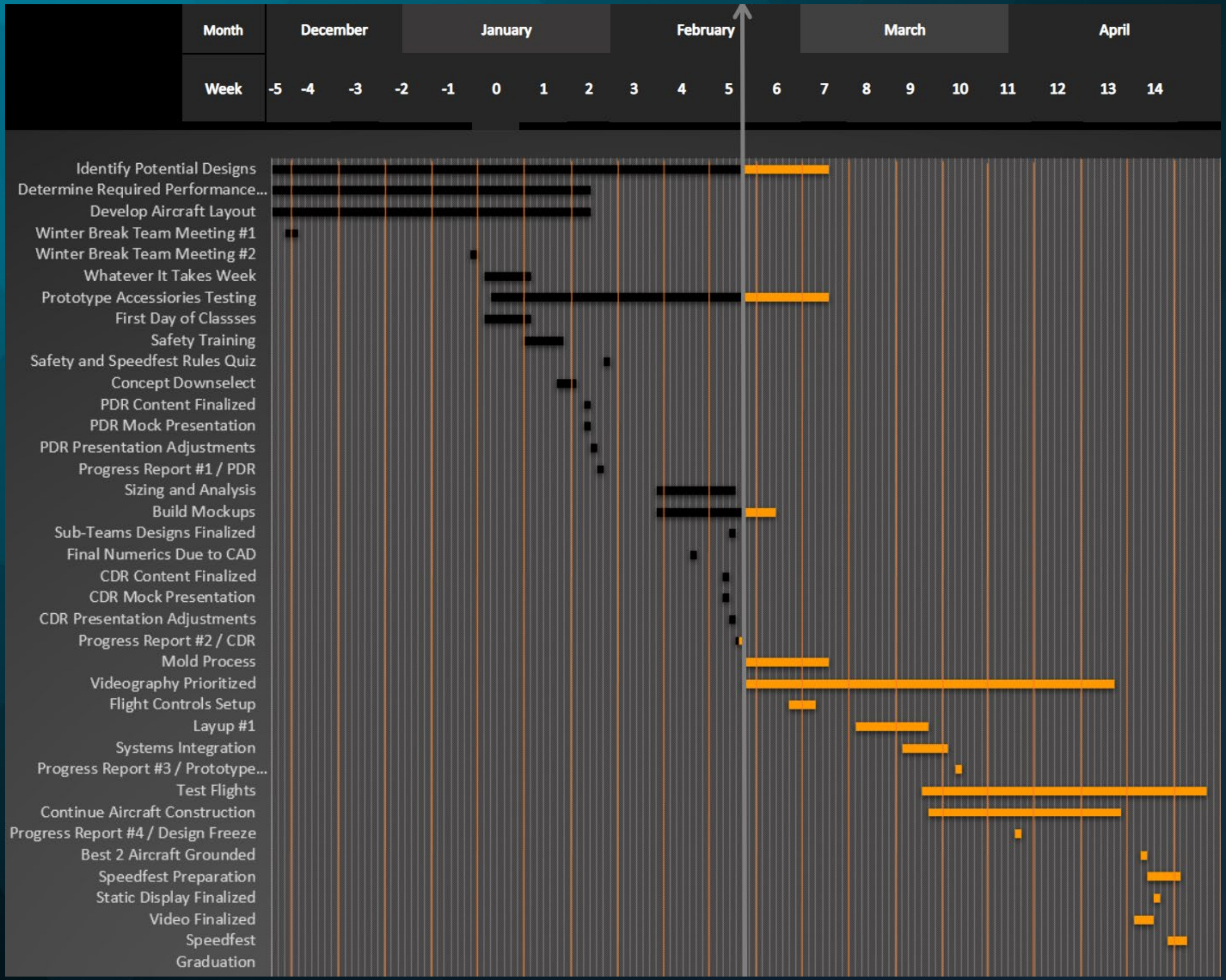
Speedfest xi black team

CRITICAL DESIGN REVIEW

Outline

1. Mission strategy
2. Design updates
3. Propulsion
4. Aerodynamics
5. Structures
6. Marketing

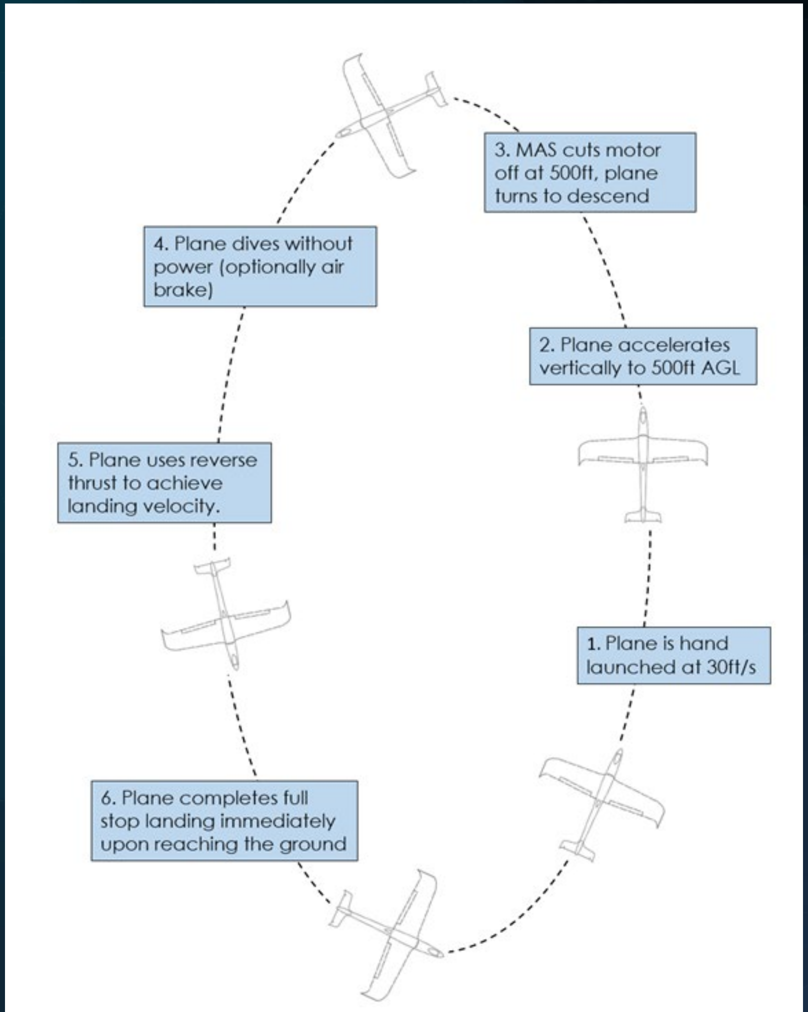
Gantt chart



Month
December
January
February
March
April
Week
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Identify Potential Designs
Determine Required Performance...
Develop Aircraft Layout
Winter Break Team Meeting #1
Winter Break Team Meeting #2
Whatever It Takes Week
Prototype Accessories Testing
First Day of Classses
Safety Training
Safety and Speedfest Rules Quiz
Concept Downselect
PDR Content Finalized
PDR Mock Presentation
PDR Presentation Adjustments
Progress Report #1 / PDR
Sizing and Analysis
Build Mockups
Sub-Teams Designs Finalized
Final Numerics Due to CAD
CDR Content Finalized
CDR Mock Presentation
CDR Presentation Adjustments
Progress Report #2 / CDR
Mold Process
Videography Prioritized
Flight Controls Setup
Layup #1
Systems Integration
Progress Report #3 / Prototype...
Test Flights
Continue Aircraft Construction
Progress Report #4 / Design Freeze
Best 2 Aircraft Grounded
Speedfest Preparation
Static Display Finalized
Video Finalized
Speedfest
Graduation

Speedfest XI Objectives

- Design an electric-powered aircraft optimized for vertical and horizontal acceleration using a 6S battery limited by a 40A fuse
- Climb to 500 ft, descend, and come to a full-stop landing in the shortest time
- Achieve the fastest speed in 10 seconds after takeoff
- Perform a 4-minute airshow, including aerobatic maneuvers
- Design the most marketable plane



CONOPS Review – Vertical drag race

Score Optimization

- Maximize the power drawn from the battery & conversion to thrust
- Minimize the weight of the aircraft to increase acceleration
- Utilize the propulsion system to decelerate with reverse thrust
- Mitigate torque without power costs
- Maintain proper controllability and handling qualities

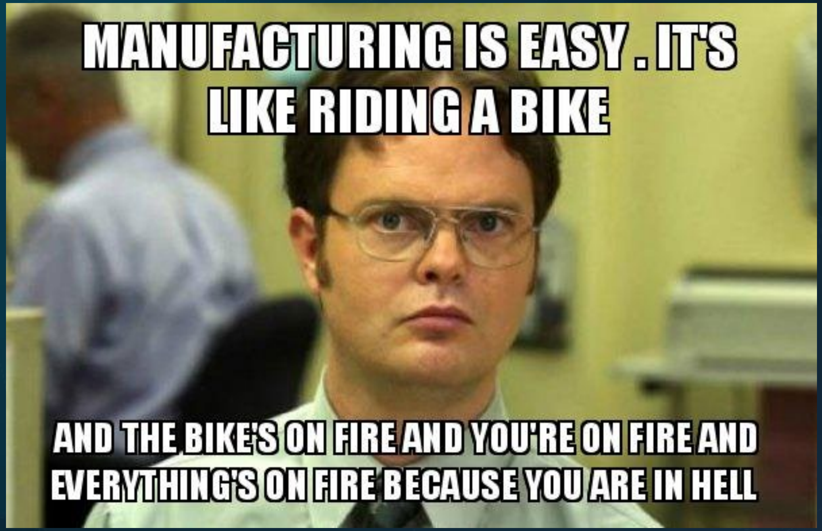
Objective scoring:

5.1.1	Vertical Drag Race	Based on place	1st 2nd 3rd and lower	15 10 5
5.1.2	Horizontal Drag Race	Based on place	1st 2nd 3rd and lower	15 10 5
			Threshold	**Objective**
5.2	Aerobatics		3	5
5.3	Unit Cost bid		2	5

Aircraft Design	
Fit and finish	0-5
Handling Qualities[1]	0-5
Design optimization	0-5
Cost bid certification	*
Subtotal Possible	**15**
Marketing	
Online Marketing Display[2]	0-5
Video	3 Threshold 5 Winner
5.4 Expert Marketing[3]	0 *or* 5 (Winner only)
Subtotal Possible	**15**

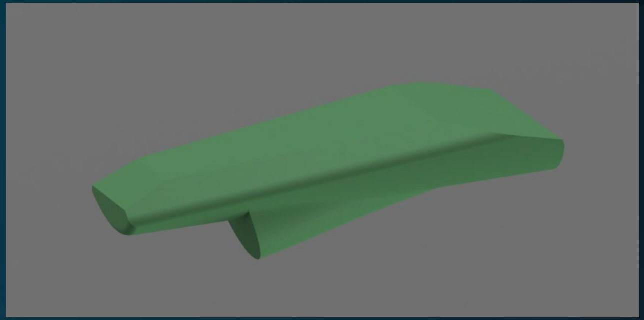
CAD

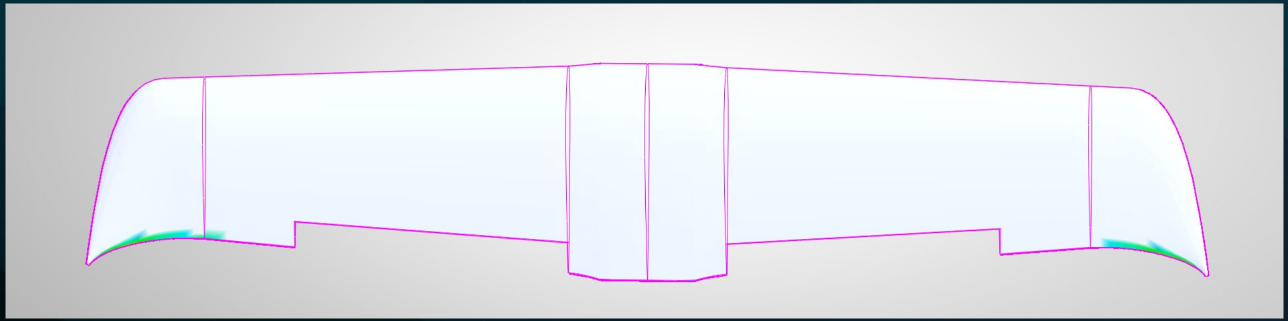
- How can CAD score points?
- What plane are we actually designing?
- Manufacturability



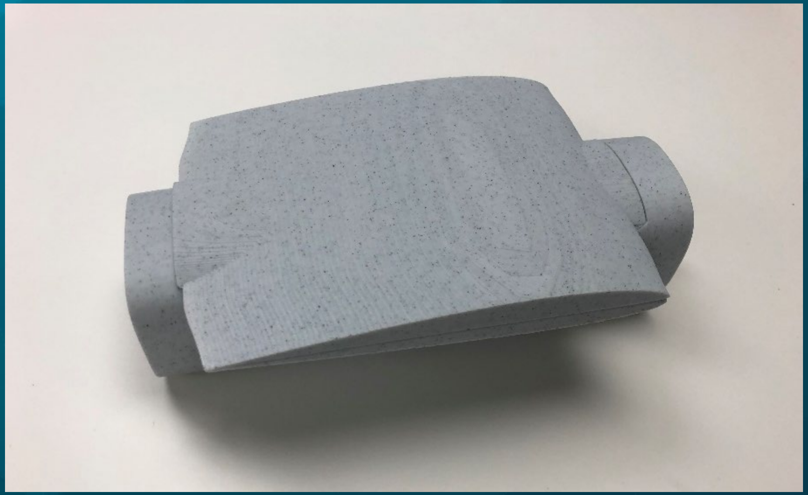
Design for Manufacturing

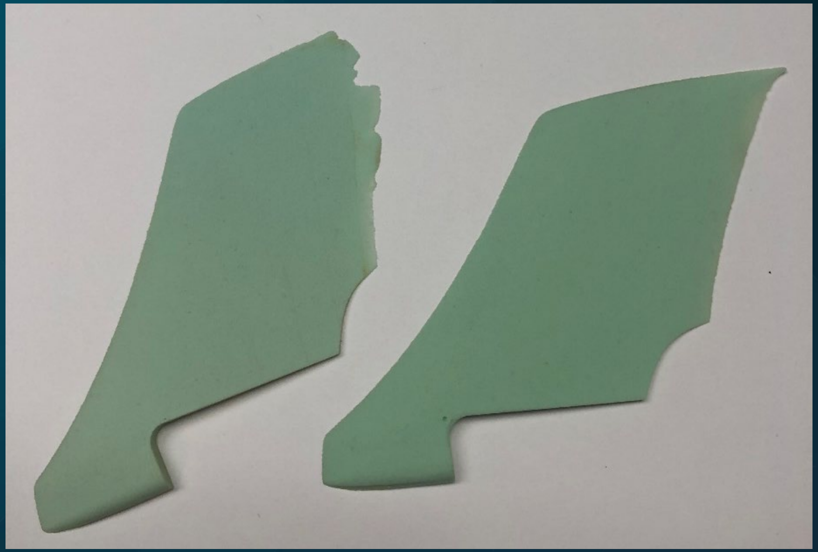
- Tolerance within Solidworks
- Design corner fitting tools for the molds
- Ensure Airplane is configurable



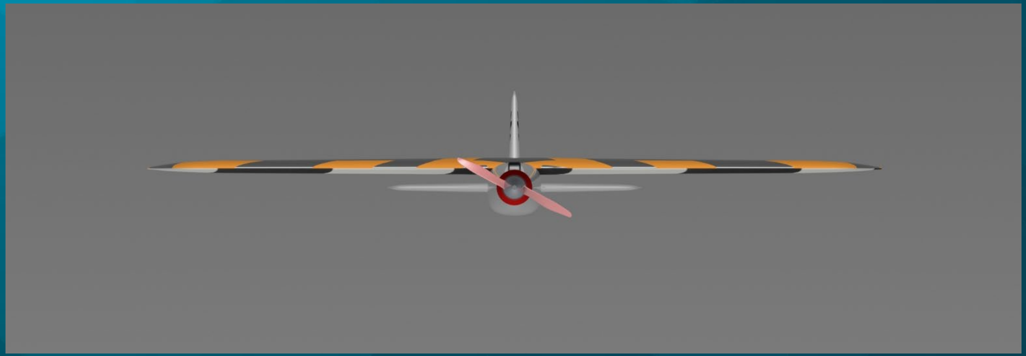


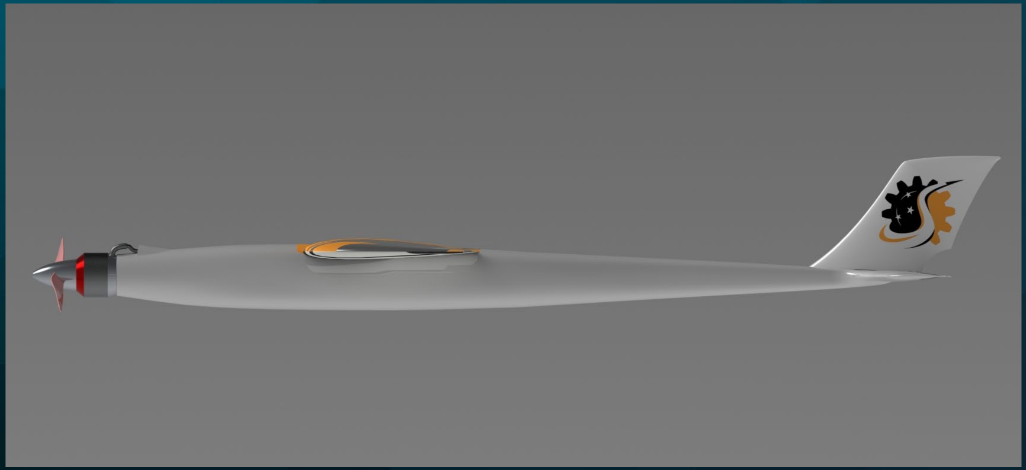
testing

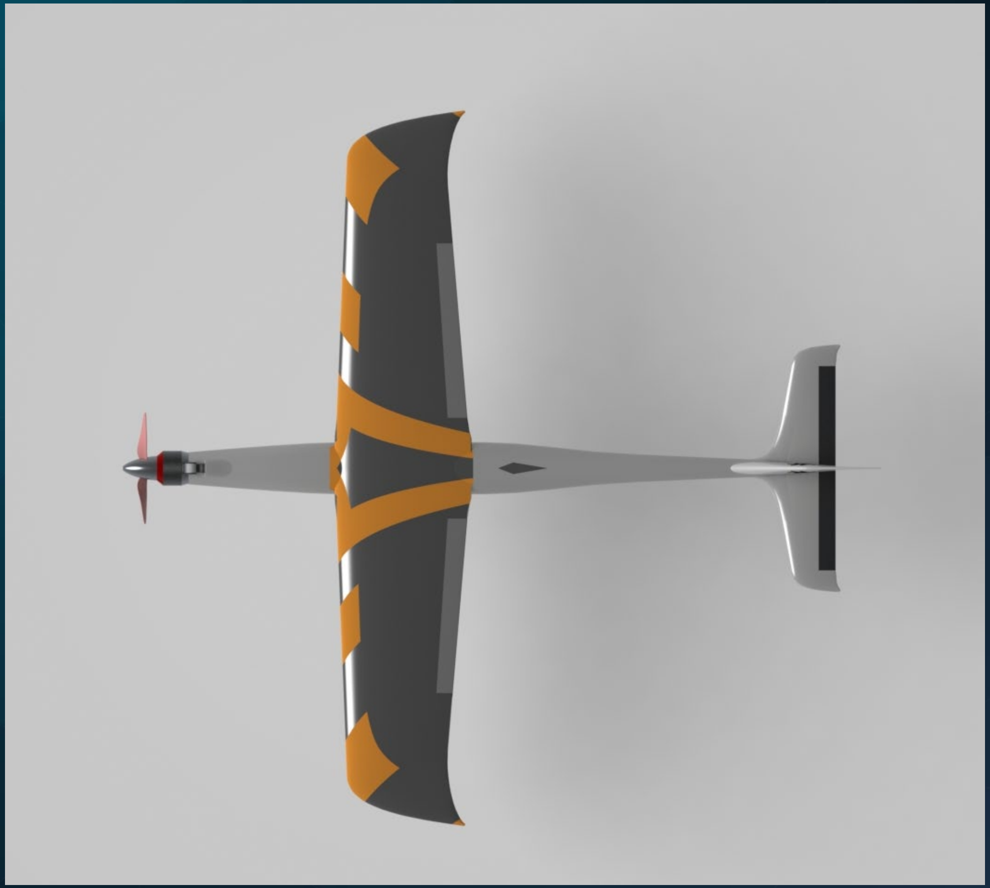




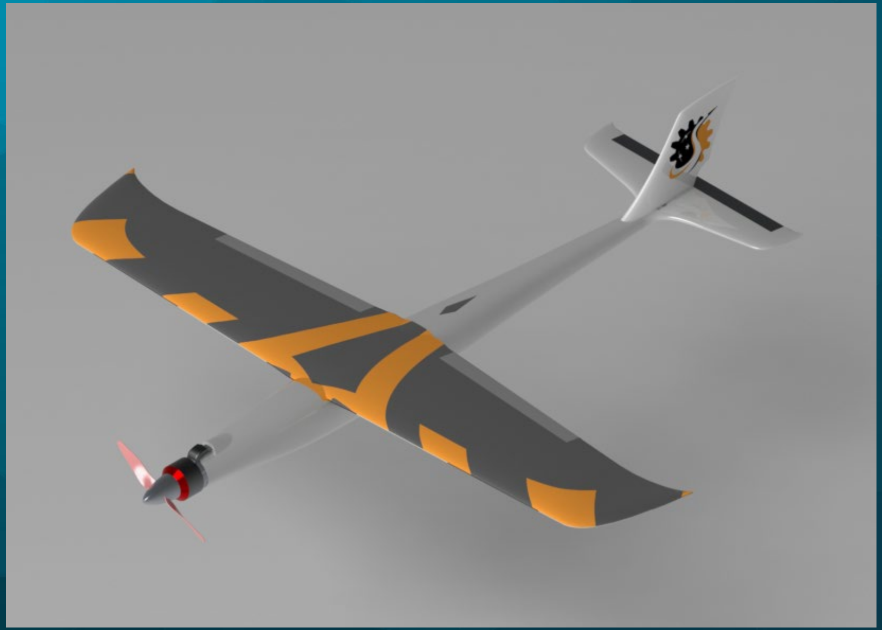
Final CAD

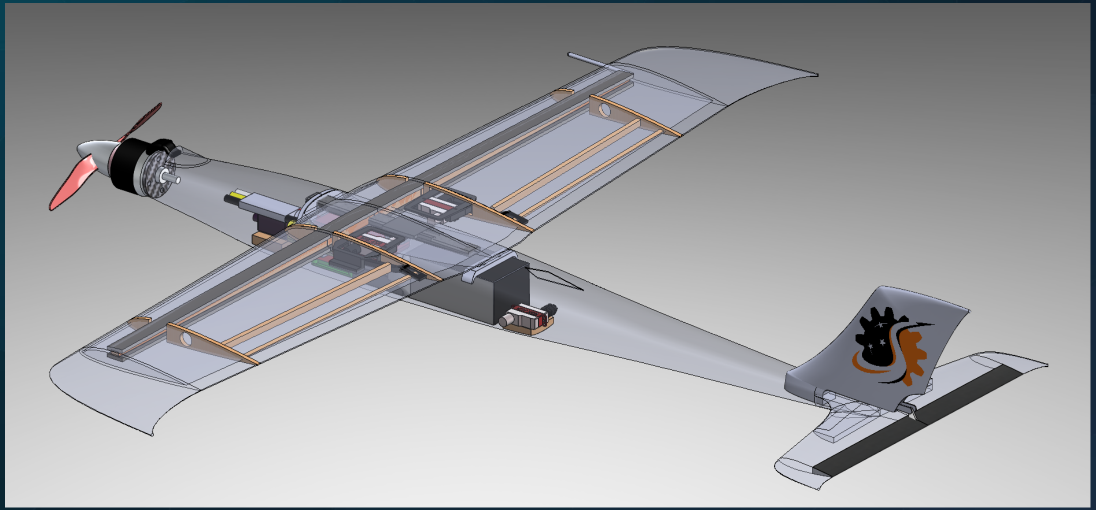






Final CAD

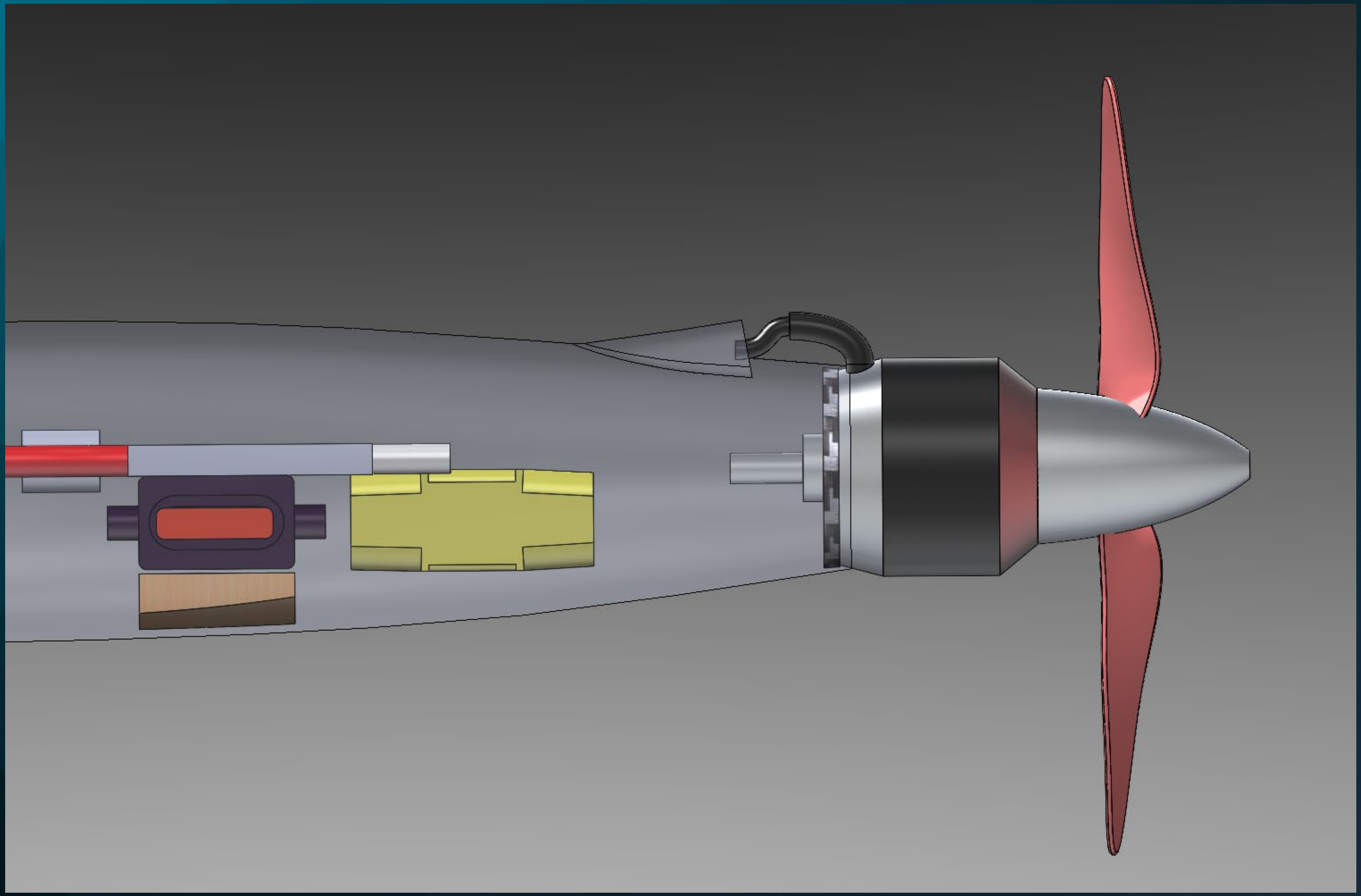




CAD Next Steps

- CNC the plugs and parting boards
- Make jigs-n-stuff for structures
- Finally get some sleep?

