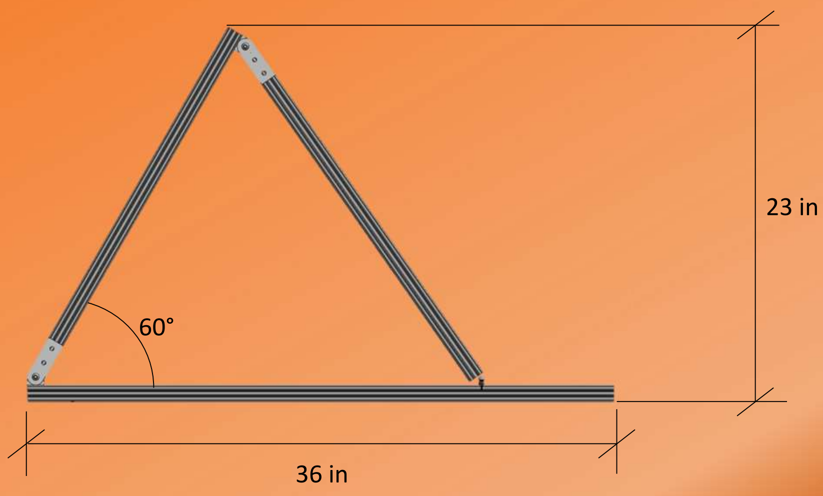
STRUCTURES

RATO Stand

Design Process

RATO Stand

Design Rationales and Specifications



Manufacturability

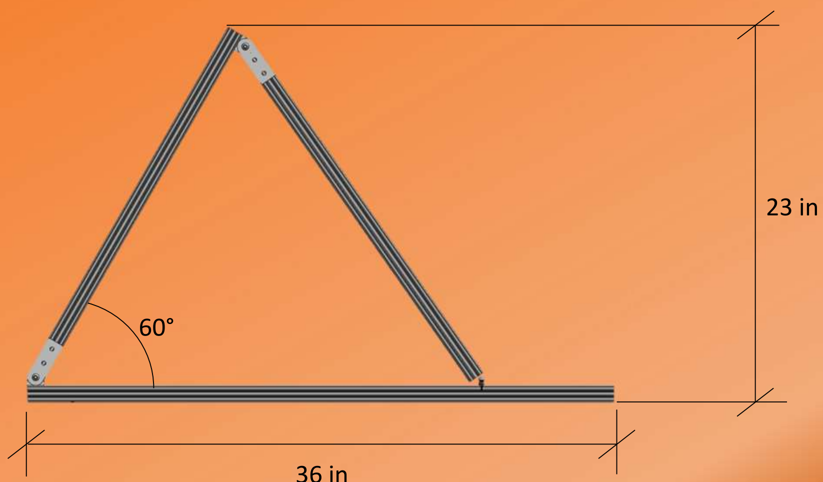
Ease of Production and Repair

- Easily Sourced Parts and Materials
  - 80/20 1” Aluminum T-Slotted Profile
- Low Assembly Time
- Self Made vs Pre-Made
- Non-Invasive Design
- Minimum Number of Parts
  - Reduction of Failure Points

STRUCTURES

RATO Stand

Design Rationales and Specifications



Marketability

Designed For Any Age and Size

- Small Footprint (3 feet by 8 in)
  - Fits easily in most vehicles for transport
- Easy Assembly/Setup
- Lightweight (0.5088 lb/ft)
  - Total weight slightly under 10 lbs.
- Variable Launch Angle
- Non-Destructive Firings
- All-Terrain Launch Capability
- Simple to Use
- Universal Launch

STRUCTURES

RATO Stand

Point of Departure

Testing

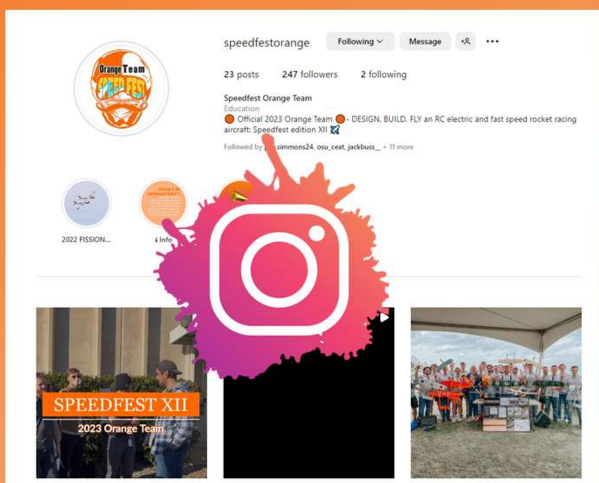
Future Rato Testing

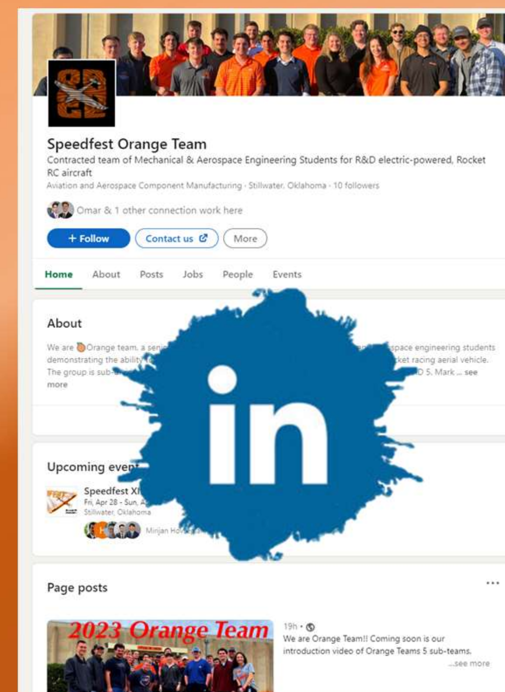
- Stand Stability Testing
- Plane Stability Testing
- Structural Testing
- All Terrain Testing
- Assembly Time Testing
- Final configuration conformation