Propulsion



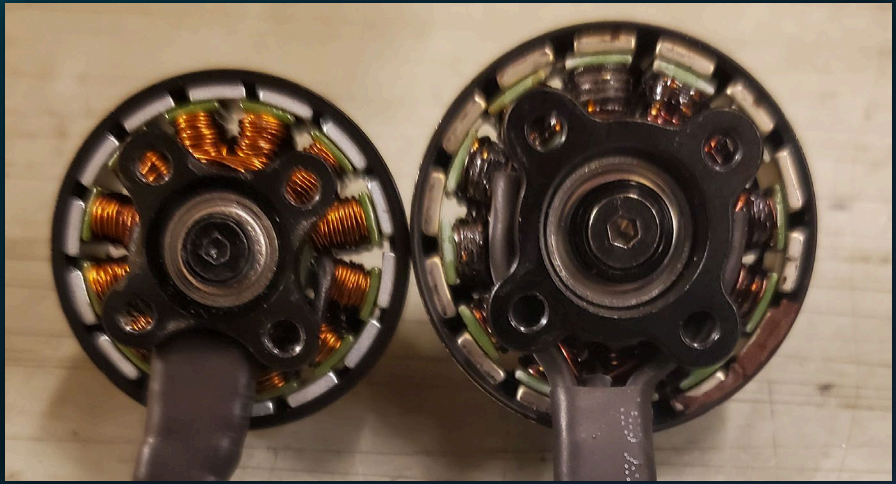
Motor testing: quad motors

Motivation

- Best thrust to weight (≤25)
- Very Light (40 grams)
- Wide range of KV Ratings

Discoveries

- None Survived >50A
- Rated for use with other motors
- Not suitable for current application



Motor Testing: Inrunners

Motivation

- Most reliable
- Acceptable Thrust-to-Weight Ratio (≤ 11)
- Outer casing helps heat mitigation
- Available to test during snowstorm

Top 10s Speed	Time to 500 ft	Static Thrust (lbs)
167 mph	6.46 s	2.8

Motor testing: BadAss Motors

Motivation

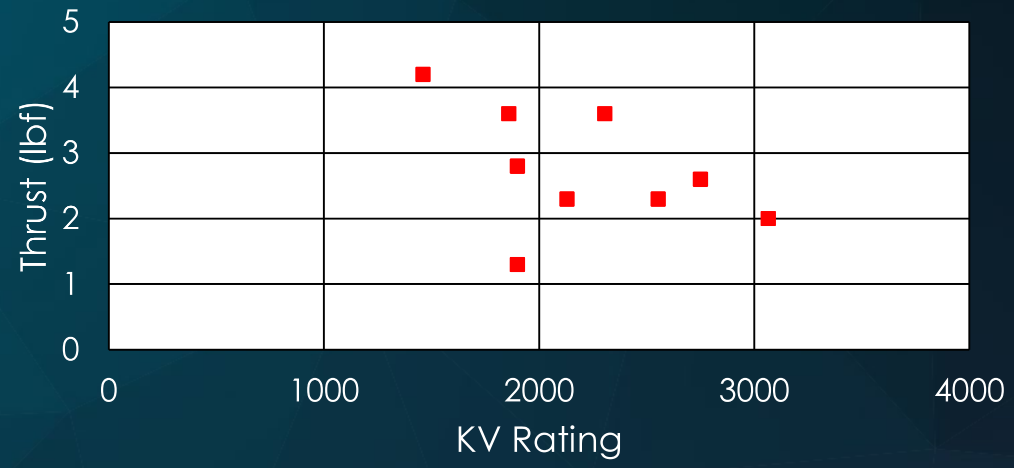
- Slightly Heavier than Quads (100 – 120 grams)
- Good Thrust-to-Weight Ratio (≈17)
- Wide Range of KV Ratings
- Better reputation than Quad motors

Top 10s Speed	Time to 500 ft	Static Thrust (lbs)
173 mph	4.84 s	4.2

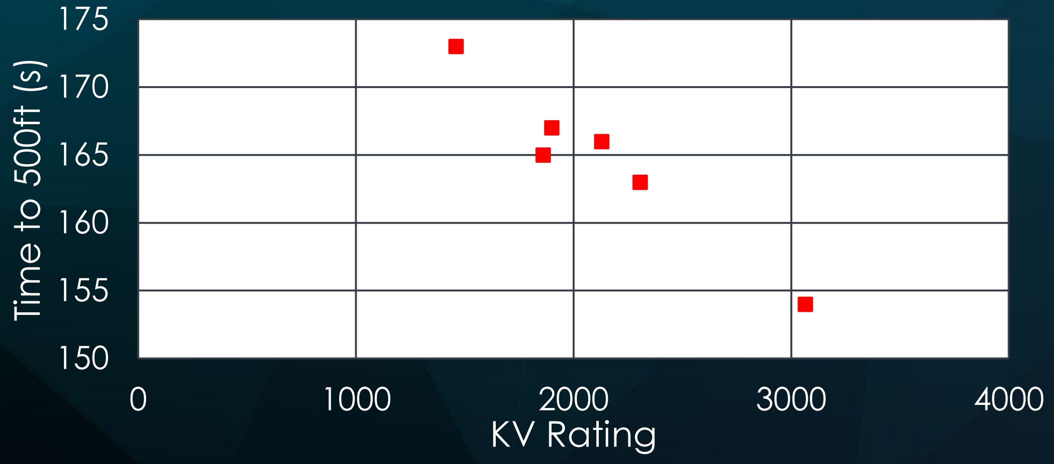
Optimum KV Range

- Motors Optimized for 65A
- Multiple props tested to find optimum configuration

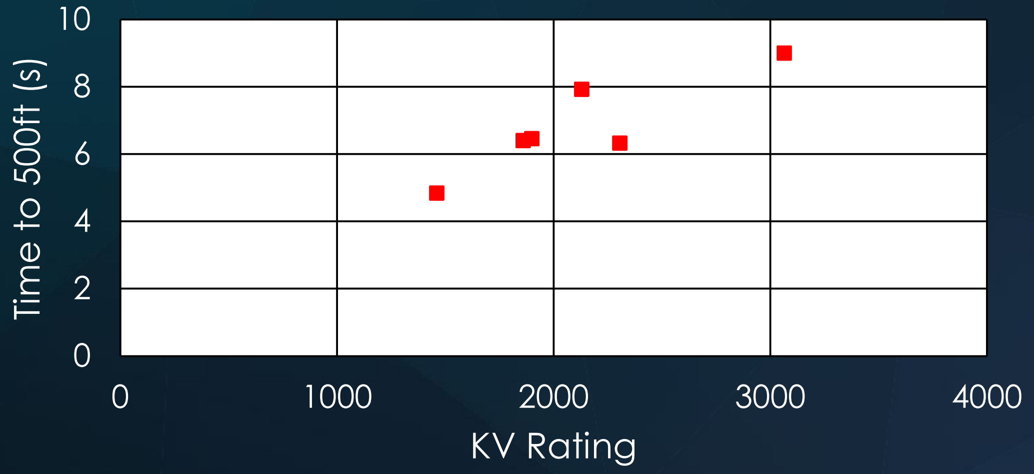
Thrust vs. KV



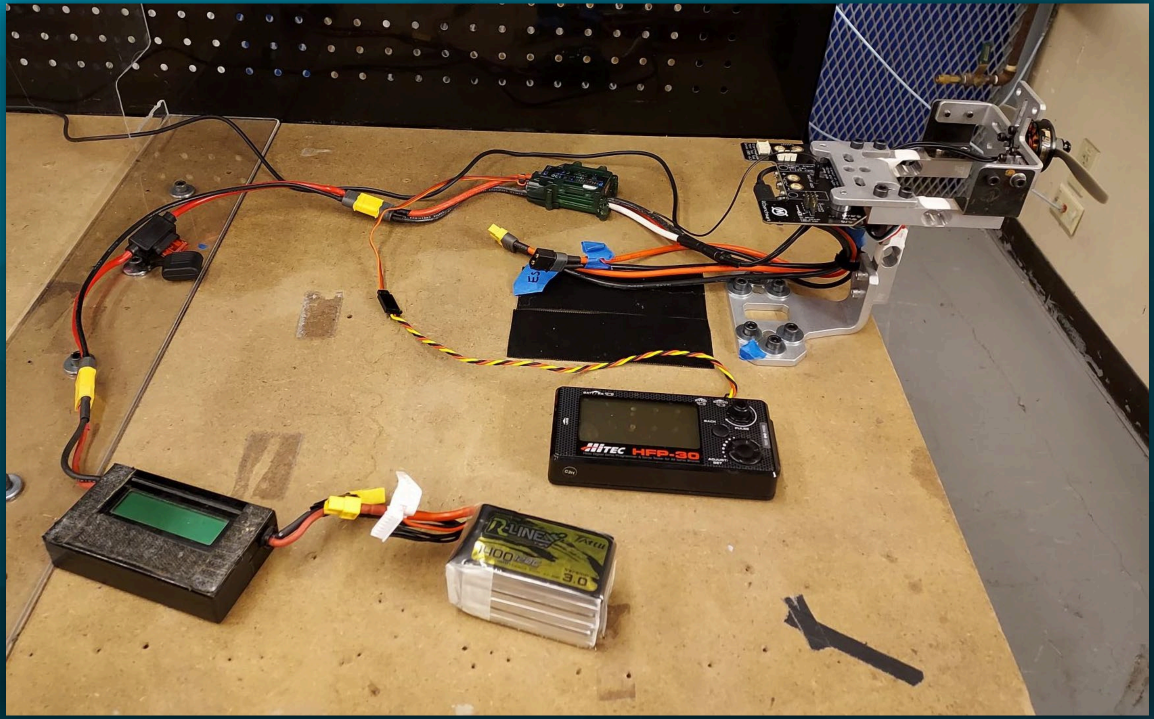
Horizontal Speed (10s) vs. KV Rating

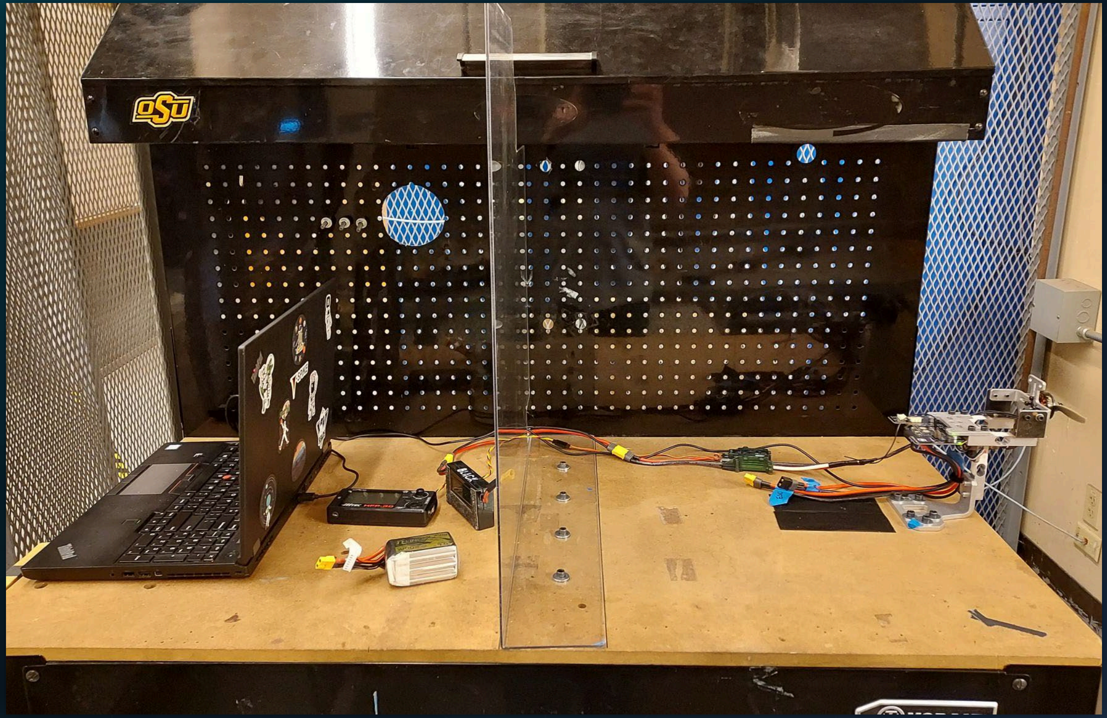


Time to 500ft vs. KV Rating



Testing setup

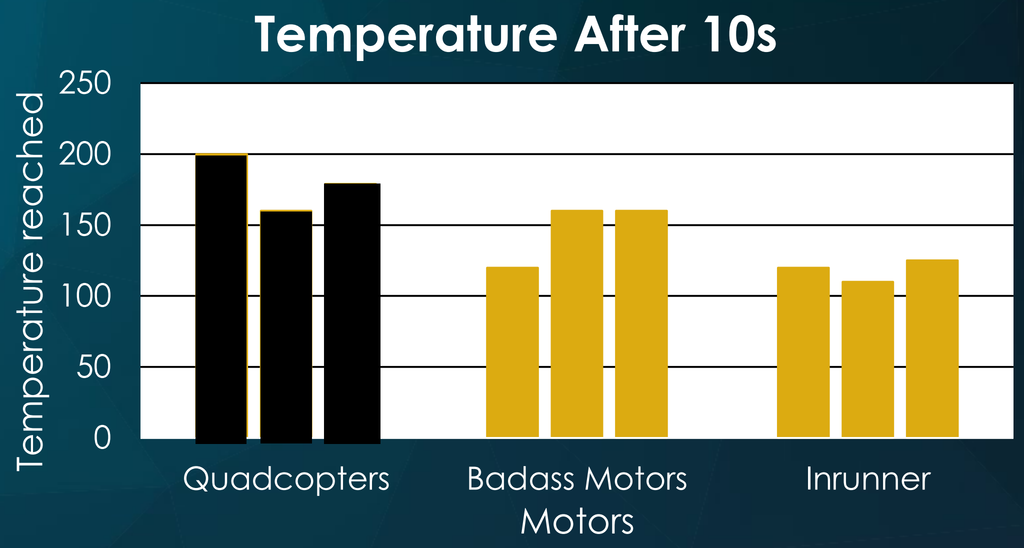


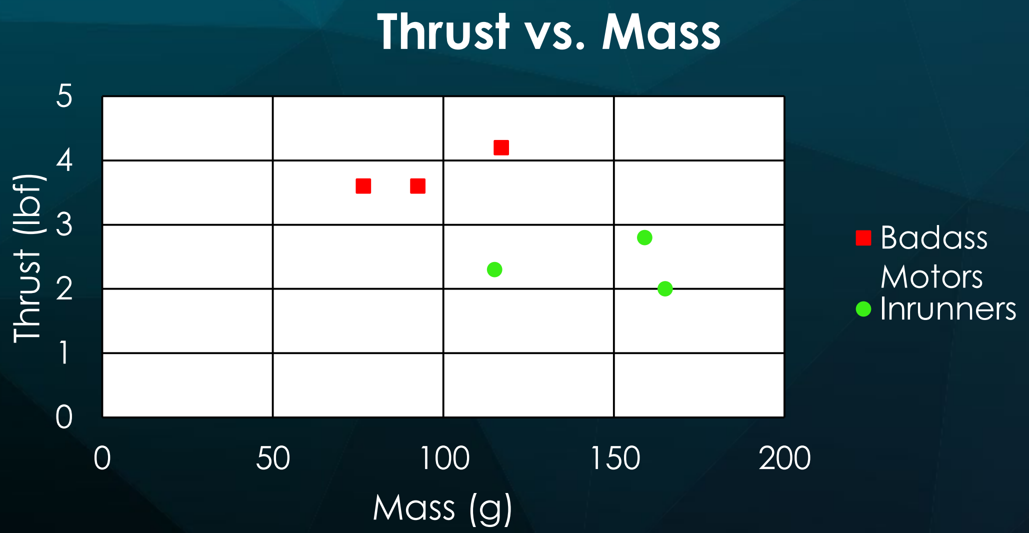


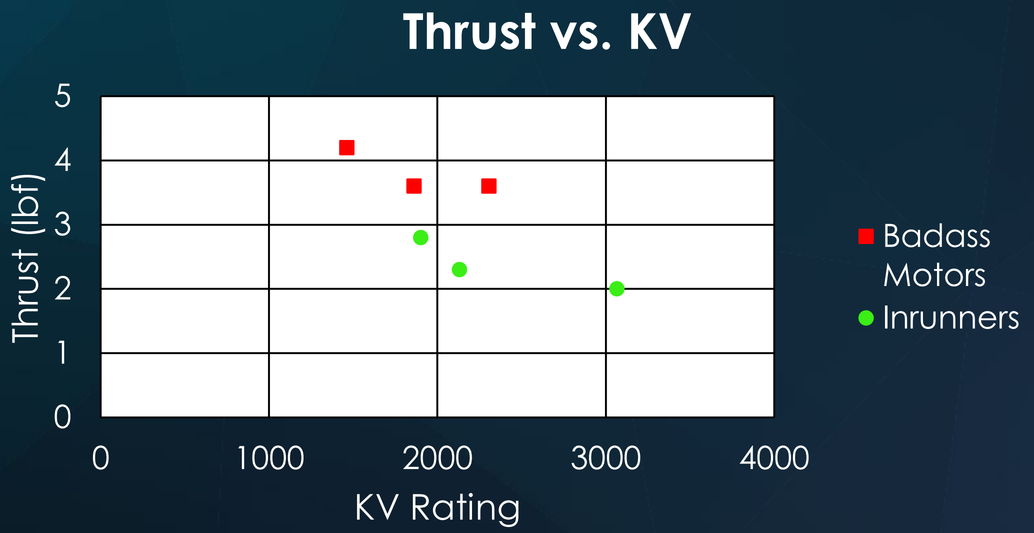
Motor Selection

MOTORS OPTIMIZED FOR 65A

MULTIPLE PROPS TESTED TO FIND OPTIMUM CONFIGURATION







Final Selection: BadAss Motors

Quantitative Benefits

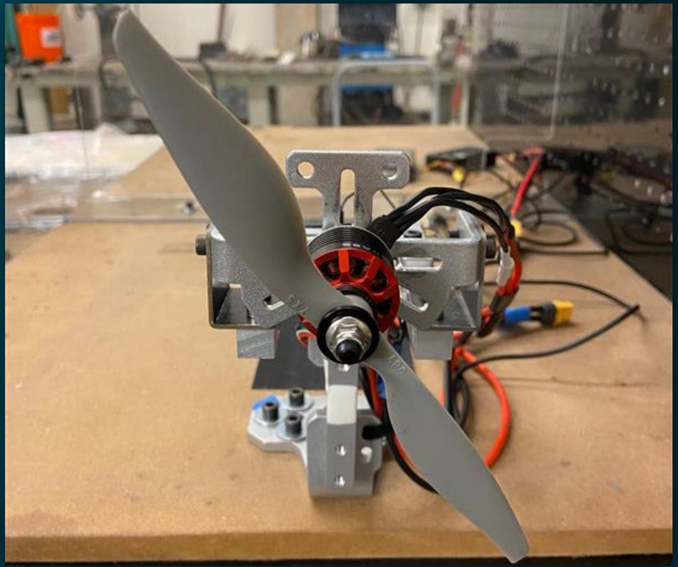
- Better thrust-to-weight
- Higher static thrust
- Superior climb rate
- Best 10s Horizontal speed

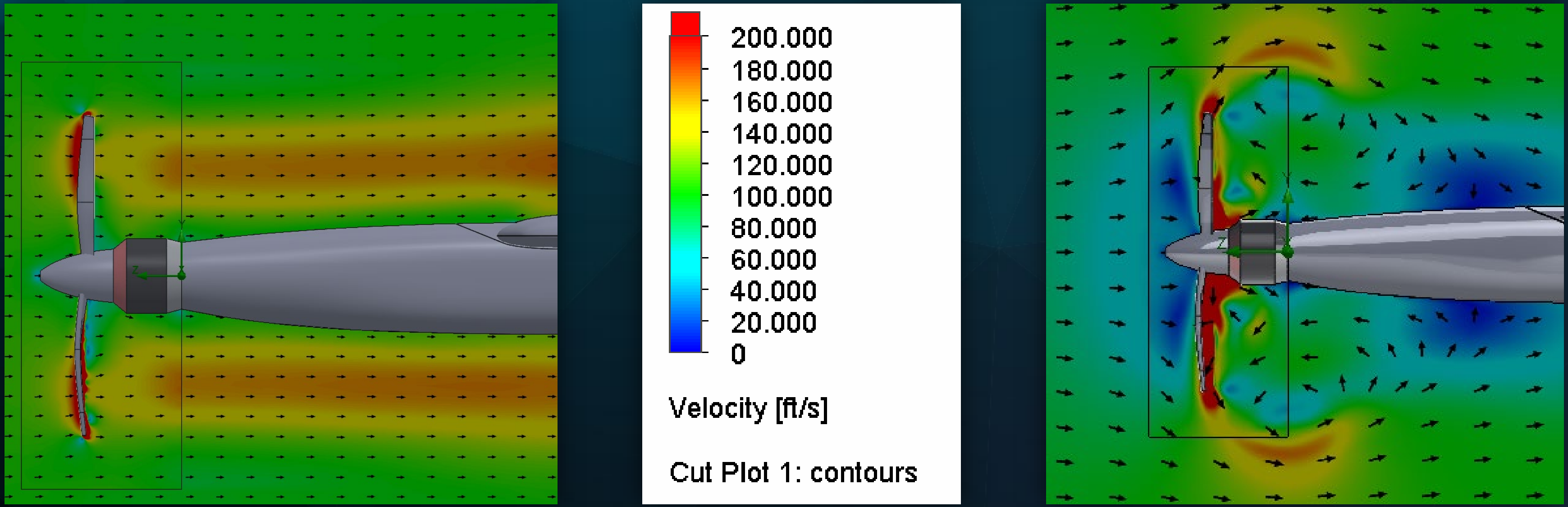
Qualitative Benefits

- Easier to obtain
- High durability
- External mounting helps internal heat generation
- Unique/Marketing Benefit

Reverse thrust testing

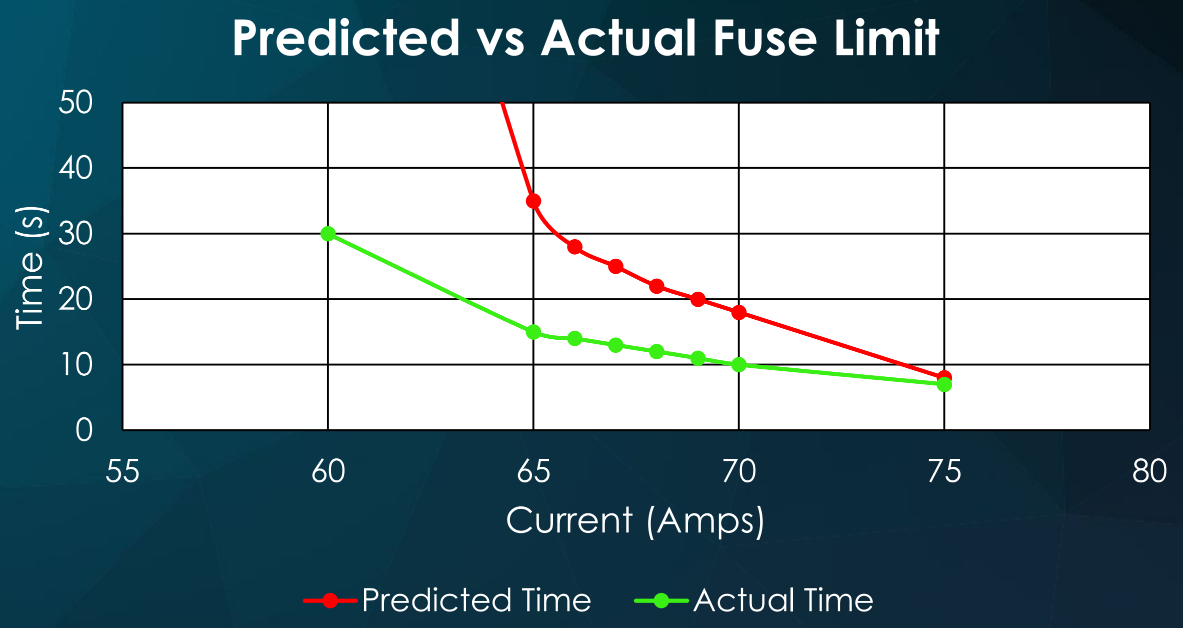
- Required for successful deceleration
- Produced about -3 lbf or ≈70% of forward thrust
- Larger propeller Required for handling
- Best results when throttled