MARKETING

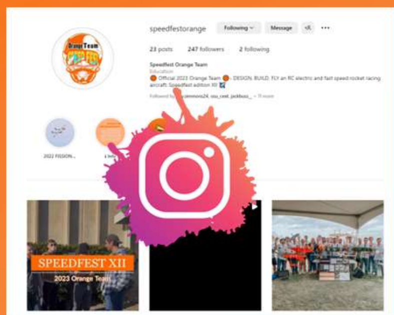
Strategy

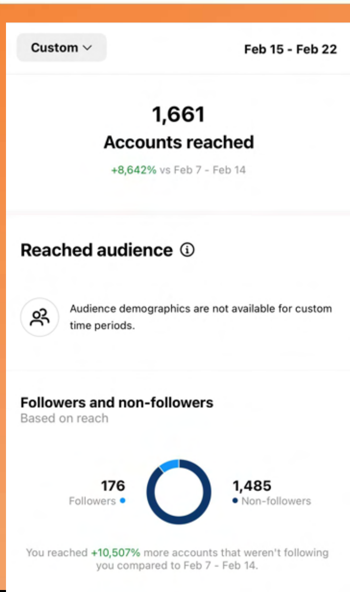
Creating an Influence



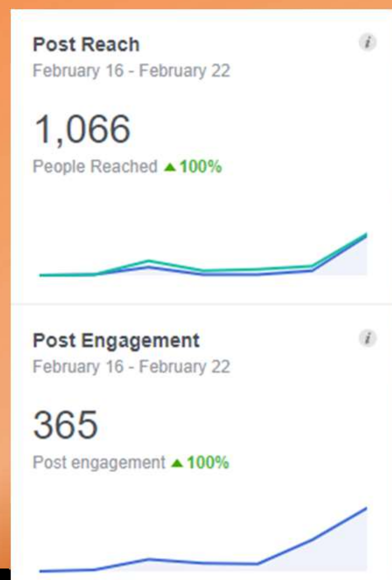


MARKETING

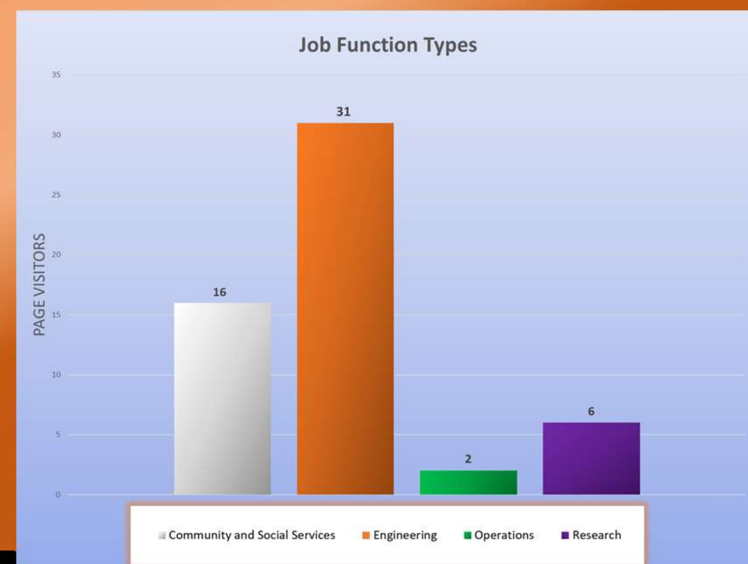

SPEEDFEST XII
2023 Orange Team


Custom
Feb 15 - Feb 22
1,661
Accounts reached
+8,642% vs Feb 7 - Feb 14
Reached audience
Audience demographics are not available for custom time periods.
Followers and non-followers
Based on reach
176
Followers
1,485
Non-followers
You reached +10,507% more accounts that weren't following you compared to Feb 7 - Feb 14.


SpeedfestOrange
SPEEDFEST XII
2023 Orange Team


Post Reach
February 16 - February 22
1,066
People Reached ▲100%
Post Engagement
February 16 - February 22
365
Post engagement ▲100%


Speedfest Orange Team
2023 Orange Team


Job Function Types
PAGE VISITORS
35
30
25
20
15
10
5
0
16
31
2
6
Community and Social Services
Engineering
Operations
Research

MARKETING

Strategy

Uniqueness and creativity

Marketing Philosophy

- Flying Wing and Speed
- RATO Capability
- Dual-use RATO Launch Sled
- Manufacturing Lead Time Savings
- Versatile Range for Rocket Types

Phoenix

@speedfestorange

MARKETING

Strategy

Future Development

Development Plan

- Launch Website (Next Week)
- Marketing Video
- Social Media Updates
- Outreach to Local/outside Organizations

Phoenix