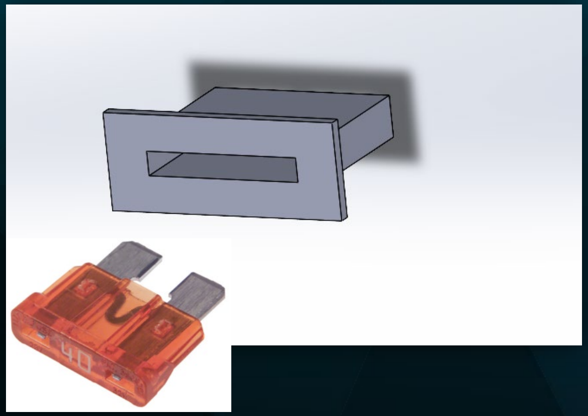


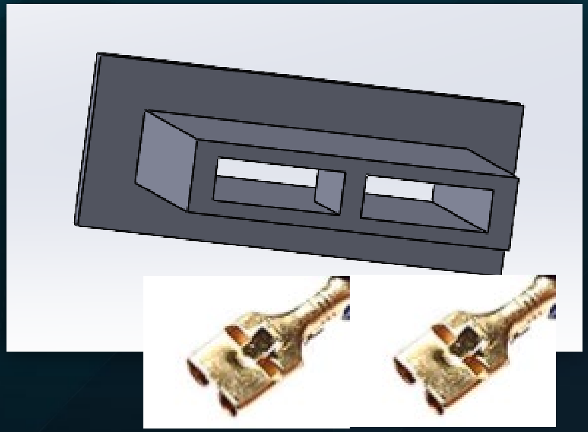


Fuse considerations

- Fuse dimensions: 0.16 x 0.73 x 0.75 in
- Fuse operating values lower than predicted
- 3D printed fuse holder to reduce weight







ESC testing

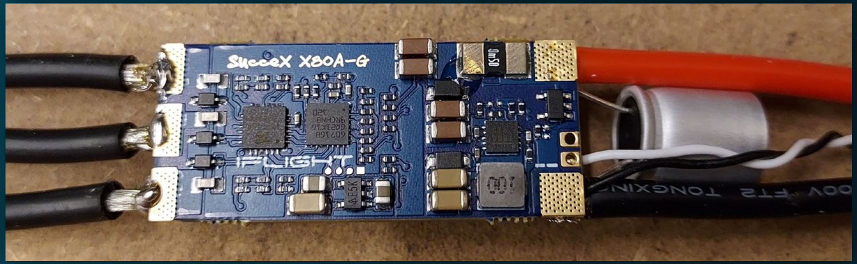
Capable of reverse thrusting: BL Heli

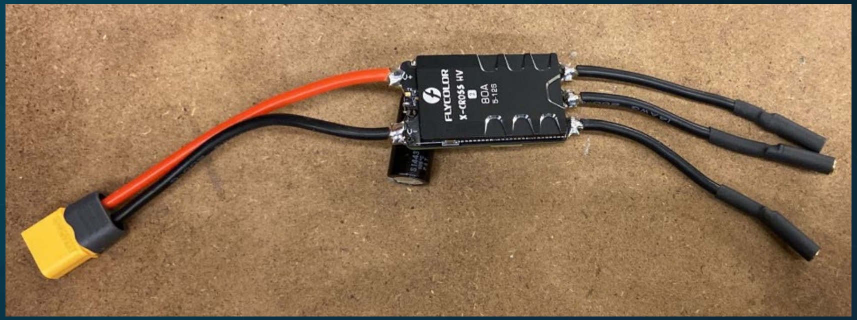
Nominal Rating: 80A

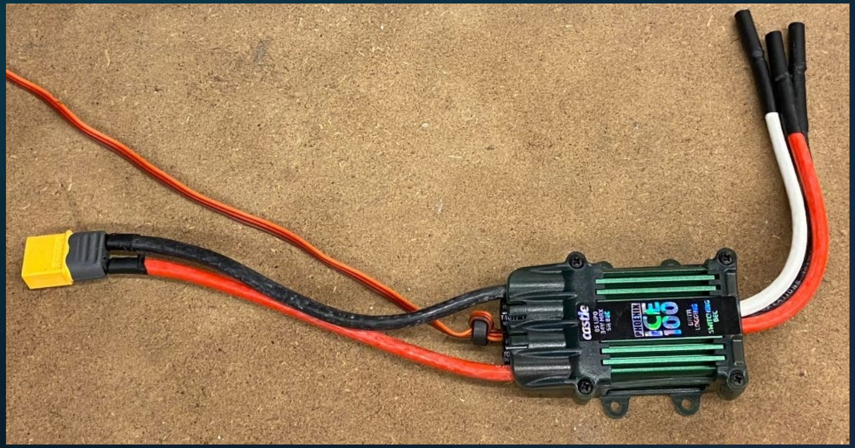
Comfortable operating at 120°F

Wire length has large impacts

- ESC: 170°F
- Capacitor: 170°F







Commutator Timing

400,000/# of Poles

Outrunner # of Poles: 14

RPM: ≤ 35,000 RPM

Upper KV Limit: ≈ 1900KV

Battery Selection

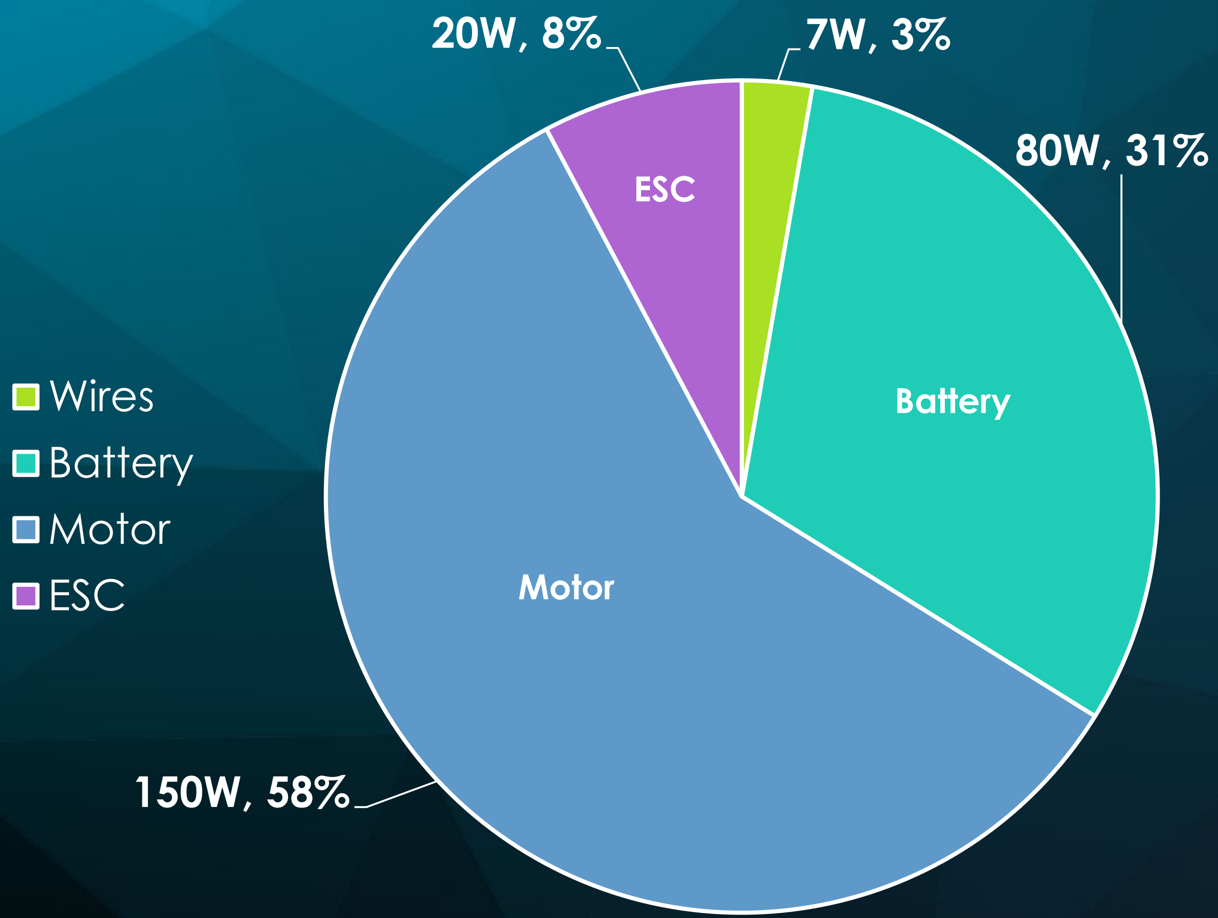
Minimum Required Capacity: 1000 mAh

Minimum Discharge Rate: ≈ 60C

Max. Recorded Temperature: 100°F

Heat generation

Heat Generation Break-Down

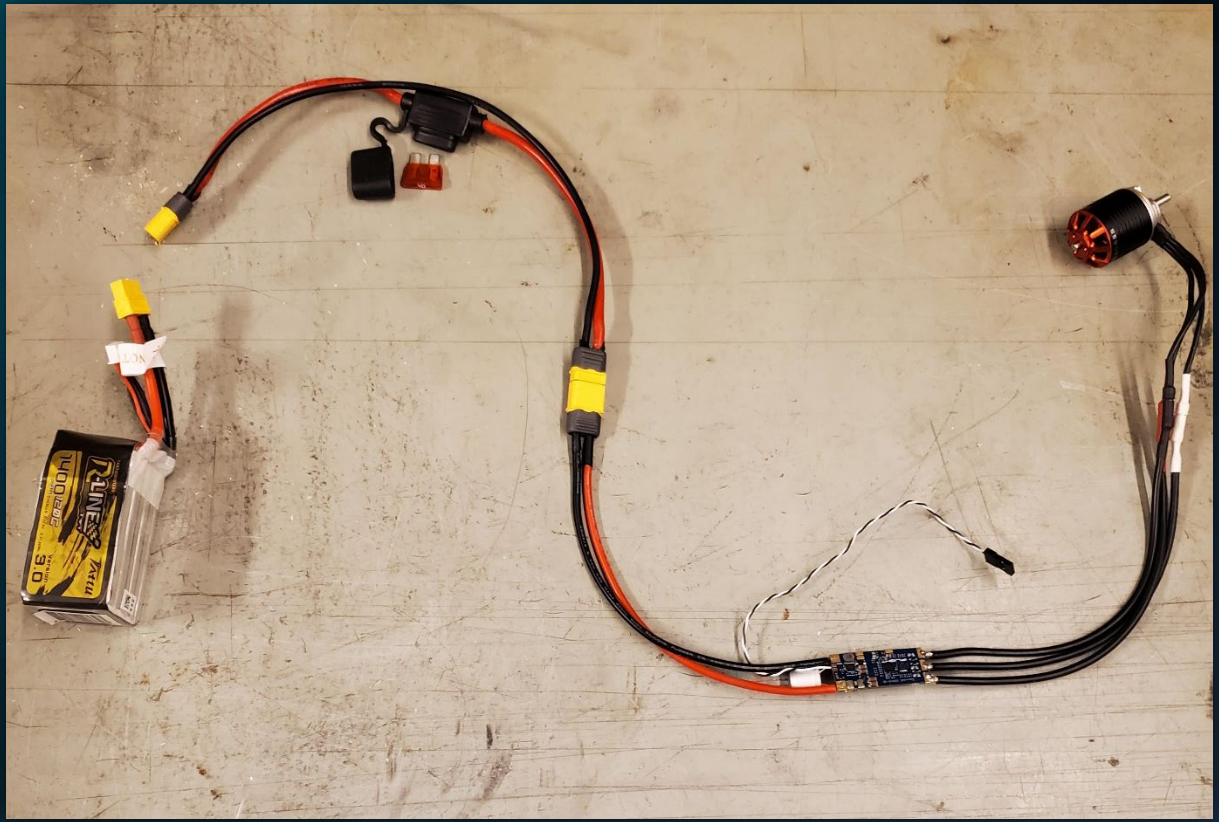


Heat Mitigation Strategies

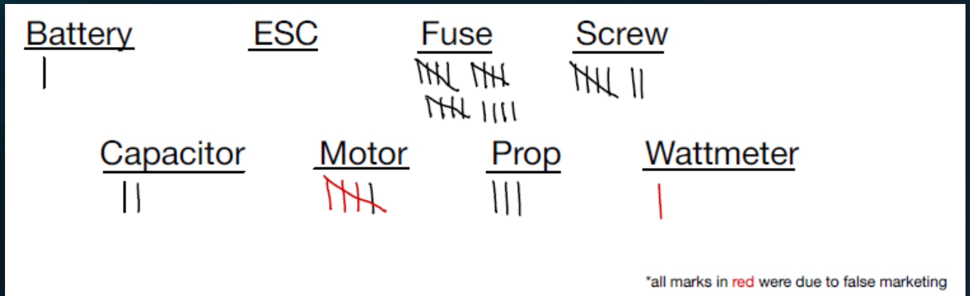
- Aluminum Heat-Sink (ESC)
- Air-Scoop
- Externally mounted motor

Current Propulsion Configuration

- Badass 2814 1560 kv motor
- APC 7X5 propeller
- BLHeli 80A ESC
- 1050 mAh battery
- 4.4 lbs static thrust @ 80% Throttle
- 3.8 lbs-in torque



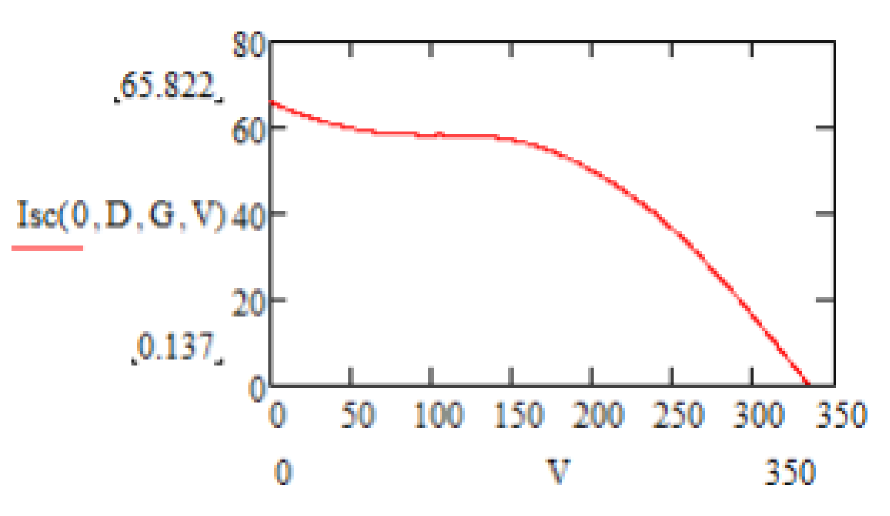
Testing casualties



Prop-timization

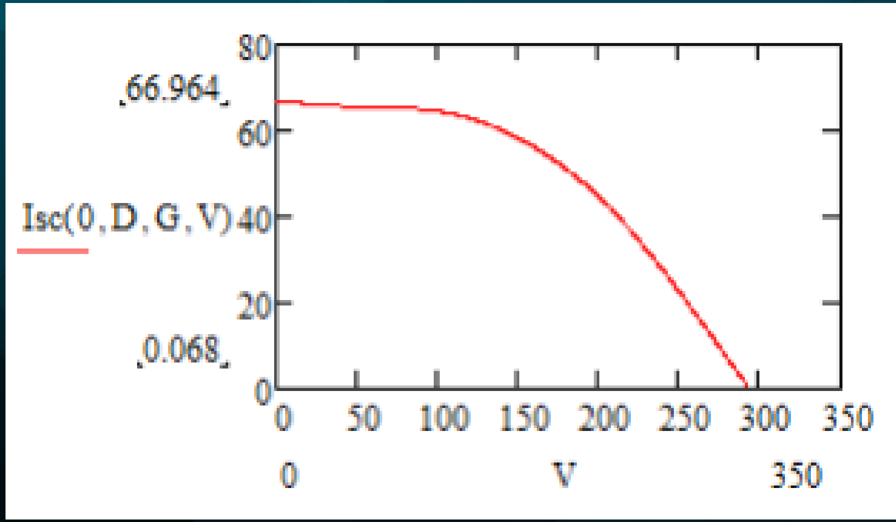
- Fine-tune diameter selection
- Allows testing of large pitch over diameter
- Compatible with 3-blade propeller
- Dremel attachment ensures even clipping

Prop-timization: Current vs. Speed

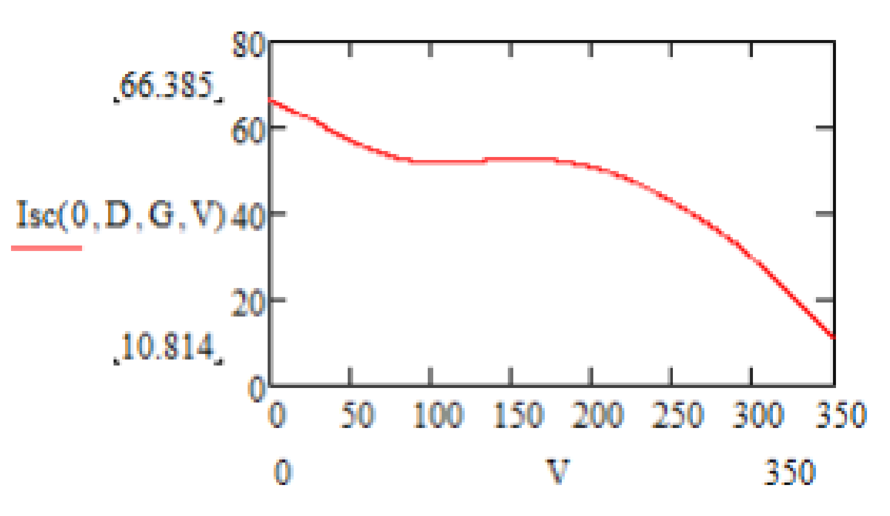


2.9 LB THRUST, P/D ≈ 1

4.4 LB THRUST, P/D ≈ .8

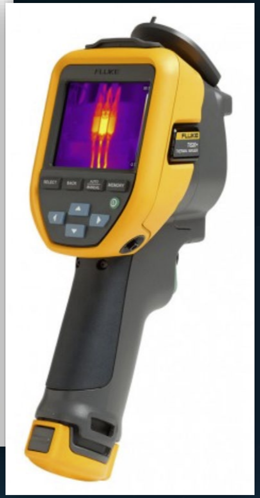


1.9 LB THRUST, P/D ≈ 1.2

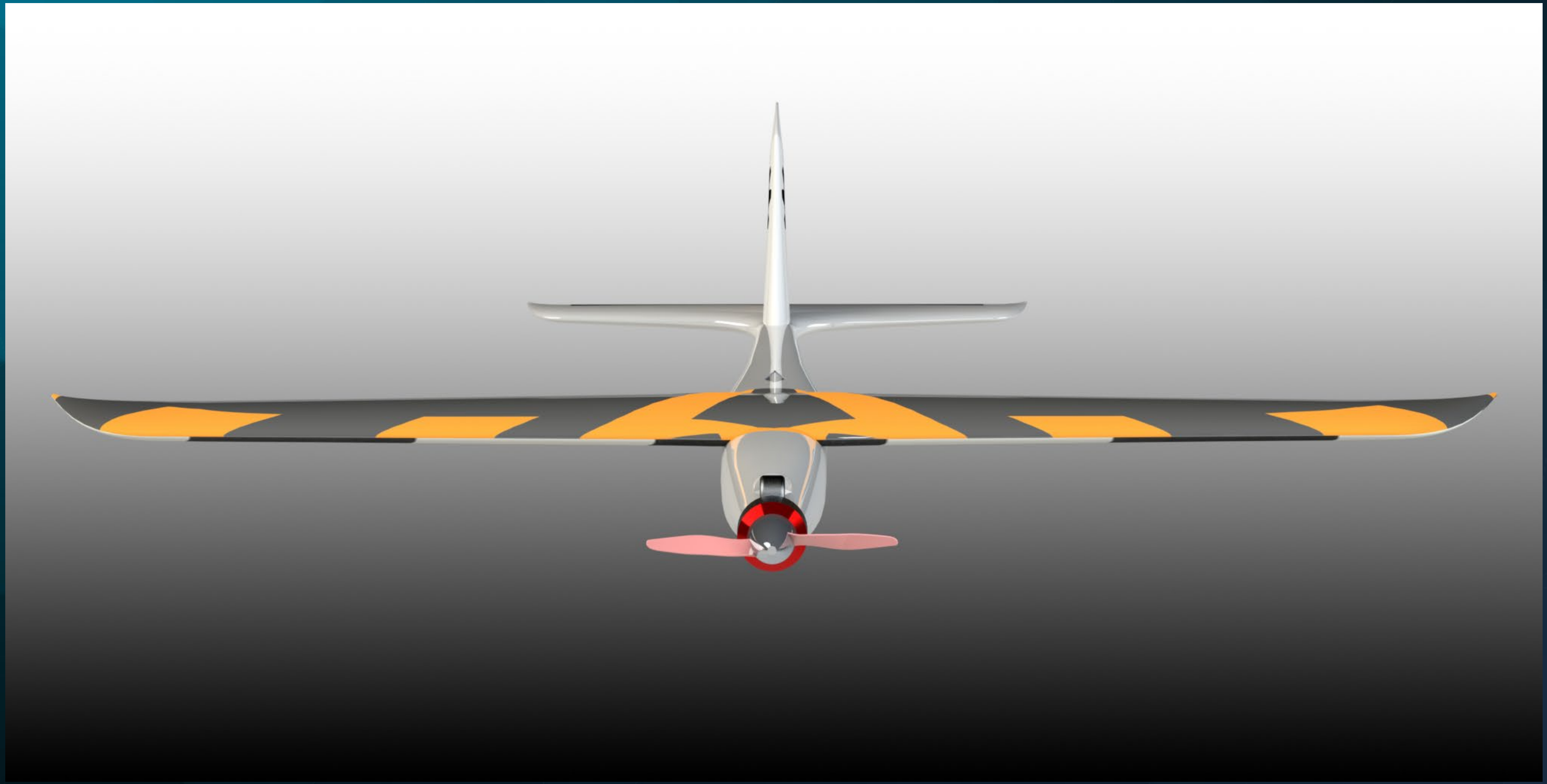


Propulsion next steps

- Pick Best BadAss
- Find Best Propeller
- Continue Reverse Thrust Testing
- Determine Optimal Wire Size
- Connect/Program the Transmitter

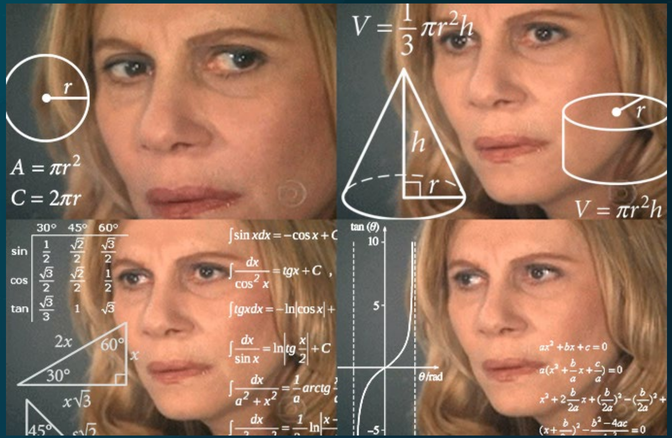


Aerodynamics



Aero optimization procedures

1. Determine how to maximize points
2. Conduct Sensitivity Analysis
3. Choose Planform that WINS !!



	Wing								Fuselage - use these for now (mostly for APG spreadsheet)			Use these values pls !! - will change at some point but I'll tell you					Wing Geom.		Electric Propulsion				
your name	Area (ft^2)	Span (ft)	mean geom. chord (ft)	AR	Taper Ratio	Sweep Angle	ng	climb angle	length (ft)	max width/height (ft)	wetted area (ft^2)	Weight (use 2.2 lb for inrunner option or 1.9 lb for outrunner option)	Thrust (lb)	Airfoil	V (ft/s)	AOA (2 deg)	AR	Wing Area	Stall speed (ft/s)	Time to launch (s)	Max H Velocity in 10 s (mph)	Time to climb (s)	time to 500 ft (s)
Trends in S	0.9	2.167	0.415	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	0.9	43	0.668	151	8.56	9.228
Trends in S	1	2.285	0.438	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	1	41	0.574	151	8.78	9.354
Trends in S	1.1	2.396	0.459	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	1.1	39	0.494	151	9	9.494
Trends in S	1.2	2.503	0.479	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	1.2	37	0.436	150	9.26	9.696
Trends in S	1.3	2.605	0.499	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	1.3	36	0.35	150	9.38	9.73
Trends in S	1.4	2.703	0.518	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	1.4	35	0.272	149	9.52	9.792
Trends in S	1.5	2.798	0.536	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	1.5	33	0.186	148	9.78	9.966
Trends in S	1.6	2.890	0.554	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	1.6	32	0.122	148	9.94	10.062
Trends in S	1.7	2.979	0.571	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	1.7	31	0.08	147	10.08	10.16
Trends in S	1.8	3.065	0.587	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	1.8	31	0.016	146	10.1	10.116
Trends in S	1.9	3.149	0.603	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	1.9	30	0	146	10.24	10.24
Trends in S	2	3.231	0.619	5.2	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.2	2	29	0	145	10.4	10.4
Trends in AR	1	1.732	0.577	3.0	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	3.0	1	41	0.56	150	8.84	9.4
Trends in AR	1	2.000	0.500	4.0	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	4.0	1	41	0.56	151	8.8	9.36
Trends in AR	1	2.236	0.447	5.0	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.0	1	41	0.574	151	8.76	9.334
Trends in AR	1	2.449	0.408	6.0	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	6.0	1	41	0.58	151	8.7	9.28
Trends in AR	1	2.646	0.378	7.0	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	7.0	1	41	0.57	151	8.74	9.31
Trends in AR	1	2.828	0.354	8.0	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	8.0	1	41	0.57	151	8.74	9.31
Minimum AR + S Combos	0.7	2.229	0.314	7.1	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	7.1	0.7					
Minimum AR + S Combos	0.8	2.173	0.368	5.9	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.9	0.8	46	0.8	151	7.9	8.7
Minimum AR + S Combos	0.9	2.142	0.420	5.1	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	5.1	0.9					
Minimum AR + S Combos	1	2.098	0.477	4.4	0.7	2	10	70	2	0.1667	0.75	2.2	2.6	NACA 2412 700k	265	2	4.4	1					

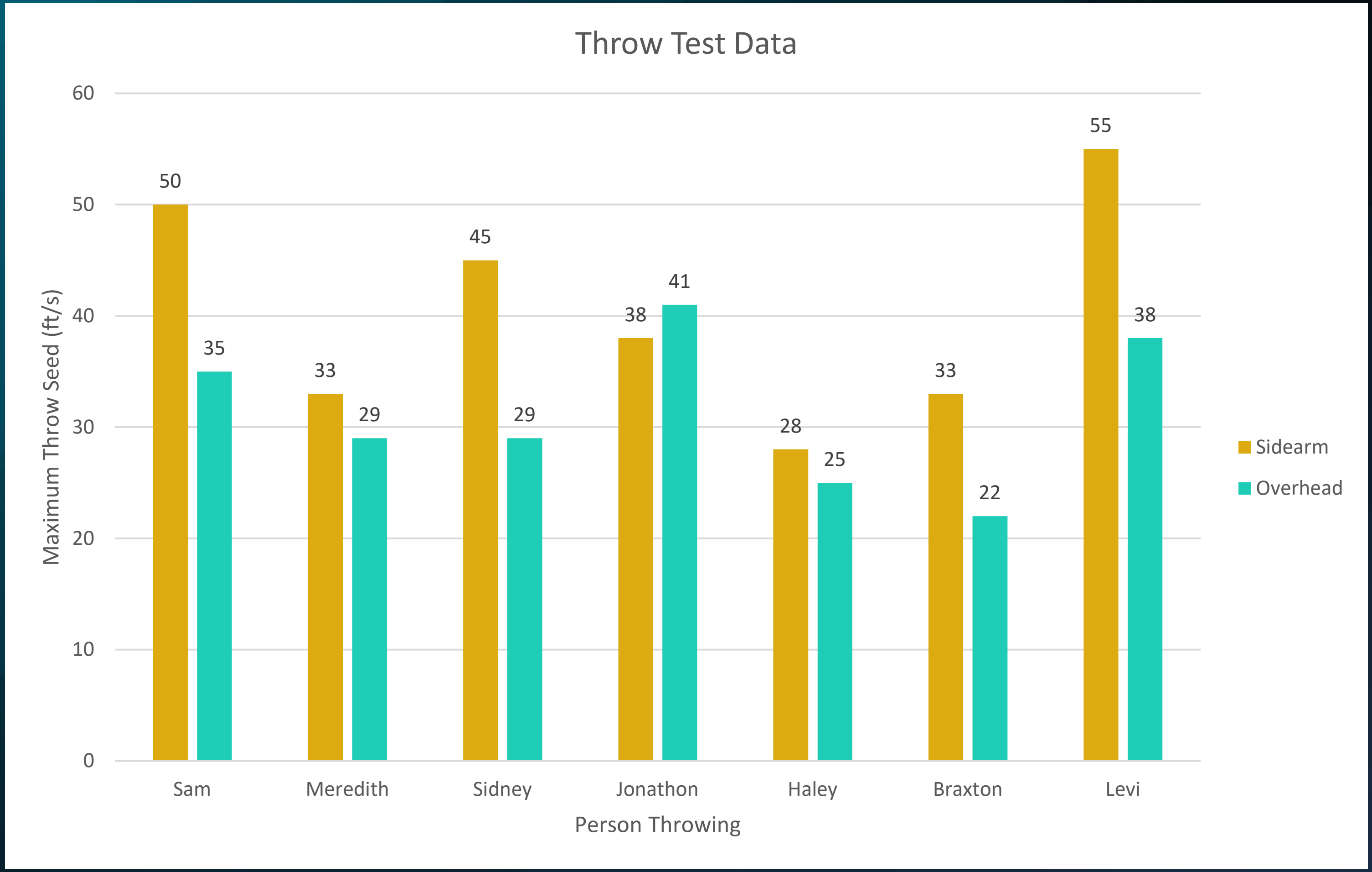
Launch Testing

GOALS

- MINIMIZE TIME TO STALL
- MAXIMIZE SPEED AT LAUNCH

METHODS - TESTING

- MULTIPLE PEOPLE
- MULTIPLE THROW METHODS



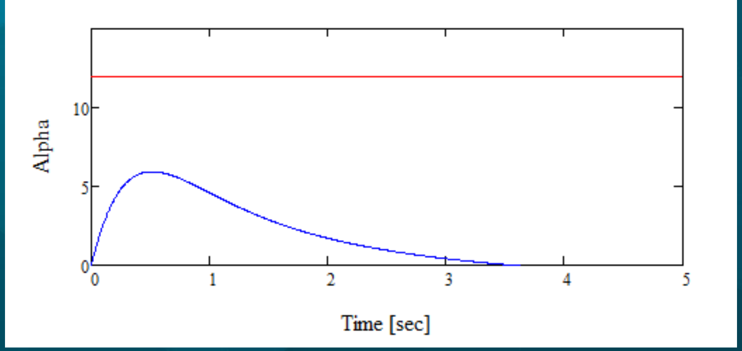
OVERHEAD LAUNCH SPEED RANGE: 22 – 41 FT/S

SIDEARM LAUNCH SPEED RANGE: 28 – 55 FT/S

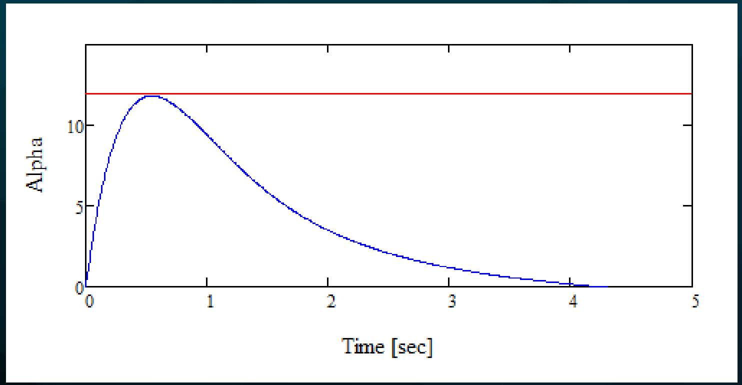
Launch: Analysis

Angle of Attack vs. Time

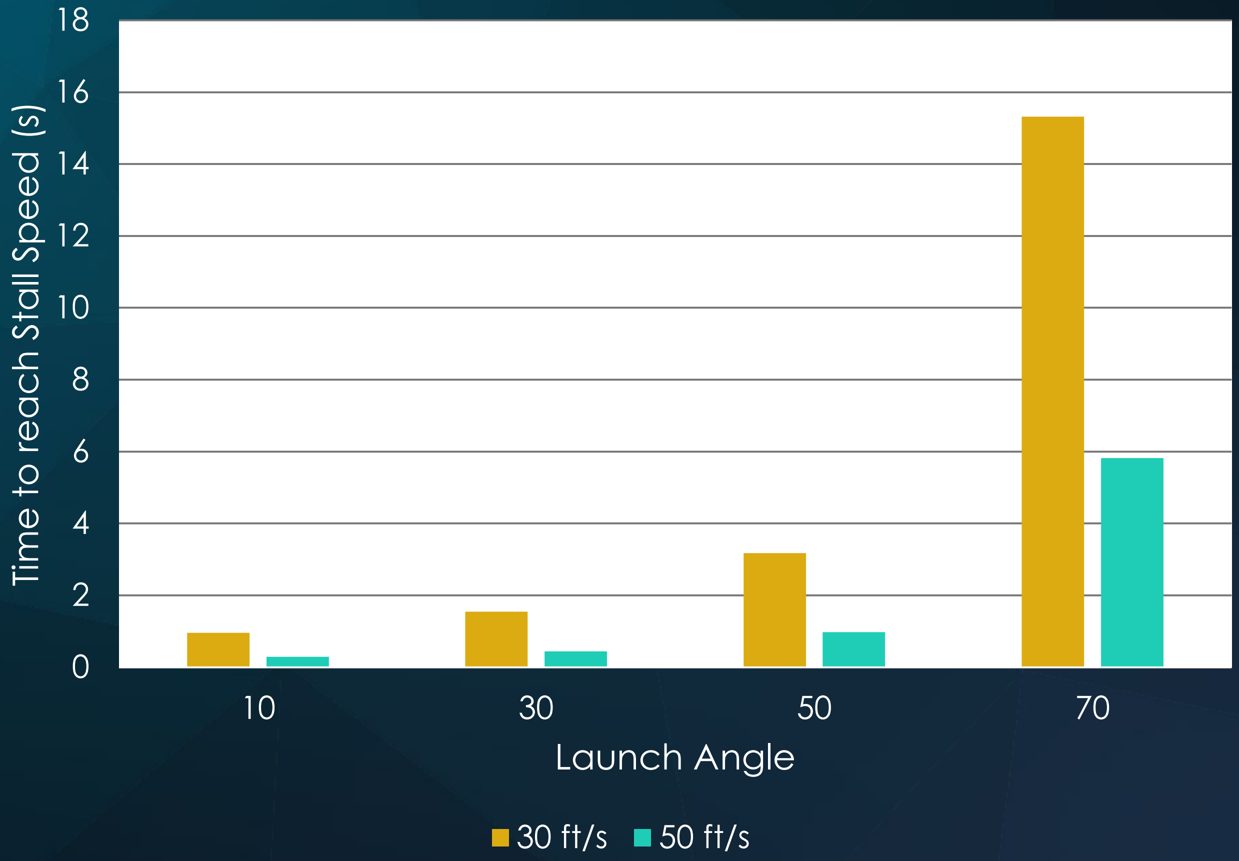
Sidearm Launch at 10 deg (50 ft/s)



Overhead Launch at 10 deg (30 ft/s)

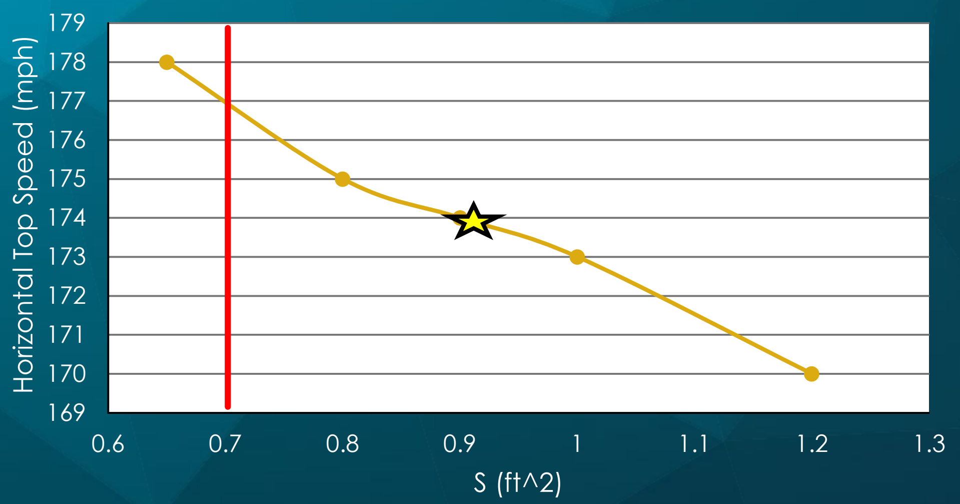


Launch Angle vs. Time to Stall Speed
1:1 Thrust to Weight

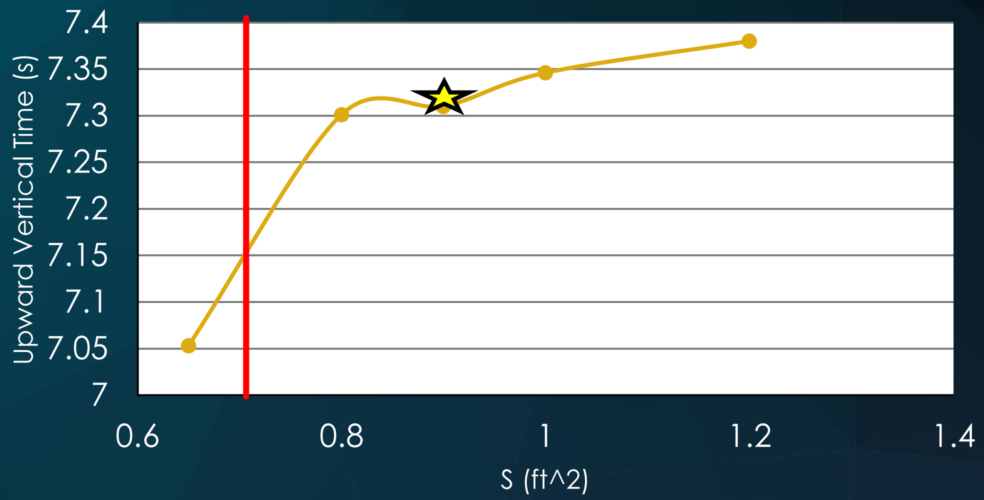


WING Design Space – wing Sizing

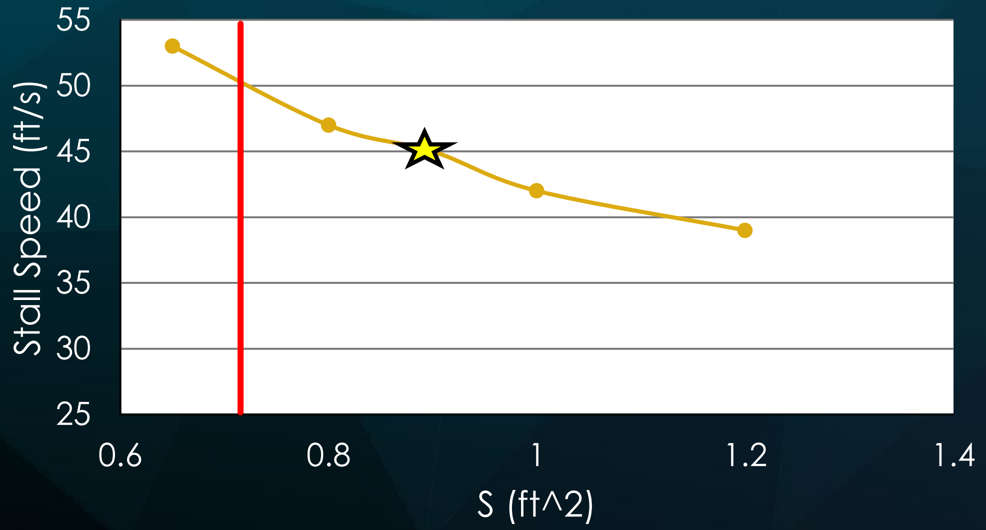
Horizontal Top Speed v. S (Uniform T, AR, Launch V)



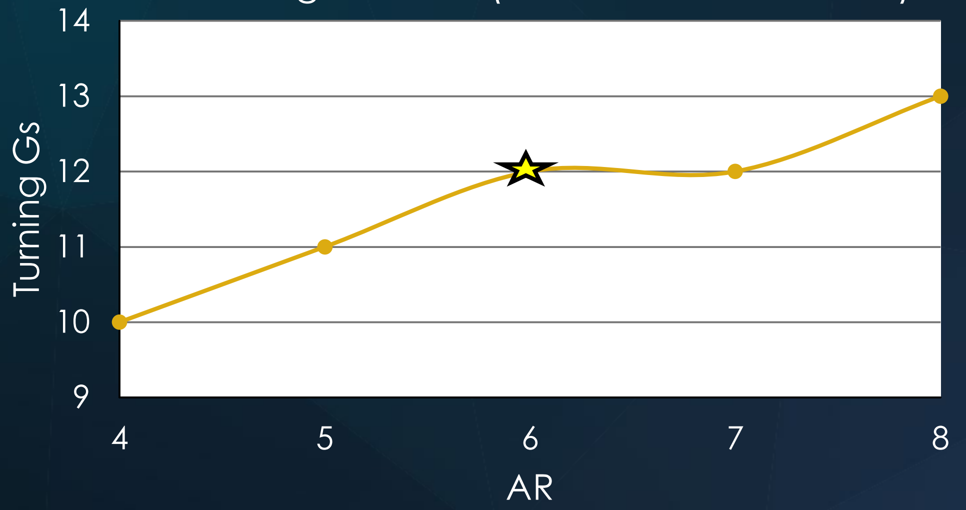
Upward Vertical Time v. S (Uniform T, AR, Launch V)



Stall Speed v. S (Uniform T, AR, Launch V)



Turning Gs v. AR (Uniform T, S, Launch V)



Sizing: wing geometry

WING SUMMARY

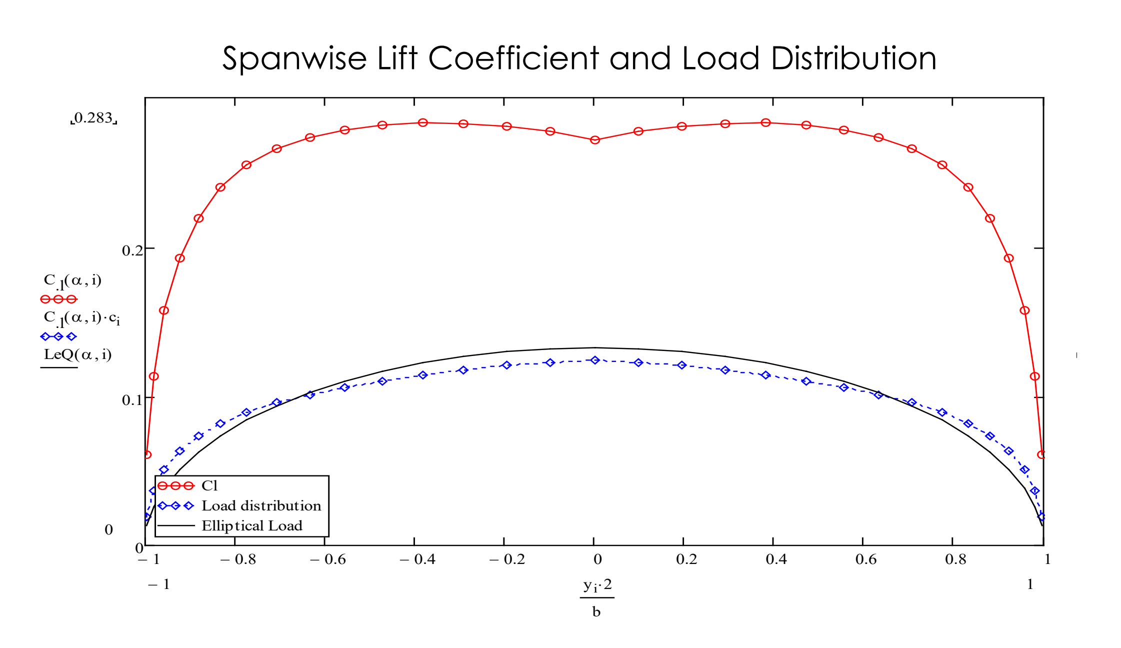
S = 0.9 FT^2

B = 28 IN

TAPER RATIO = 0.7

- MOVES STALL POINT OUTBOARD FROM ROOT (76% OF B/2) BUT PREVENTS TIP STALL
- STRUCTURAL STRENGTH

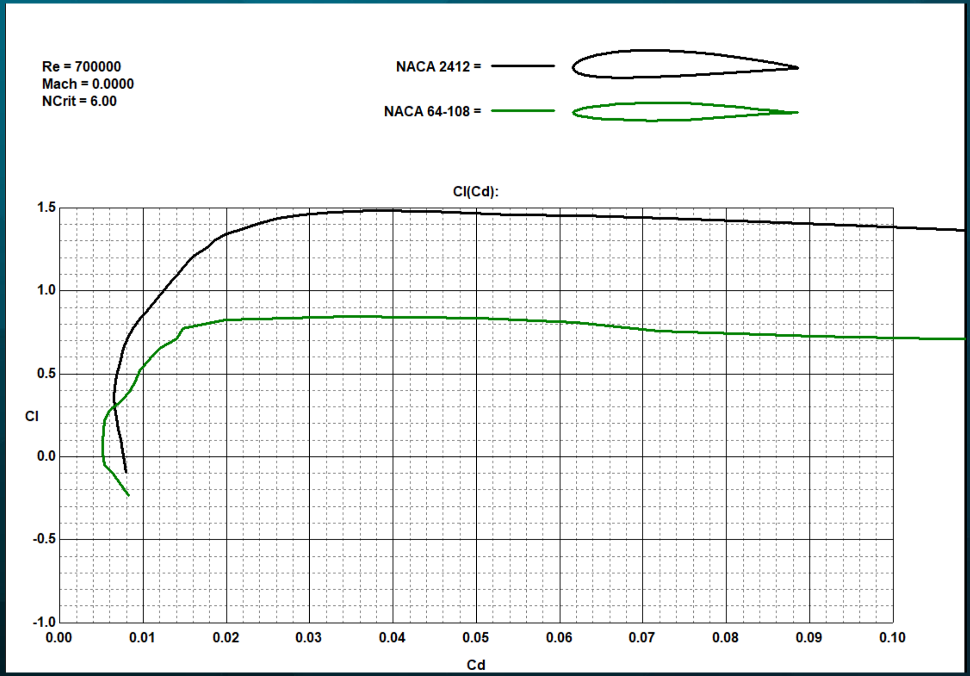
SWEEP = -0.5 DEG



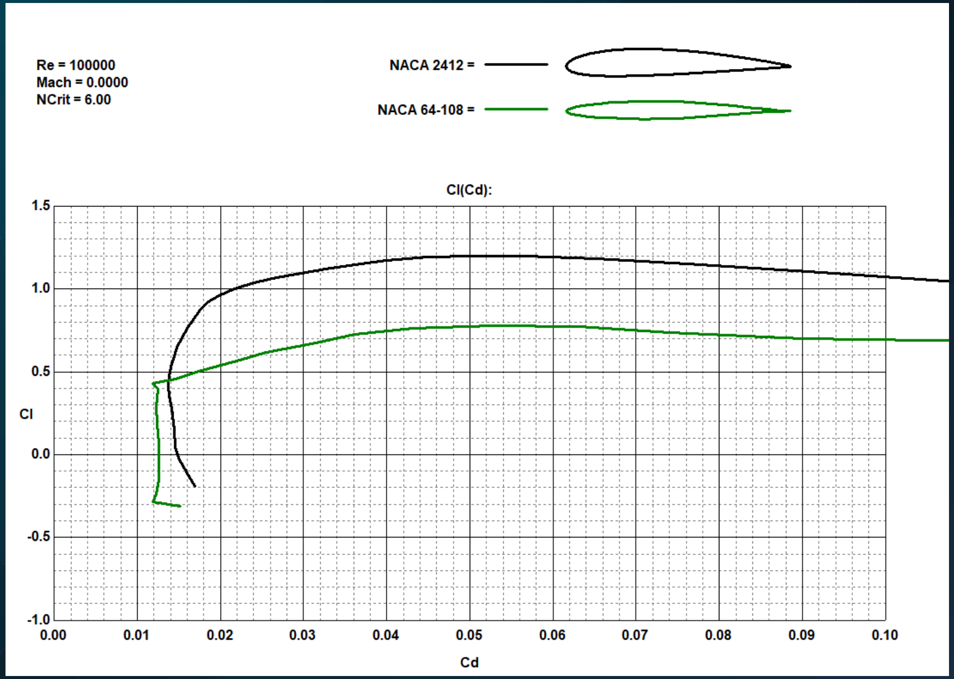
Airfoils: mission strategies

THIN AIRFOILS - OPTIMIZED FOR LOW DRAG AT HIGH SPEEDS (EX. NACA 64-108)

THICK AIRFOILS - OPTIMIZED FOR GREATER LIFT COEFFICIENT (EX. NACA 2412)

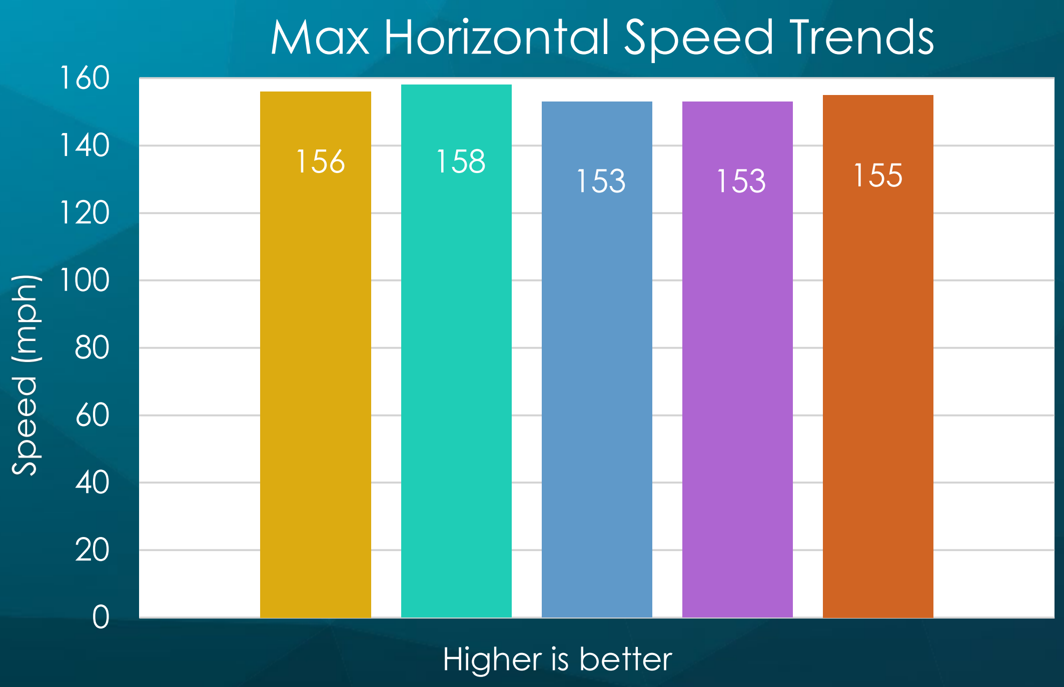


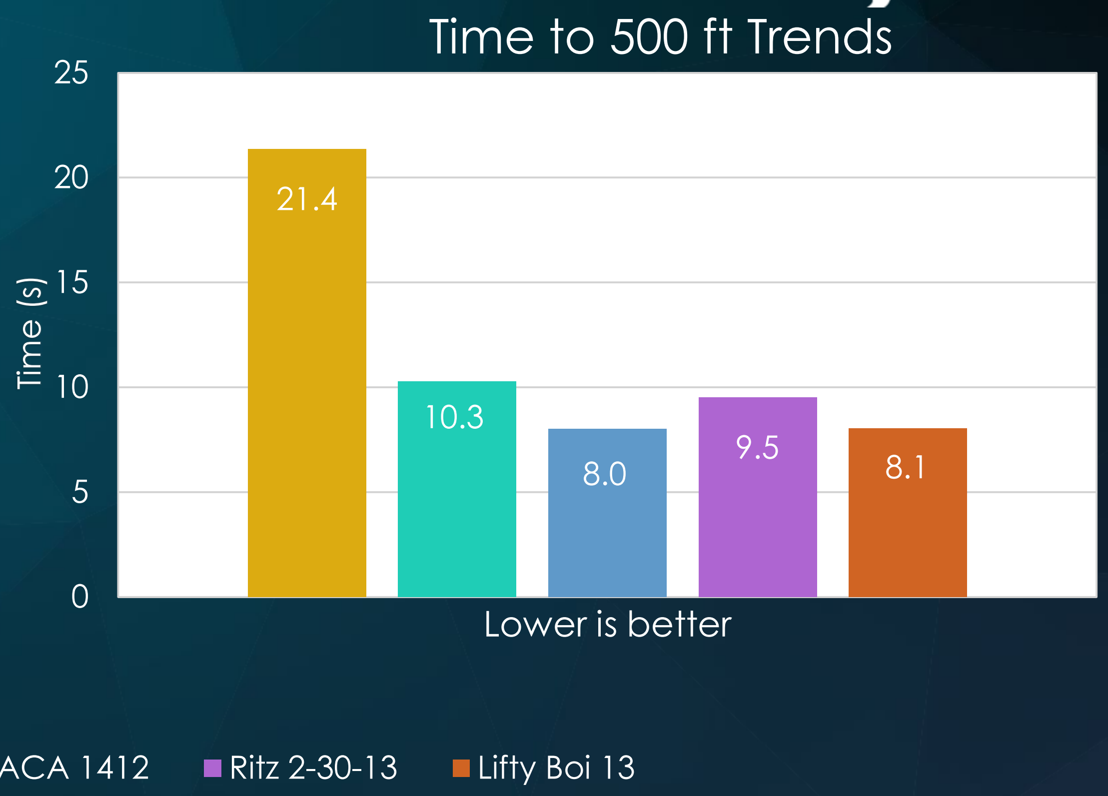
DRAG POLAR AT TOP SPEED (RE = 700,000)



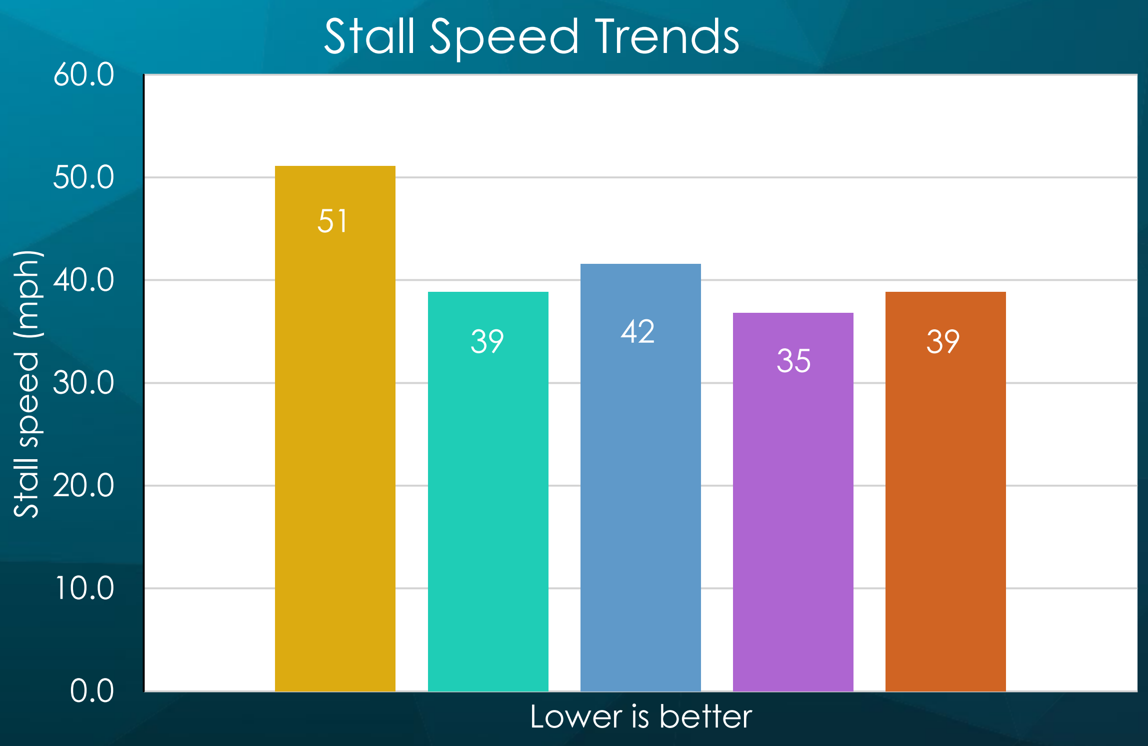
DRAG POLAR AT LAUNCH SPEED (RE = 100,000)

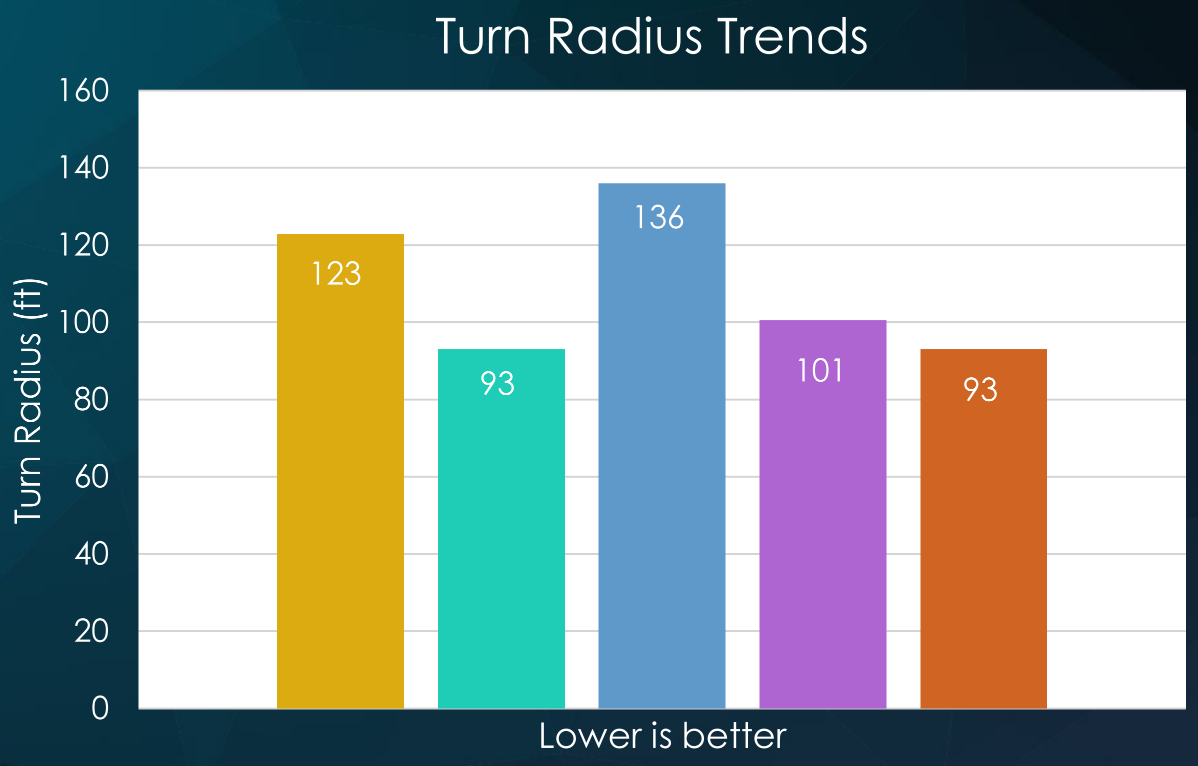
Airfoil: High Speed OPS





AirfoiL: Low Speed OPS

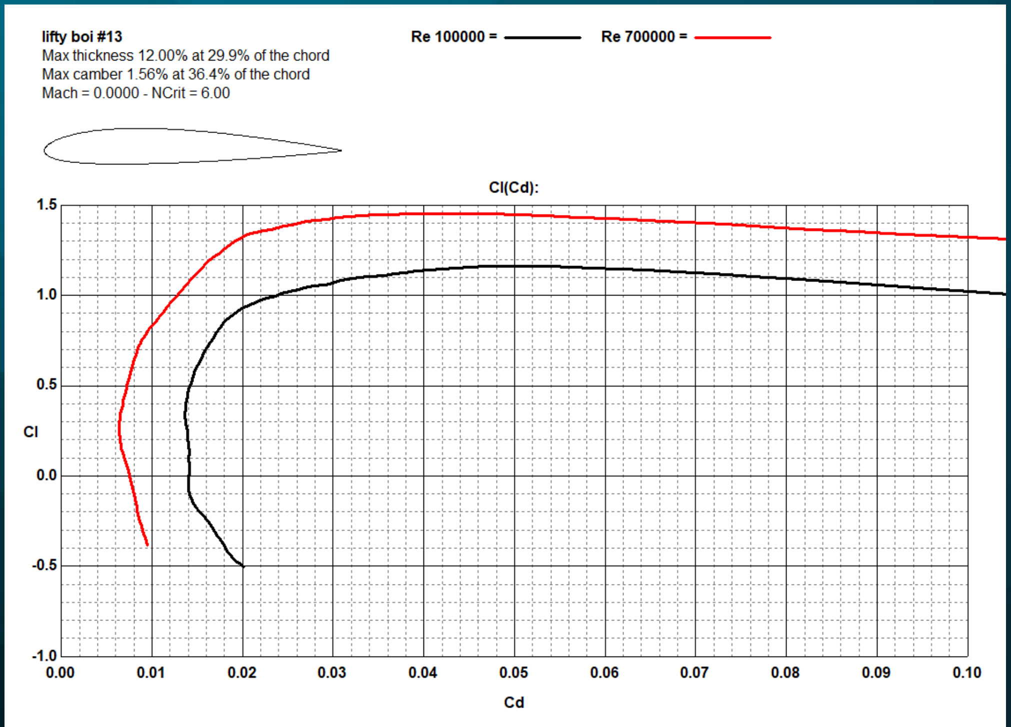




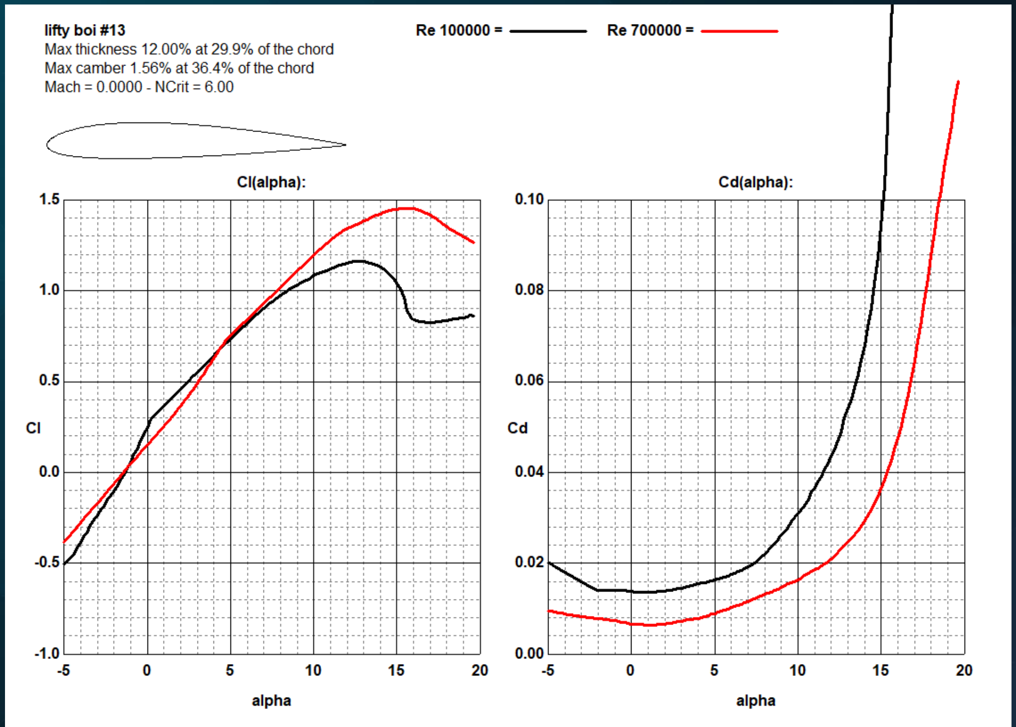
NACA 64-108 NACA 2412 NACA 1412 Ritz 2-30-13 Lifty Boi 13

Airfoil: Lifty boi 13

Forward half based on NACA 2412 - Rear half based on NACA 1412



Drag Polars



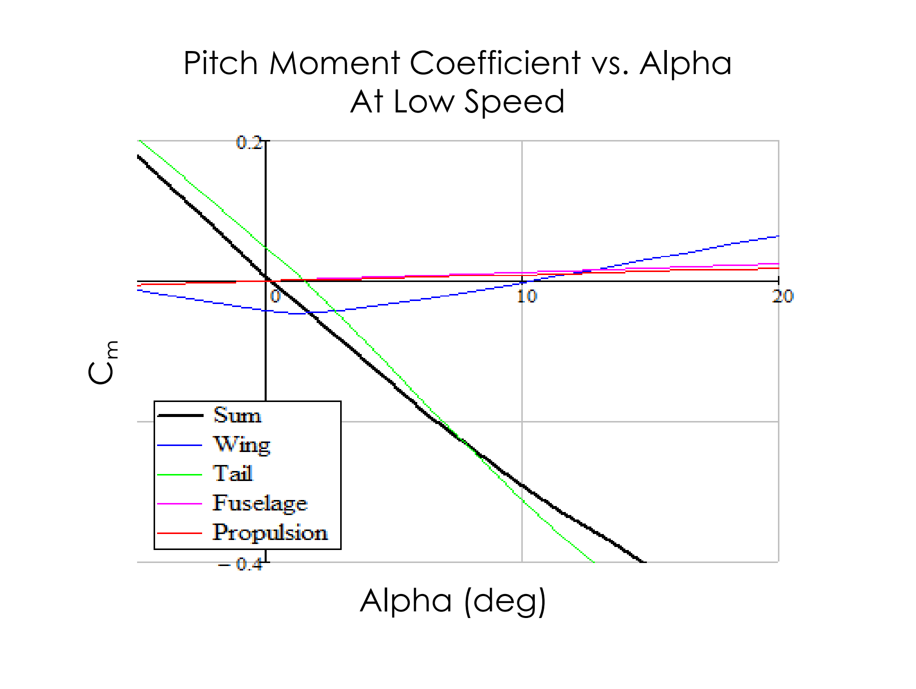
Lift Curve

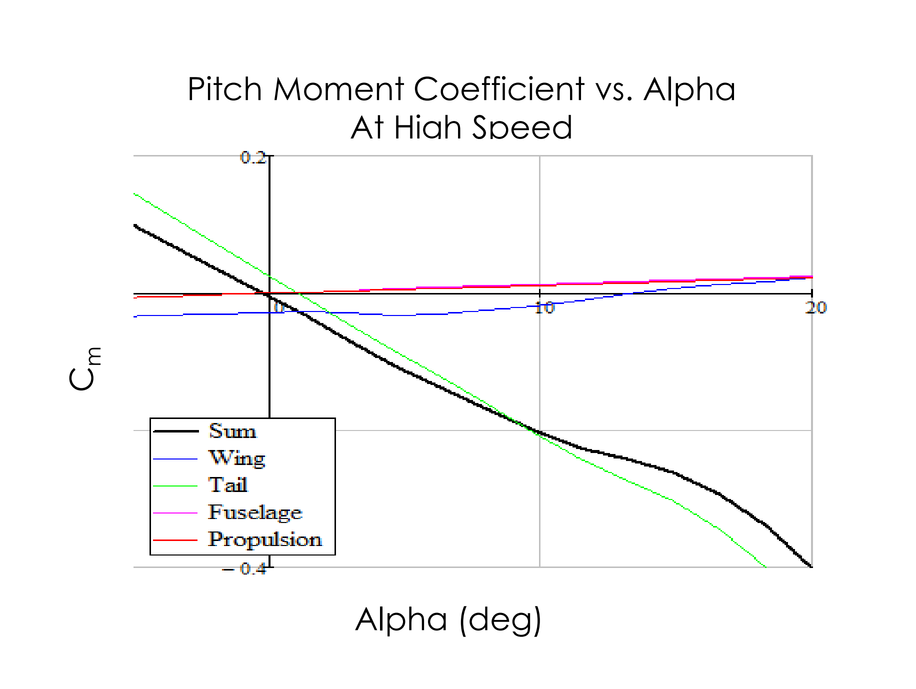
Analog flight testing

CONTROL ISSUES DURING DIVE REVERSE THRUST TESTING MOTIVATED SOME TAIL DESIGN CONSIDERATIONS AND CFD ANALYSIS

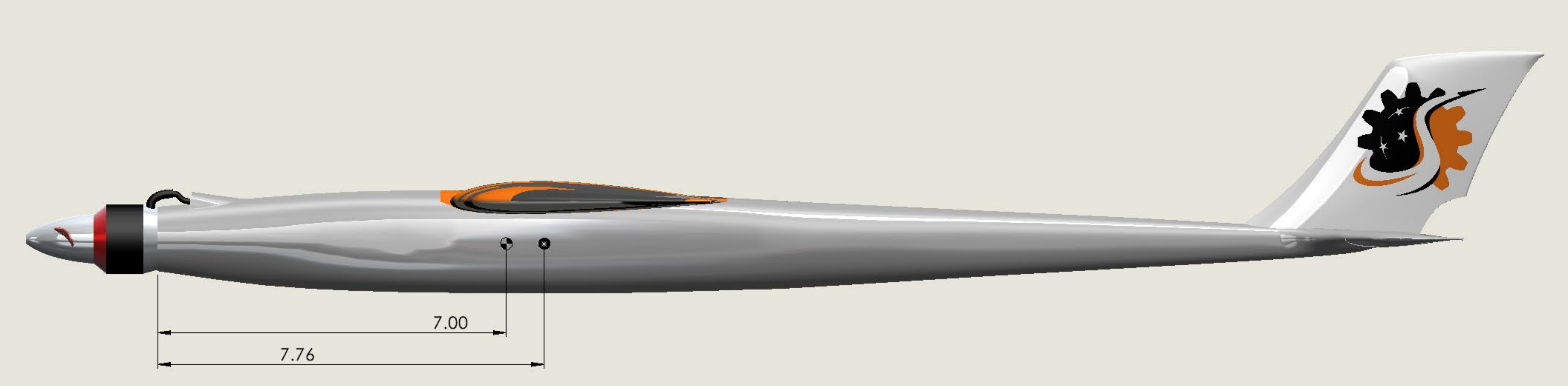
Tail sizing

Surface	Airfoil	Area (ft^2)	Span (in)	Tail Volume Coefficient	Static Margin (Low Speed)	Static Margin (High Speed)
Horizontal Tail	NACA 0014	0.14	9	0.61	12%	22%
Vertical Tail	NACA 0012-0010 Blend	0.08	4	0.05	197%	157%





Stability / CG analysis



Control surface sizing

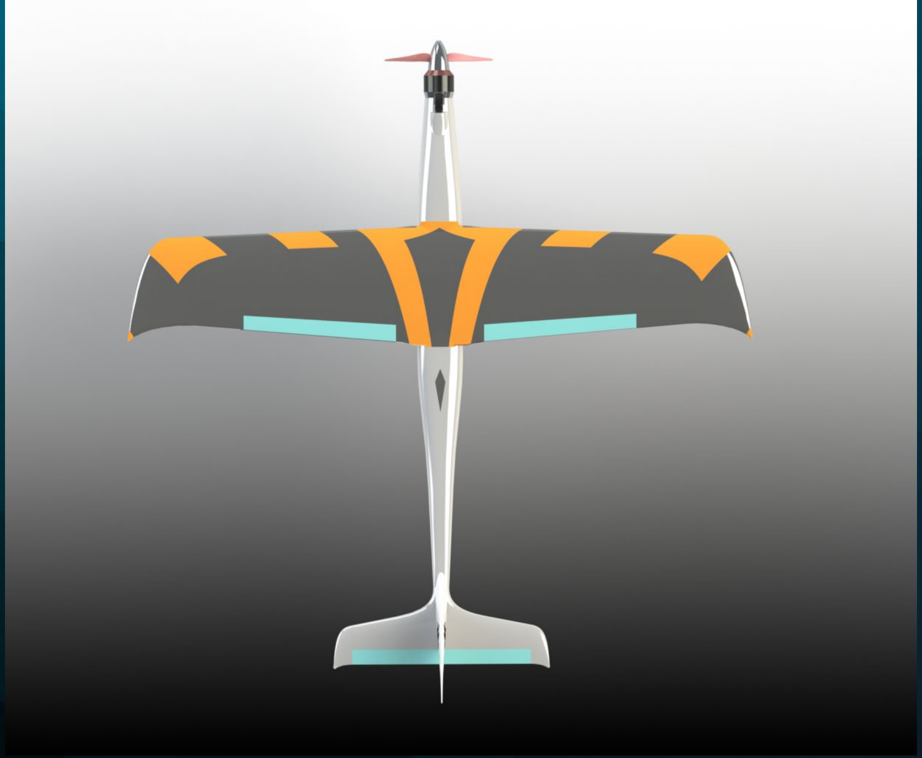
Control surface sizing

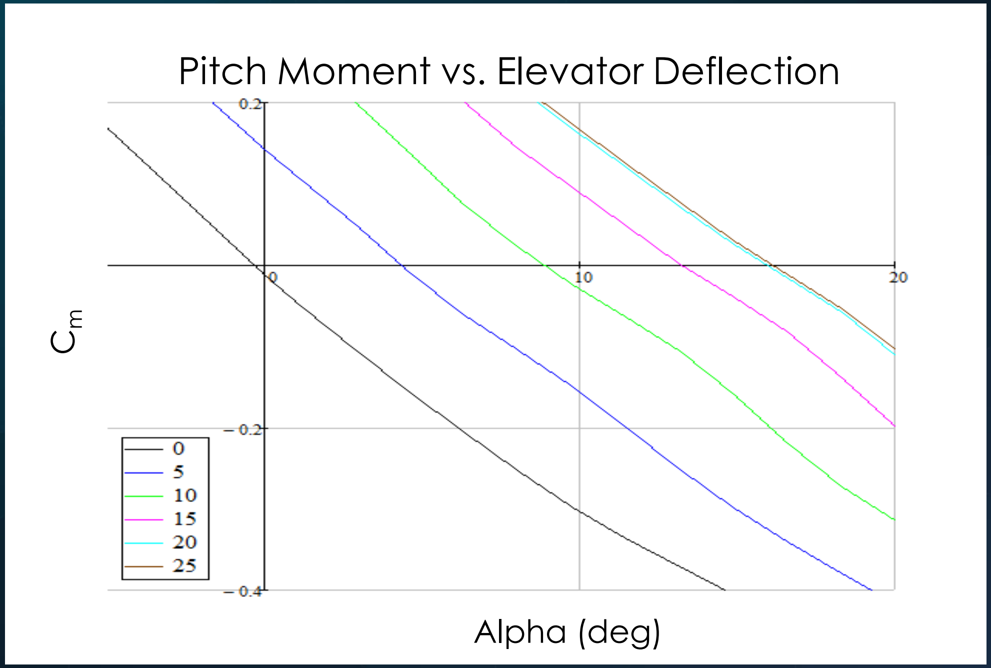
AILERON SIZE

- 7 IN SPAN
- 20% CHORD
- MAX DEFLECTION ANGLE OF 15 DEG

ELEVATOR SIZE

- CONTINUOUS ELEVATOR
- 30% CHORD
- MAX DEFLECTION ANGLE OF 20 DEG

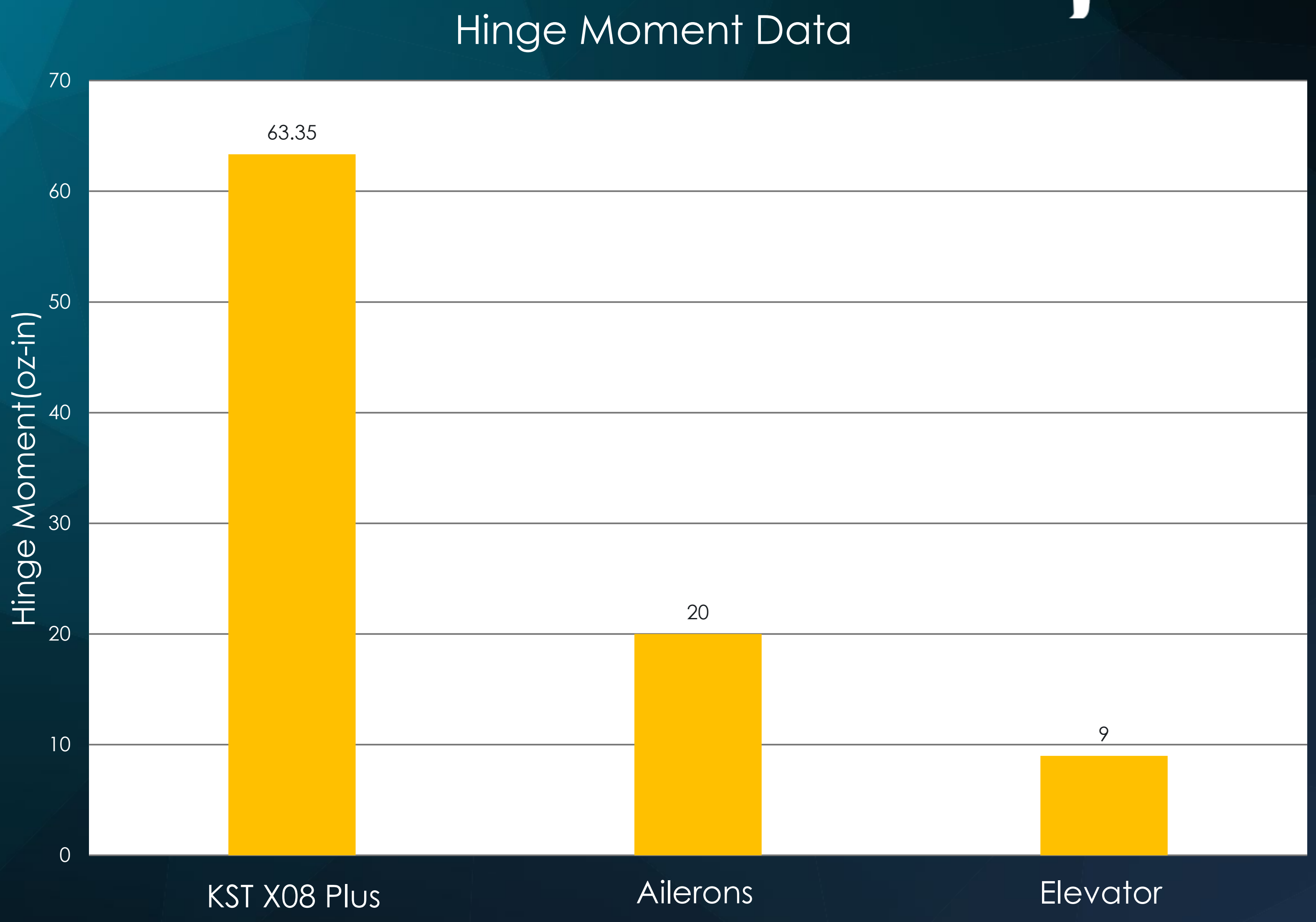




Servo sizing

KST X08 Plus

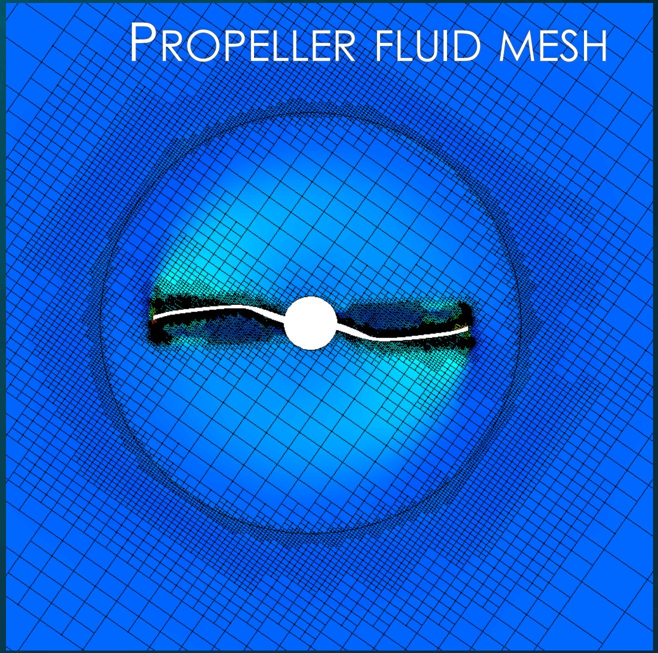
- 7.4 V operating voltage
- 0.32-ounce weight (smallest we could find)
- 0.3-inch thickness (smallest we could find)

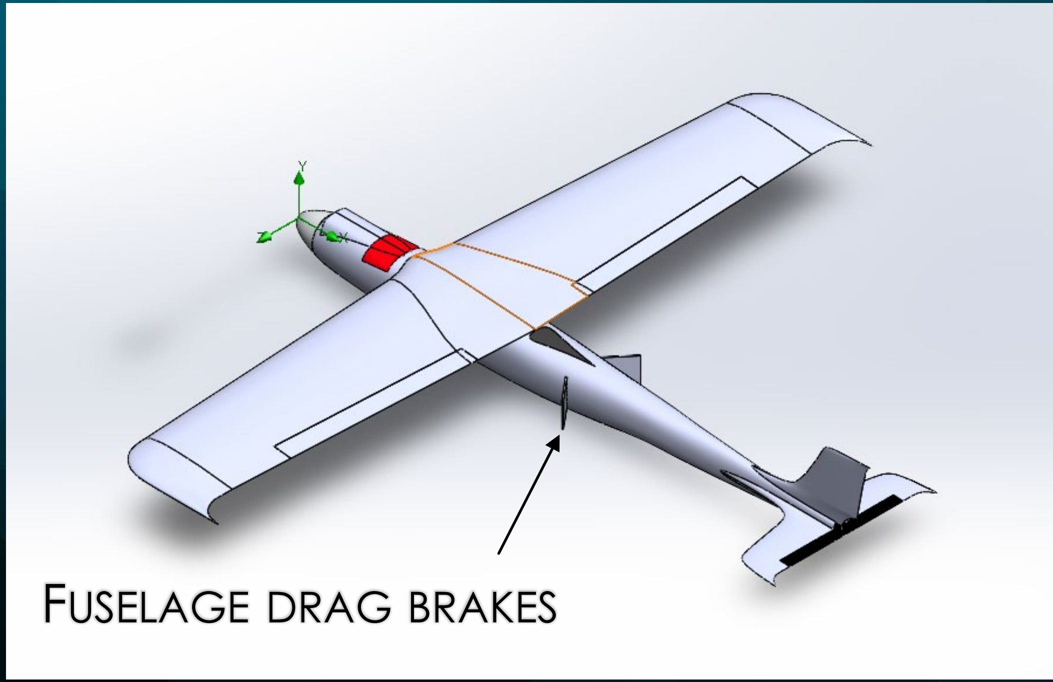


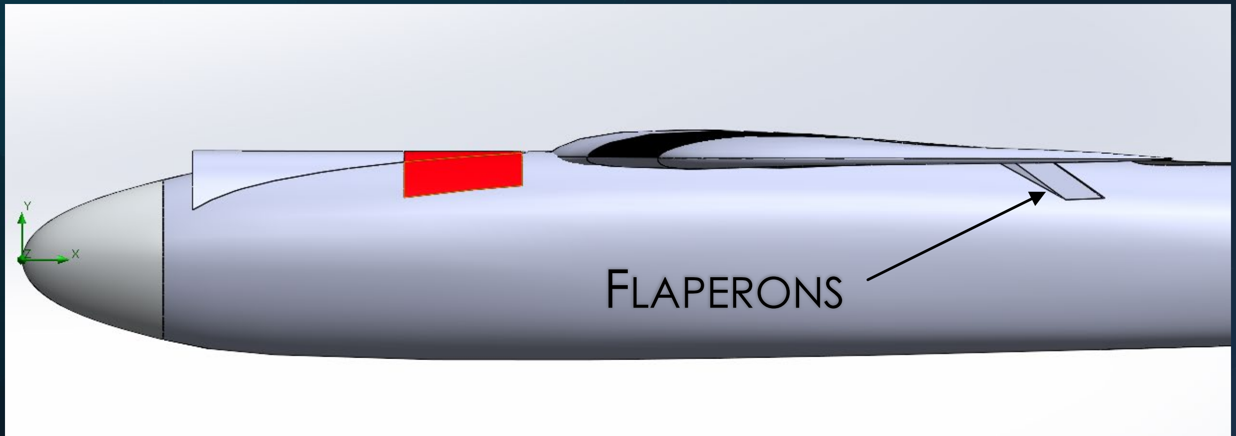
CFD

GOALS

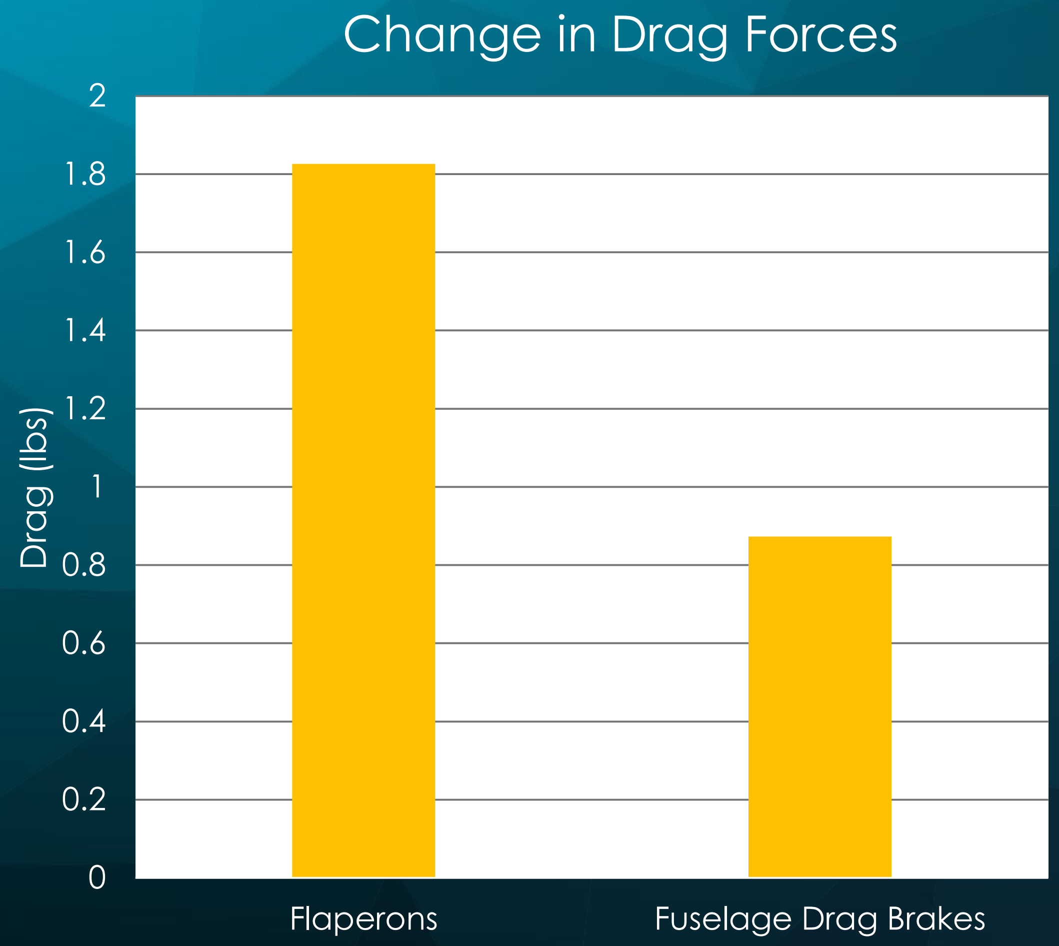
- Drag Braking Methods
- Controls in Reverse Thrust

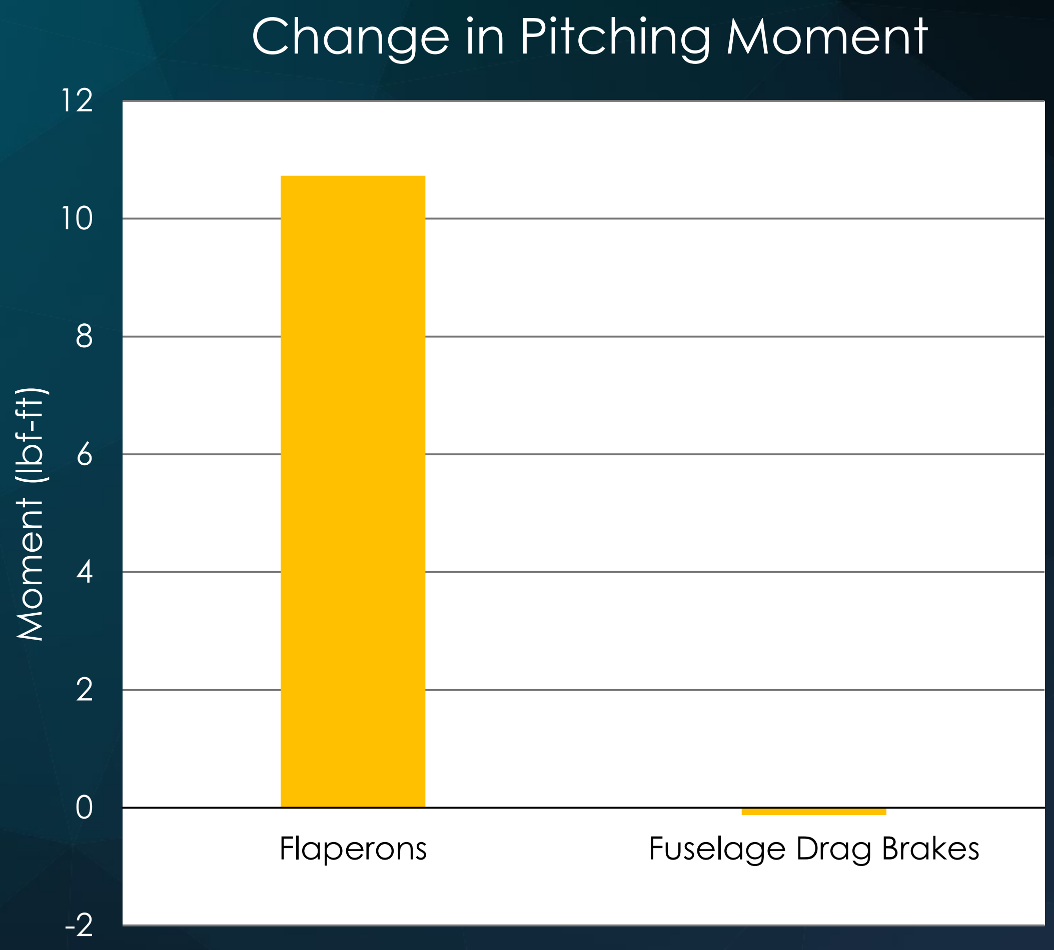






CFD: drag braking methods





PREFER FLAPERONS OVER DRAG BRAKES FOR EFFECTIVENESS AND COMPLEXITY, BUT NEED TO OVERCOME PITCHING MOMENT

CFd: forward thrust

FORWARD THRUST

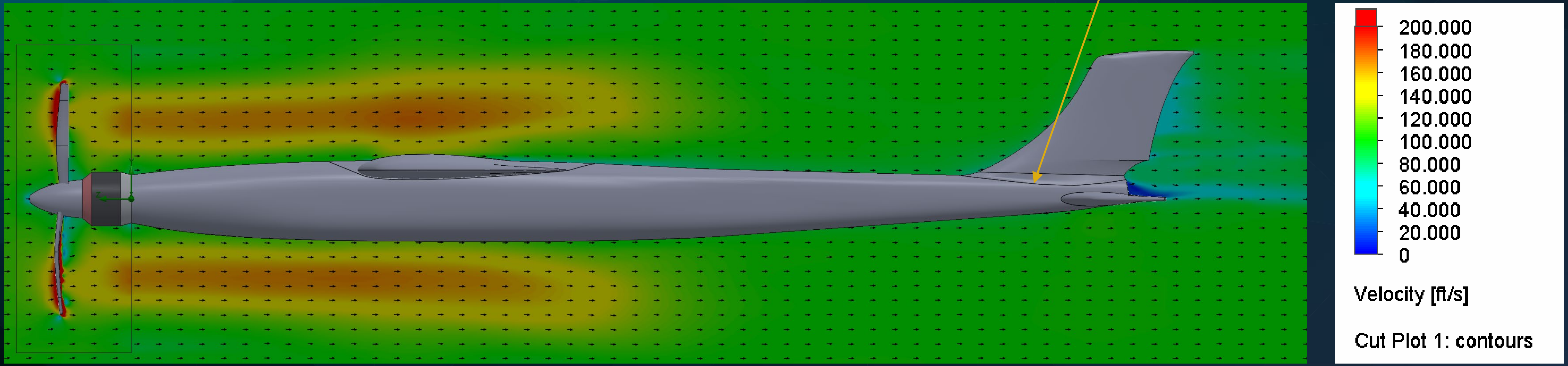
- WING RECEIVES GOOD PROPWASH SO AILERONS WILL BE MORE EFFECTIVE
- TAIL RELATIVELY UNAFFECTED
- DISCLAIMER: DONE TO SHOW TRENDS, NOT FINAL CAD

MESH: 7,300,000 FLUID CELLS

FLUID CELLS CONTAINING SOLIDS: 323,000

FREE STREAM VELOCITY: 100 FT/S

POINT VELOCITY: 98 FT/S



Cfd: reverse thrust

REVERSE THRUST

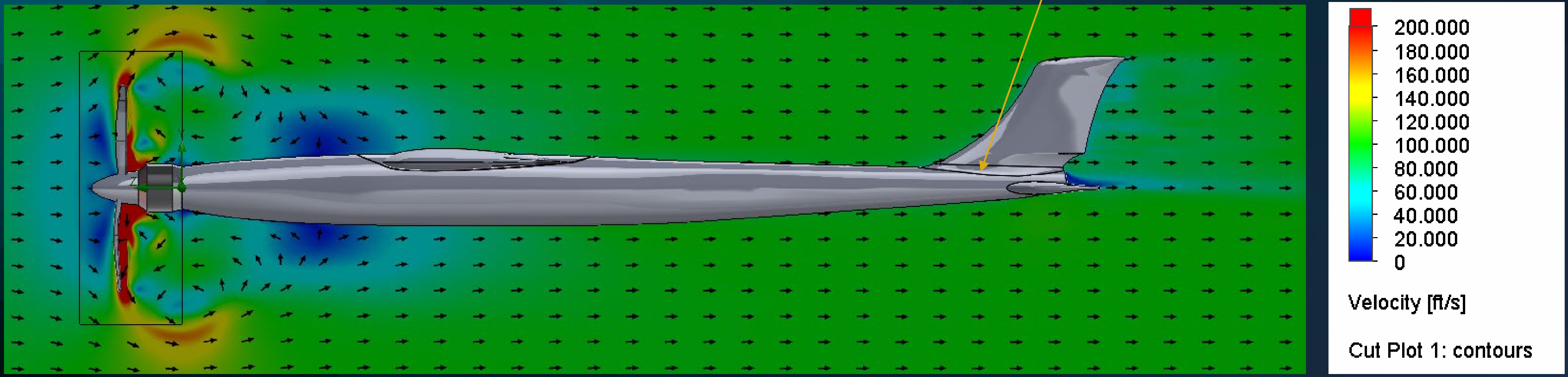
- DISCOVERED THAT AT HIGH RPM, THE WING RECEIVES SIGNIFICANT REVERSE PROPWASH – ATTEMPTED WITH TWO RPM CASES
- TAIL REMAINS RELATIVELY UNAFFECTED
- NOT FINAL CAD

MESH: 14,500,000 FLUID CELLS

FLUID CELLS CONTAINING SOLIDS: 715,000

FREE STREAM VELOCITY: 100 FT/S

POINT VELOCITY: 97 FT/S



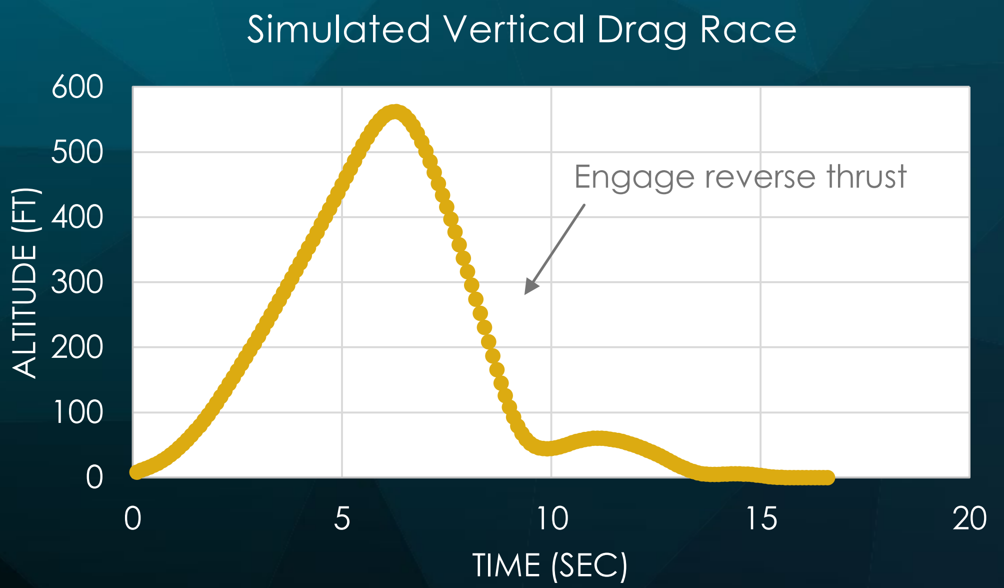
Expected performance

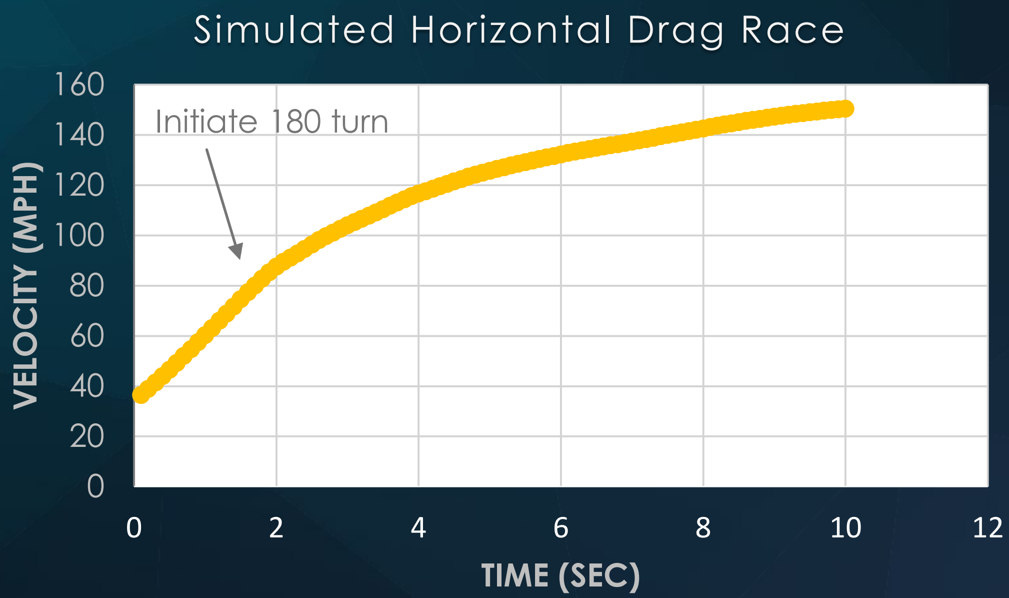
FLIGHT SIMULATOR ALLOWS FOR A ROUGH ESTIMATE OF HANDLING AND ANALOG FOR REAL WORLD PERFORMANCE

ACHIEVED PERFORMANCE (UNTRAINED PILOT)

VERTICAL DRAG RACE: 16 SEC

HORIZONTAL DRAG RACE: ~150 MPH IN 10 SEC





Aero next steps

AILERON SIZING

AVIONICS CONFIGURATION

ASSISTING STRUCTURES

MARKETING

Structures

Goals:

- Design structure to meet the aerodynamic and propulsion needs
- Test and finalize material selection
- Learn and optimize manufacturing processes

Since PDR:

- 20+ composite layups tested
- Compared bonding techniques
- Tested core types and composite application methods

WING layout

SINGLE SPAR

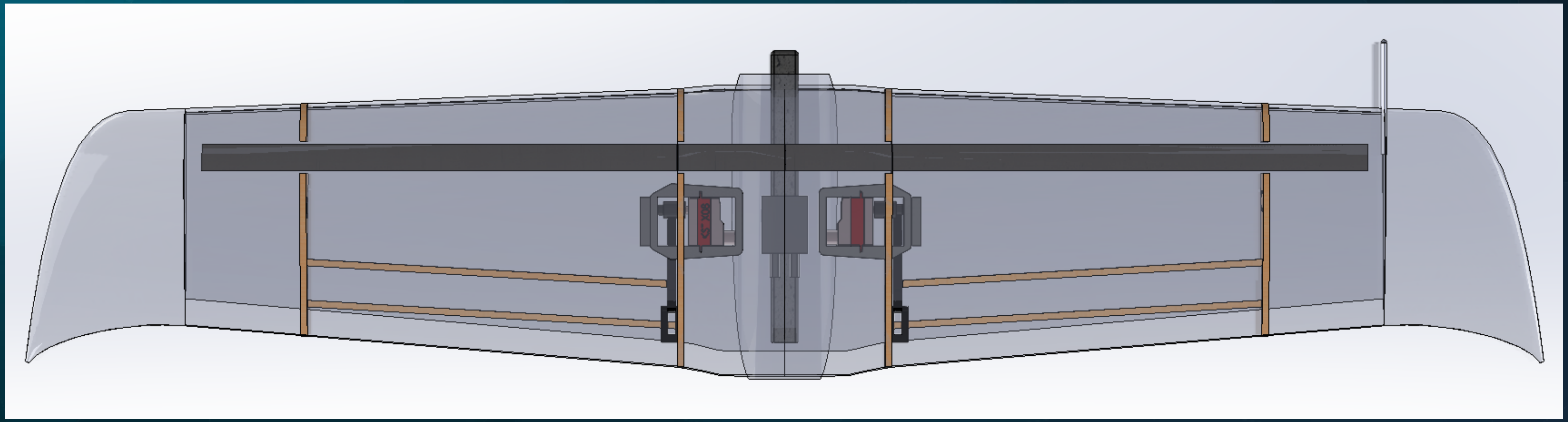
- 22 INCHES
- BALSA AND CARBON TOW

FOUR-RIB DESIGN

- BALSA WOOD
- BOOKENDING AILERONS

PITOT

- AFFIXED TO LE 3D PRINTED MOUNT



SHEAR WEBS

- REINFORCE WING AND AILERON

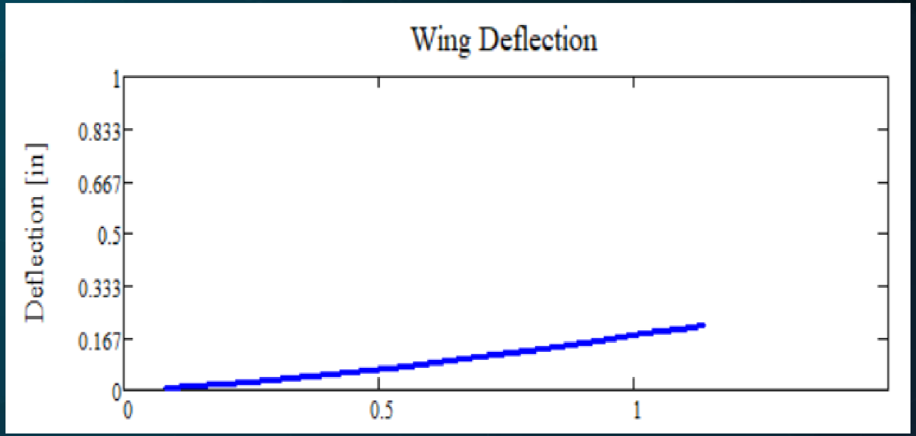
SERVO

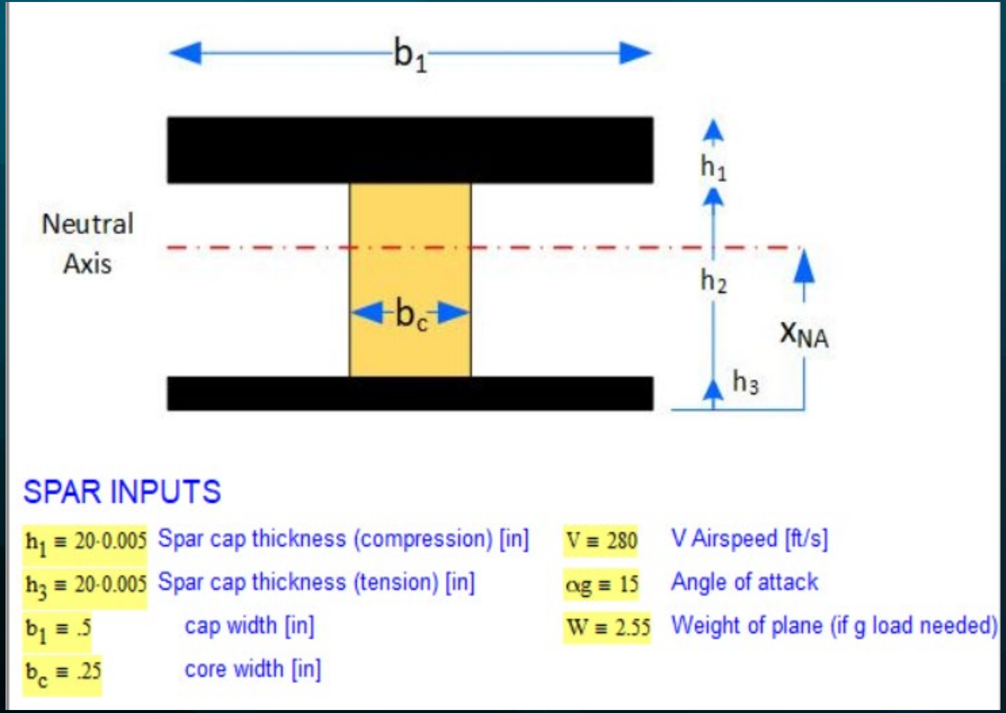
- BONDED TO TOP OF WING INTERNAL SKIN
- OPTIONAL BLISTER

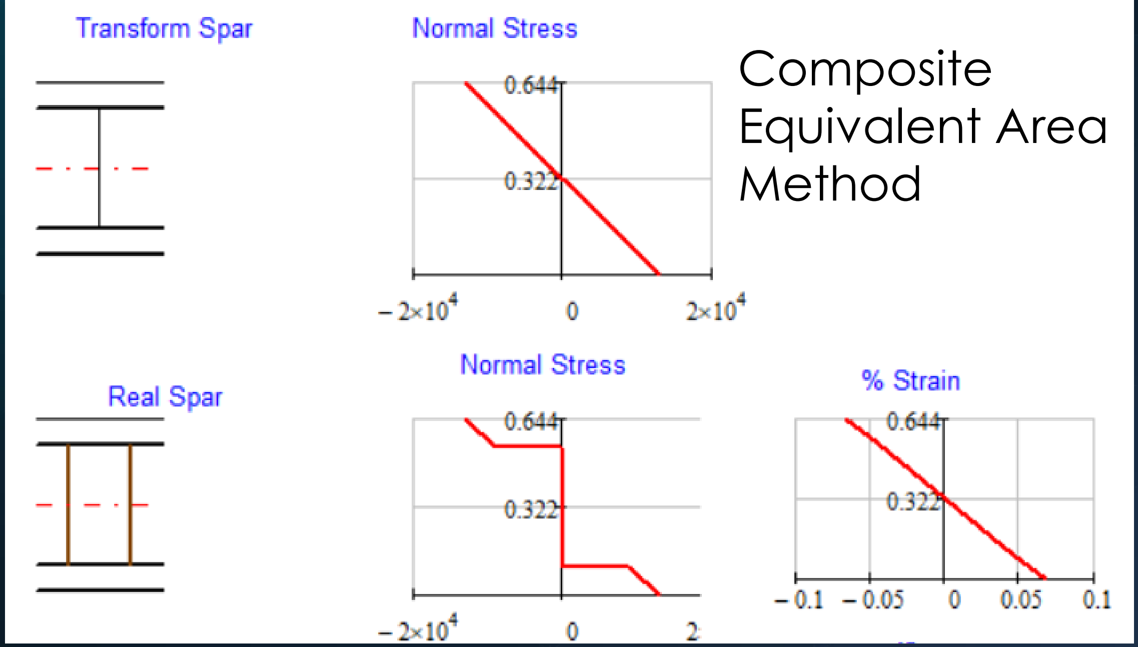
Wing spar design

WING SPAR WAS SIZED WITH A GOAL OF A MAXIMUM 1% WINGTIP DEFLECTION.

Core Width	G loading	Deflection %
1/16"	26.3	1
1/4"	39	1
1/2"	39	1

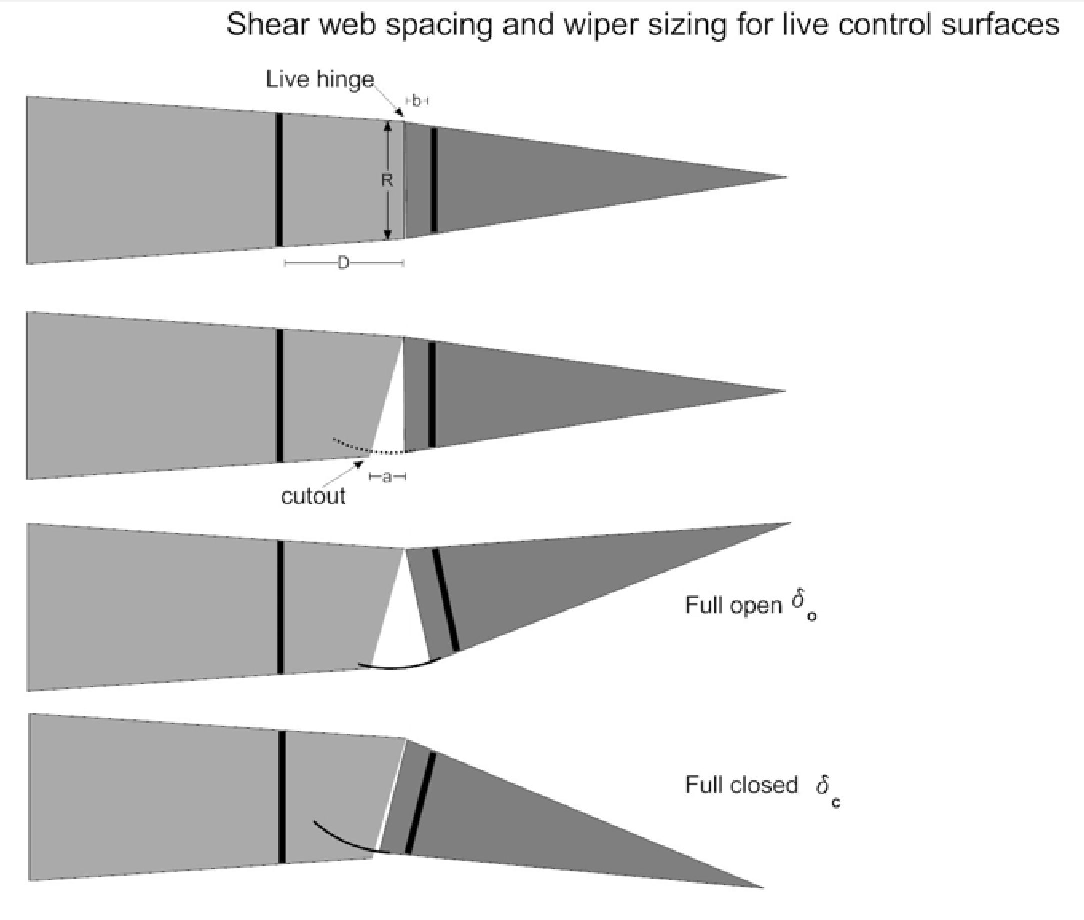






Composite Equivalent Area Method

Ailerons and Wipers



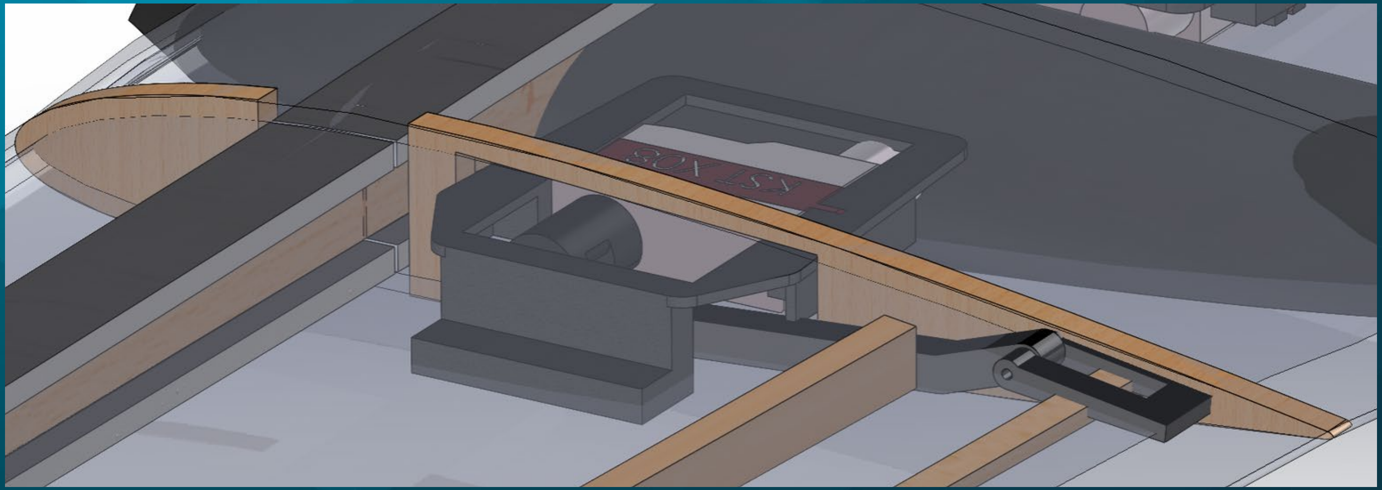
Shear Web Locations

- Live hinge at 80% chord
- Aft wing shear web 0.45 inches forward of hinge
- Aileron shear web 0.25 inches aft of hinge

Wiper Sizing

- Maximum deflection of 30 degrees
- Cutout 0.15 inches
- Wiper sized to be 0.32 inches

Servo systems



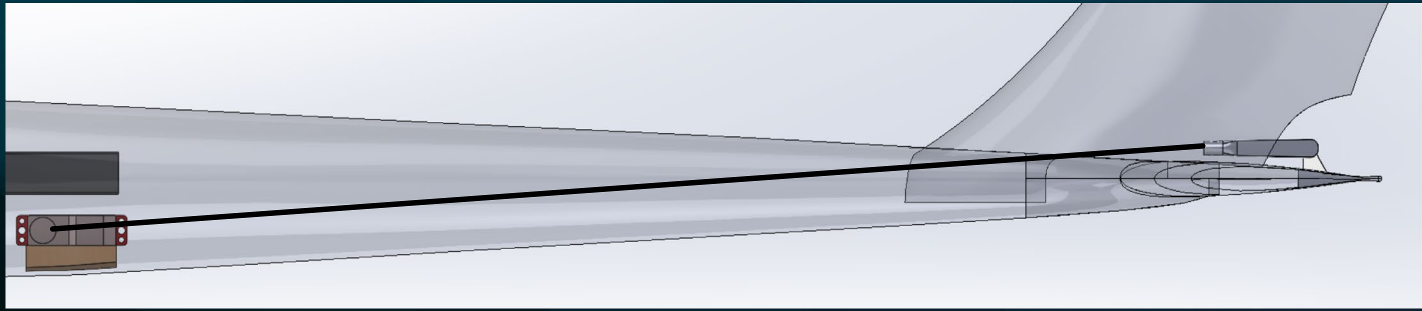
Aileron Servo - 63.65 oz-in

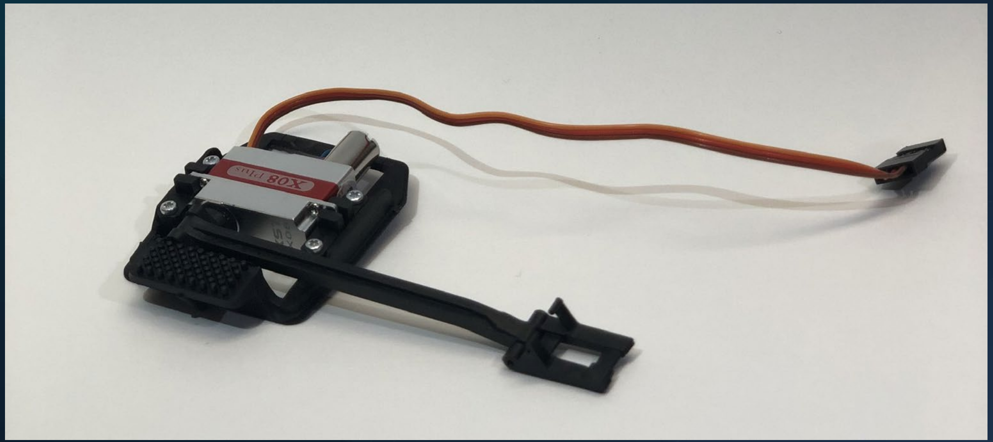
Integrated Drive System (IDS) For Wing

- 30-degree max deflection
- Slimmer system removing need for blister

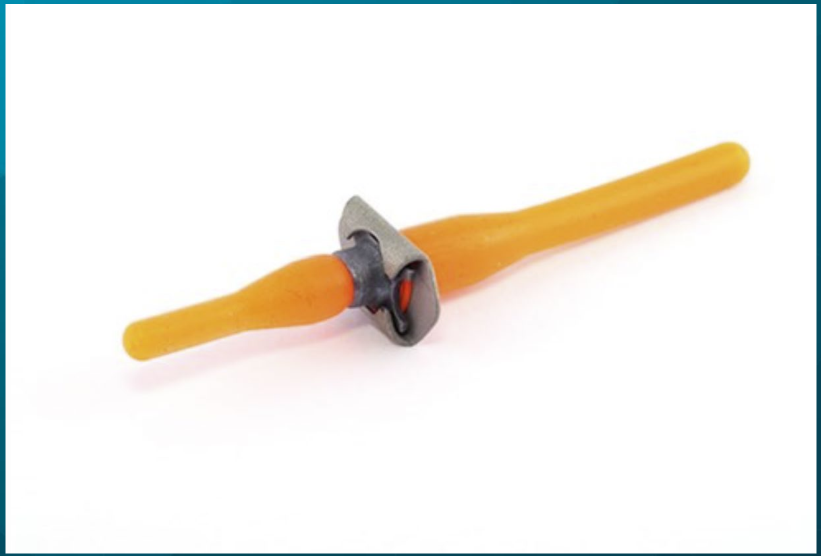
Elevator Servo

- 20-degree max deflection angle
- Rigid 0.05" CF push-rod
- Top mounted control horn





WING attachment



GOALS: STRONG, EASY, LIGHT

LEADING EDGE TAB

- CARBON TOW
- 20 LAYERS, APPROX. ¼ INCH

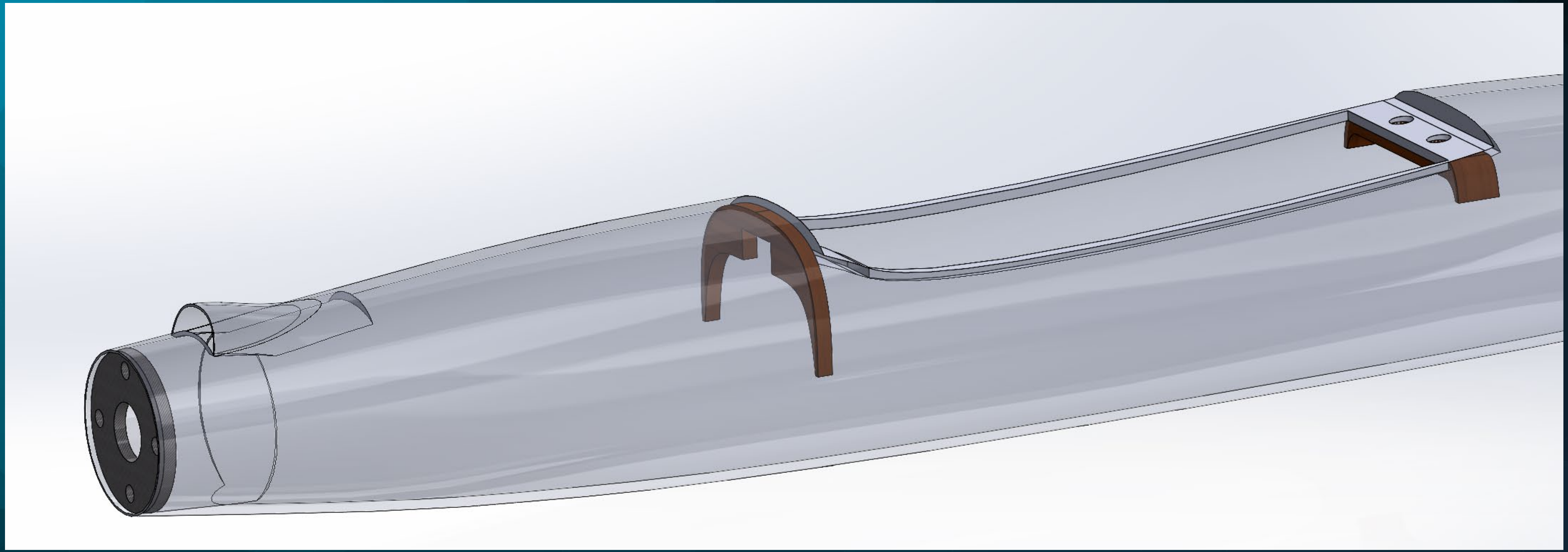
TRAILING EDGE SCREWS

- SIZE 8-32 CLICK BOND NUT PLATE
- SIZE 8-32 TORX HEAD SCREW
- TINNERMAN WASHERS

ATTACHMENT POINTS – PARTIAL BULKHEADS

- BALSA
- LOCATED ON LE AND TE OF WING TAB
- REINFORCED SKIN WITH CARBON TOW

Bulkheads



FIREWALL

- 0.1" Carbon fiber, 1.35" diameter
- Outrunner mount
- Carbon tow reinforced skin
- Balsa core stops as rear support

BULKHEADS

- Reduced weight & extra fuselage room
- Spread tow skin reinforcement post layups
- LE has tab slot
- TE has screw mount

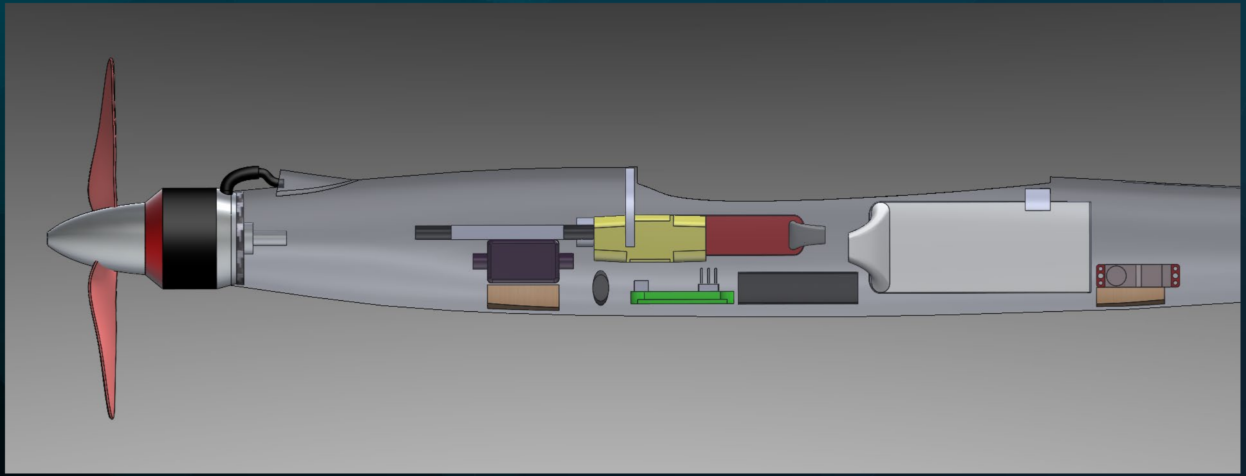
Fuselage design

GOALS

- Room for the Components
- Stability

METHODS

- Created to size designs of fuselage and rearranged components repeatedly
- 3D-Printed Models
- Incremented the length of fuselage
- Incremented the width of fuselage



Fuselage length:

28.5 in with motor and spinner

(26 in without motor and spinner)

Max width: 2.1 in

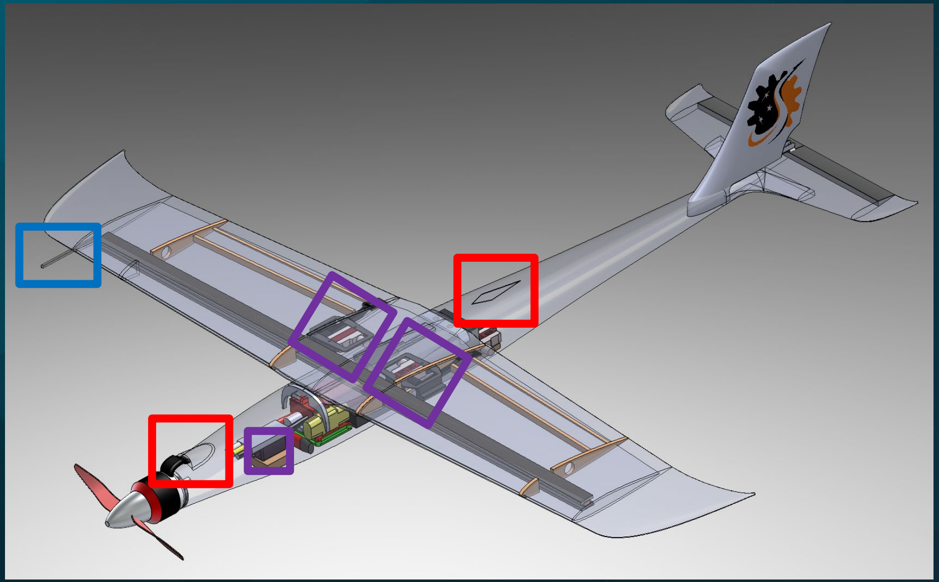
Max height: 2.1 in

Fuselage layout

GOAL: AS FEW HOLES IN THE PLANE AS POSSIBLE

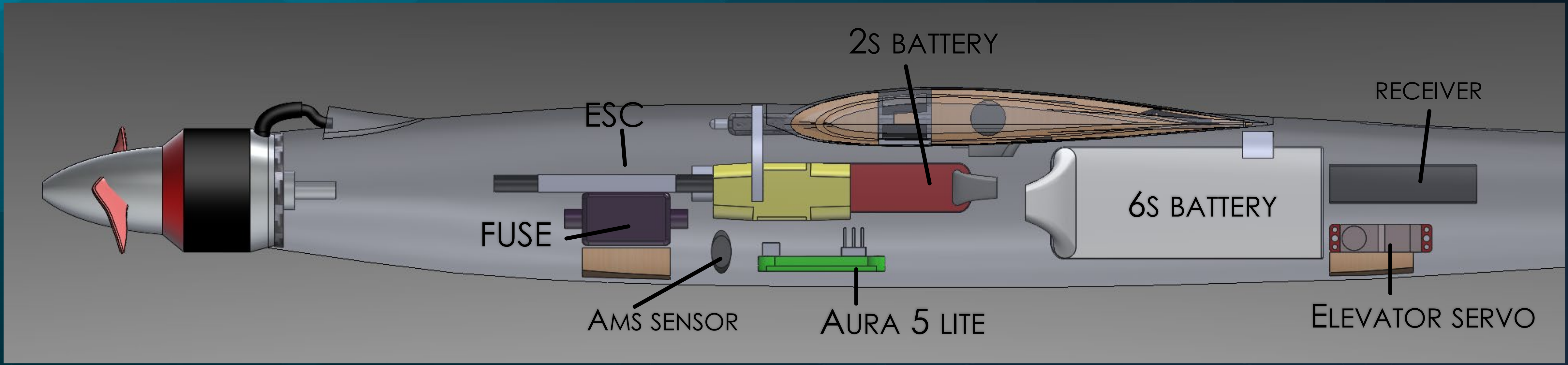
AIRFLOW
- INLET SCOOP
- REAR 'EXHAUST VENT'
- LOCATION FOR RECEIVER ANTENNAS

PITOT TUBE
- 3D PRINTED MOUNT
- ALLOWS FOR EASY REPAIR/REPLACEMENT



HATCH LOCATIONS
- REMOVABLE WING
- FUSE PORT
- SERVO MAINTENANCE POINTS ON UNDERSIDE OF WING

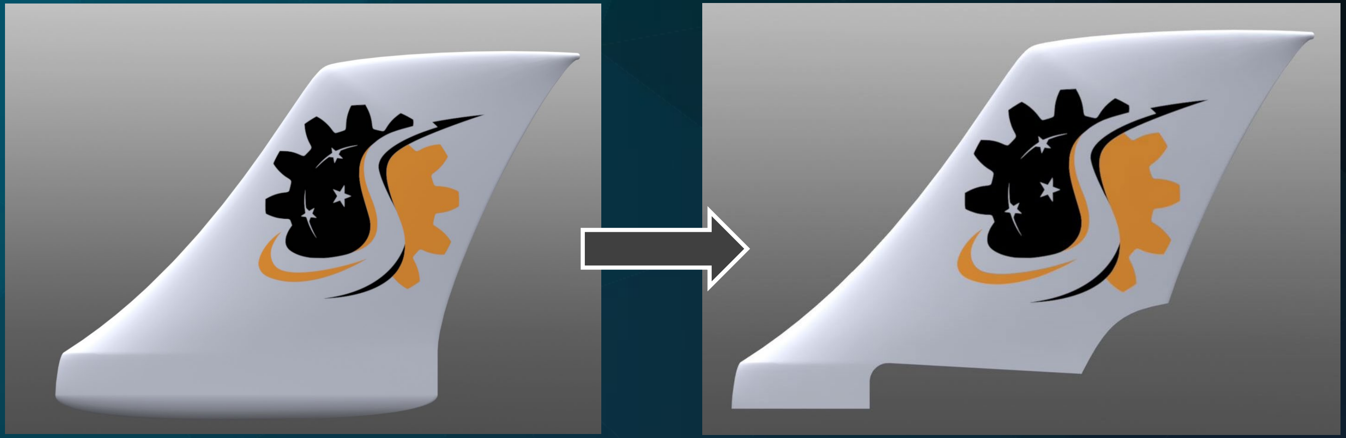
Fuselage layout

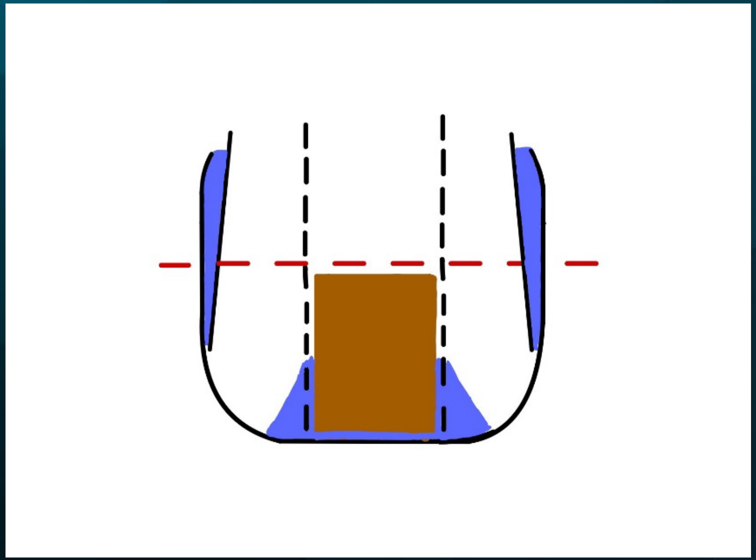


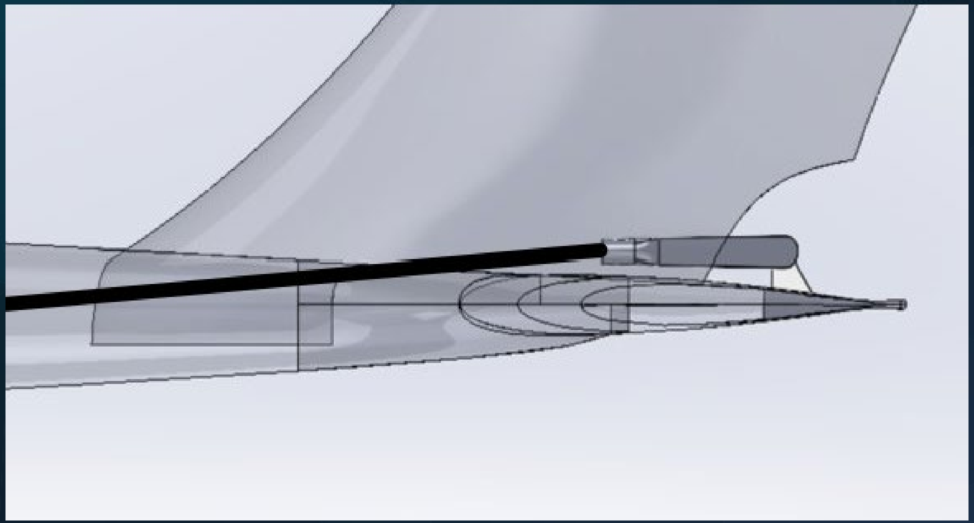
Vertical tail layout

Vertical Stabilizer

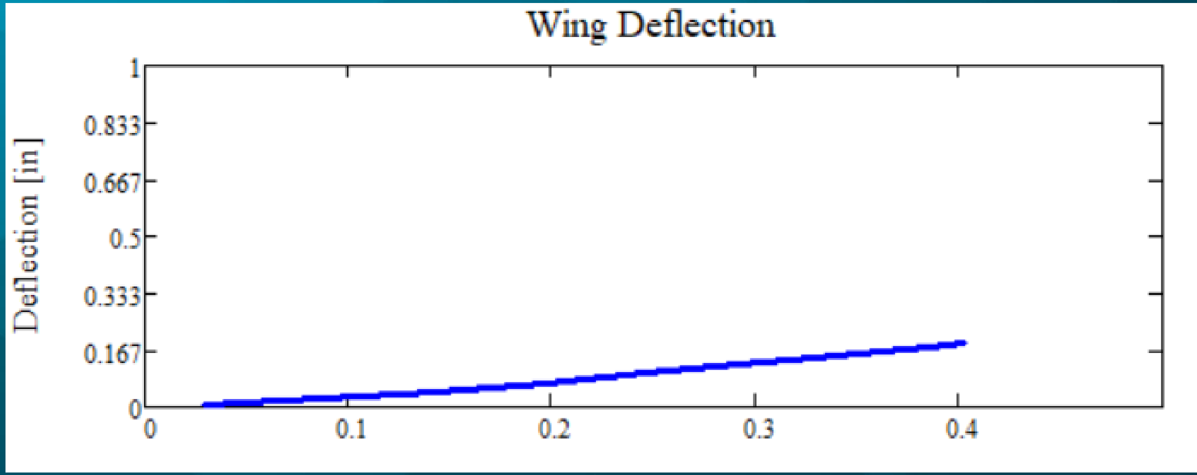
- Slot cut into fuselage with a jig
- Attached to fuselage using epoxy on sidewalls
- Slotted along mold line for push rod passage







Horizontal tail layout

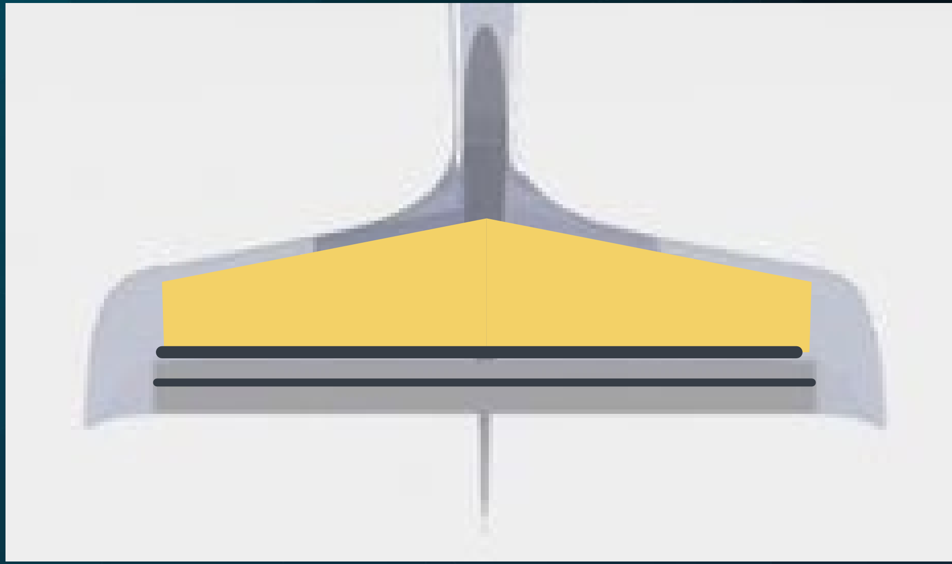


$h_{2root} = 0.04$ Core Height [in]

$\delta(n2 - 1) = 0.2$ Wingtip Deflection [in]

$\delta(n2 - 1) \cdot \frac{2}{12 \cdot b} \cdot 100 = 4$ Wingtip Deflection [%]

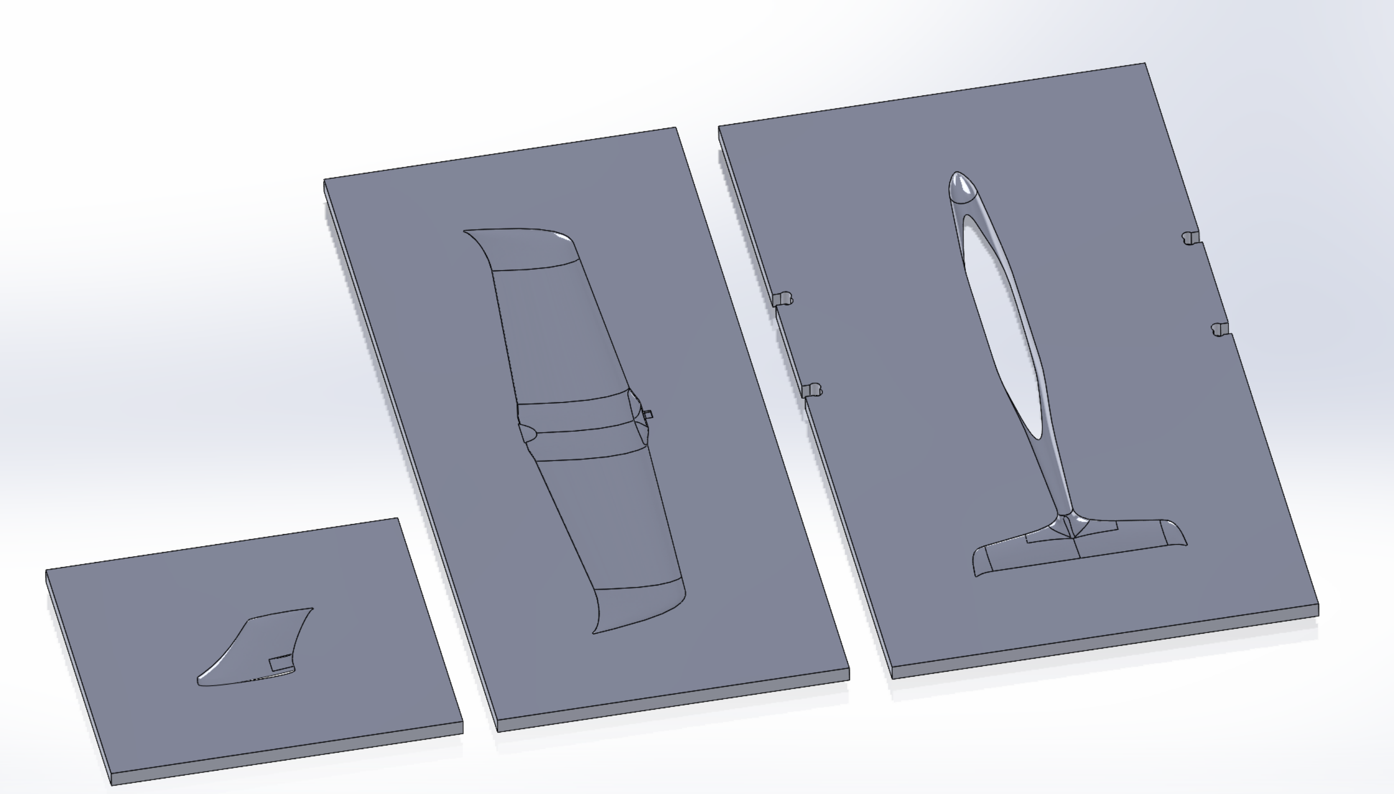
$\frac{L(\alpha g)}{W} = 4.8$ g load. The highest g-load possible for the wing will be a near-stall α, and the highest speed V.



Horizontal Stabilizer

- Part of fuselage mold
- Core in front of elevator hinge line
- Shear webs to reinforce skin around hinge line

Mold lines



Fuselage

- Top/bottom
- Allows for sexy leading edge on horizontal tail

Wing

- Top/bottom mold
- Speed sensor can sit under tab in wing hatch slot

Vertical Tail

- Side/side mold
- Flared bottom to allow for bonding to fuselage
- Ease of installation of elevator servo

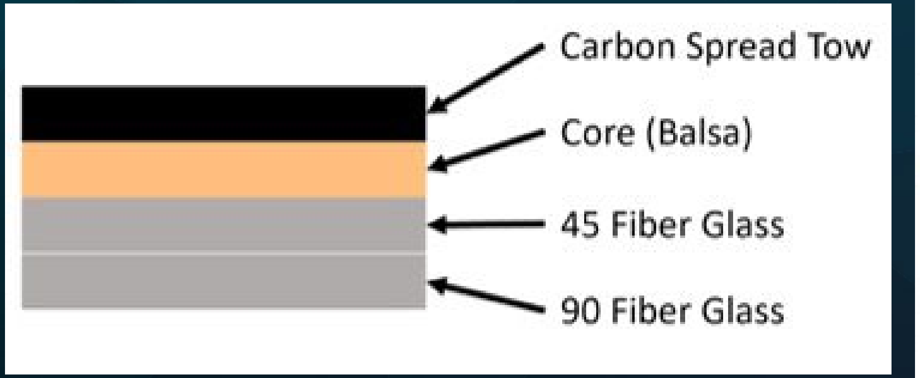
Materials

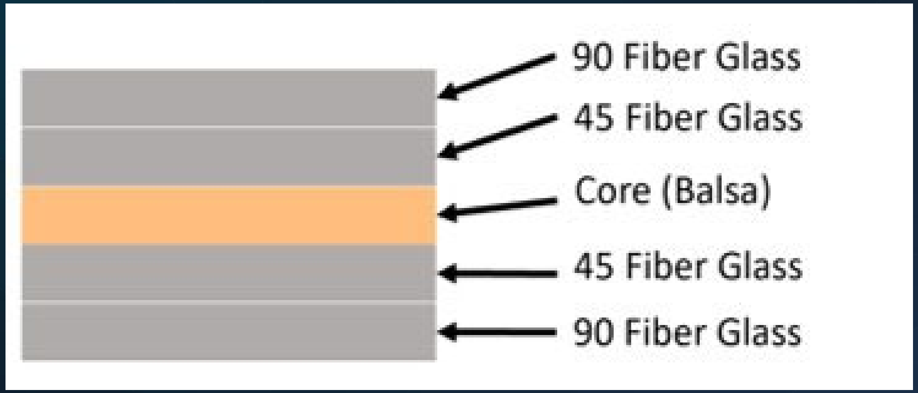
Materials Tested:

- Fiberglass – 0.73 oz, 1.4 oz, 2.0 oz, 2.75 oz
- 1k Carbon Fiber Weave – 3.5 oz
- Carbon Spread Tow – 2.36 oz

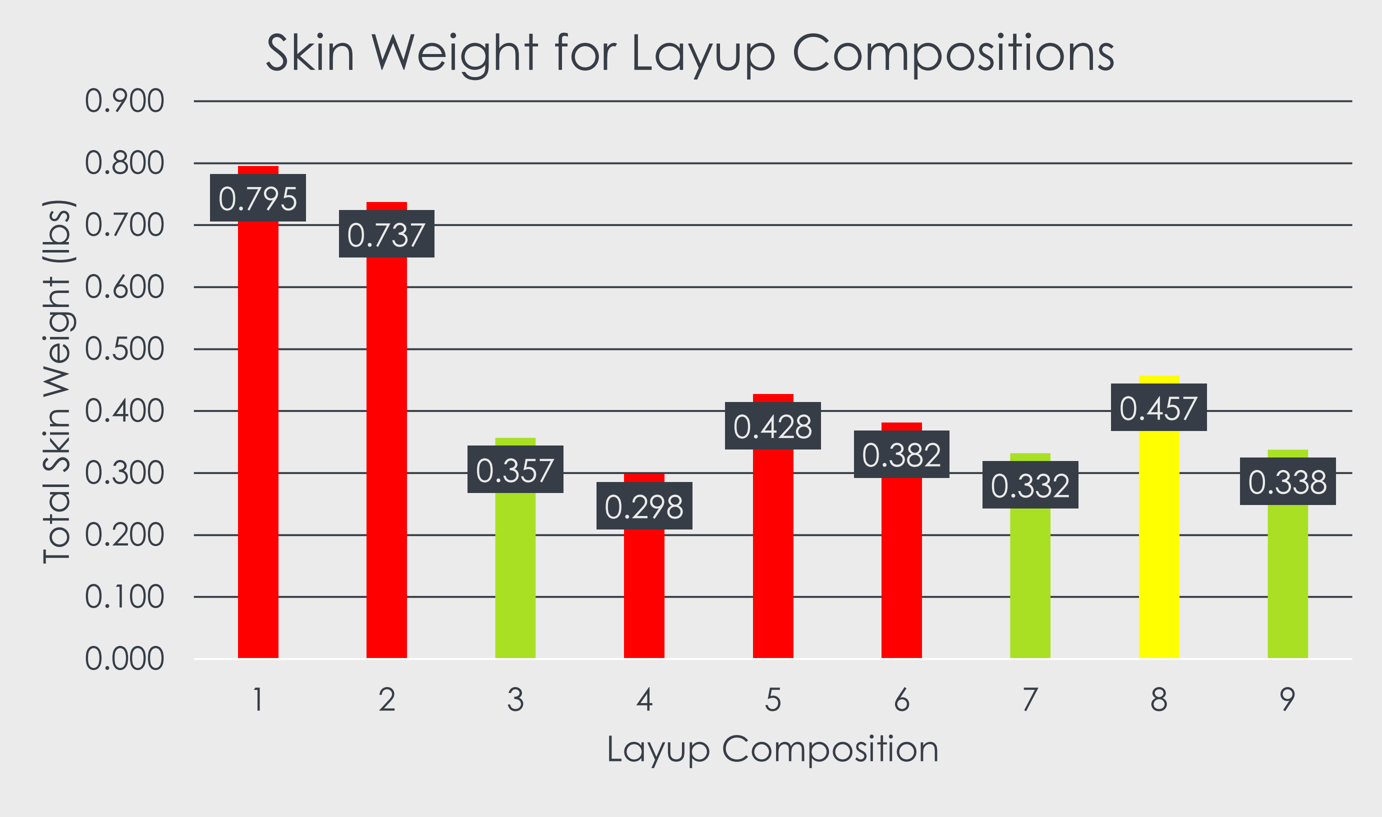
Core Tested:

- Divinycell
- Tooling Glass
- Balsa





Skin Weight



CAD skin areas

Calculated/researched weight densities

Double fiber layers for epoxy approximations

Combination selected, shown as option 9

- Wing and VTail are CST, balsa core, 45/90 FG
- Fuselage and HTail are 90/45 FG, balsa core, 45/90 FG

Internal Weight

SPAR					
Shear Web					
width	0.25	in	Weight		
height	0.45	in	0.137363	oz	
length	22	in	0.008585	lb	
Volume	2.475	in^3			
Caps					
width	0.5	in	Weight		
length	22	in	1.3354	oz	
layers	20	-	0.083463	lb	
thickness	0.1	in			
Volume	1.1	in^3			
		Total Weight		0.092048	lb

TAB	guessing 0.5in by 0.25in tab area				
width	0.15	in		Weight	
length	6.5	in		0.177548	oz
layers	30	-		0.011097	lb
thickness	0.15	in			
Volume	0.14625	in^3			
		Total Weight		0.011097	lb

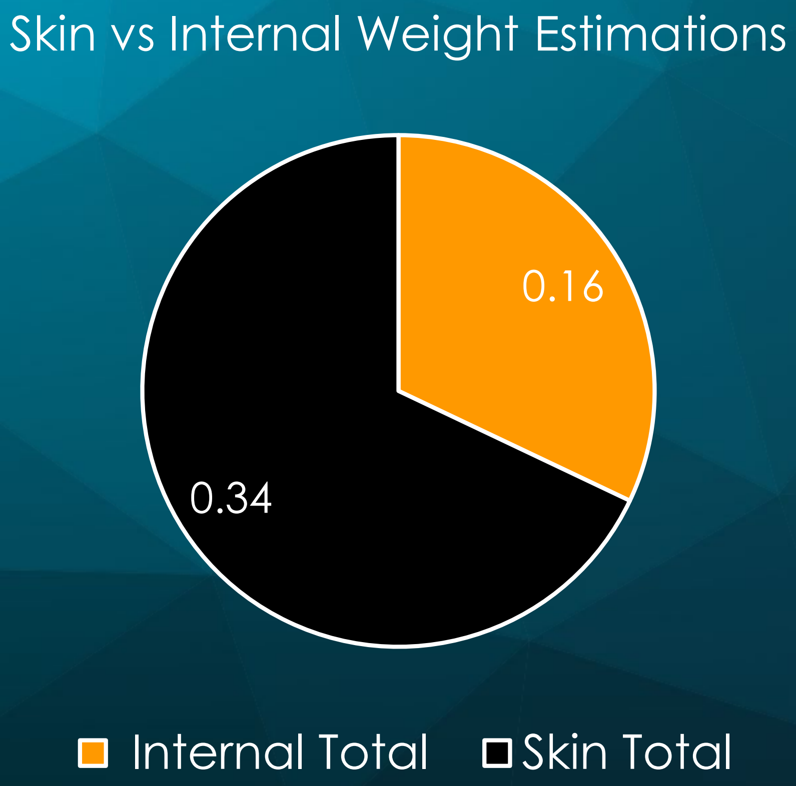
AFT SHEAR WEBS	located just in front of 80% chord				
width	0.125	in	Weight		
height	0.3	in	0.029138	oz	
length	14	in	0.001821	lb	
Volume	0.525	in^3			
		Total Weight		0.001821	lb

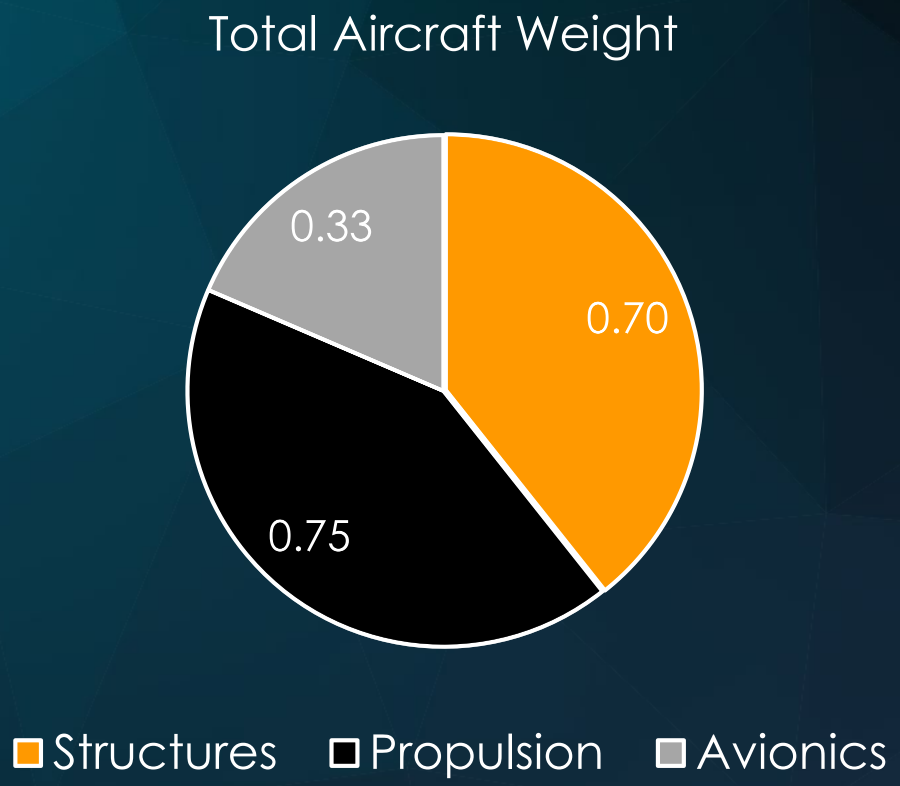
FIREWALL				Weight	
Diameter	1.4	in		0.005011	lb
width	0.125	in			
Volume	0.192423	in^3			
TAB BULKHEAD				Plywood Weight	
Diameter	2	in		0.001091	lb
height of arc	0.85	in			
% of circle	0.425	-		CST Weight	
thickness	0.125	in		0.047674	oz
volume	0.166897	in^3		0.00298	lb
Slot					
height	0.25	in			
width	0.5	in		Total Tab	
CST Strip				0.004071	lb
width	1	in			
layers	5	-			
thickness	0.025	in			
strip volume	0.07854	in^3			
Total Volume	0.041897	in^3			
TE BULKHEAD				Plywood Weight	
Diameter	2	in		0.008693	lb
height of arc	0.85	in			
% of circle	0.425	-		CST Weight	
thickness	0.25	in		0.047674	oz
volume	0.333794	in^3		0.00298	lb
CST Strip					
width	1	in			
layers	5	-			
thickness	0.025	in		Total BH	
strip volume	0.07854	in^3		0.011672	lb
Total Volume	0.412334	in^3			

AFT SHEAR WEB	located just in front of 80% chord				
width	0.125	in	Weight		
height	0.3	in	0.018731	oz	
length	9	in	0.001171	lb	
Volume	0.3375	in^3			
		Total Weight		0.001171	lb

- Initial internal dimensions
- Material densities for balsa, carbon tow, and aero birch plywood
- All weights used to find CG

Weight Estimations





TOTAL STRUCTURAL WEIGHT ESTIMATED TO BE 0.7LBS

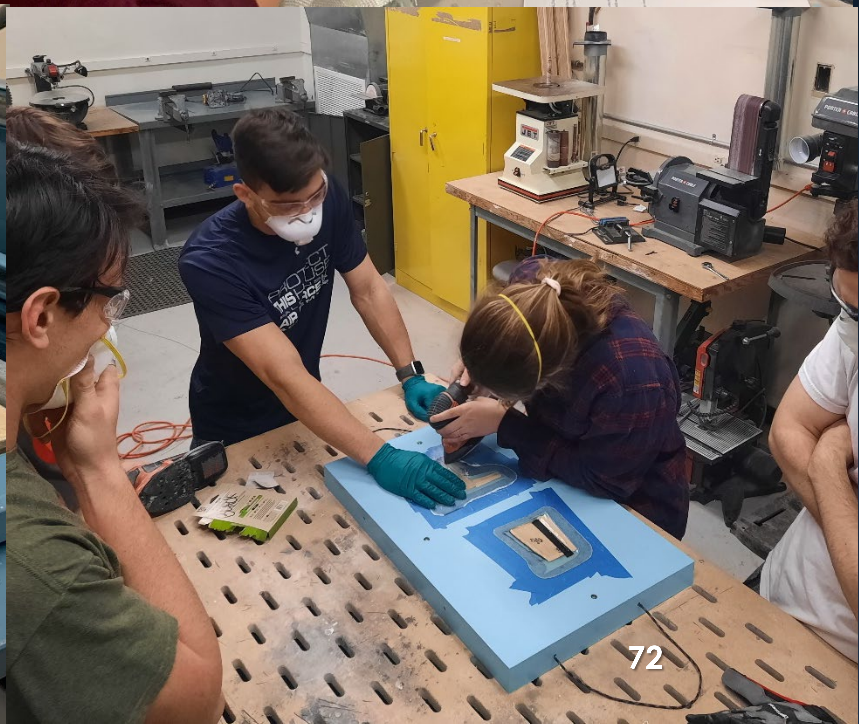
MOSTLY SKIN WEIGHT

TOTAL PLANE WEIGHT ESTIMATED TO BE 1.8LBS

Preliminary testing

- Over 20 test layups
- Practice molds
  - Core placement
  - Balsa forming
  - Aileron rigidity
  - Spar
- Fiberglass vs balsa bonding dams
- 3D Printed Hatches


WARNING
Burn hazard.
WARNING
Pinch point.
Keep hands clear during operation.



Marketing

Marketing: General

Design the definitive RC dragster in a new class of airplane

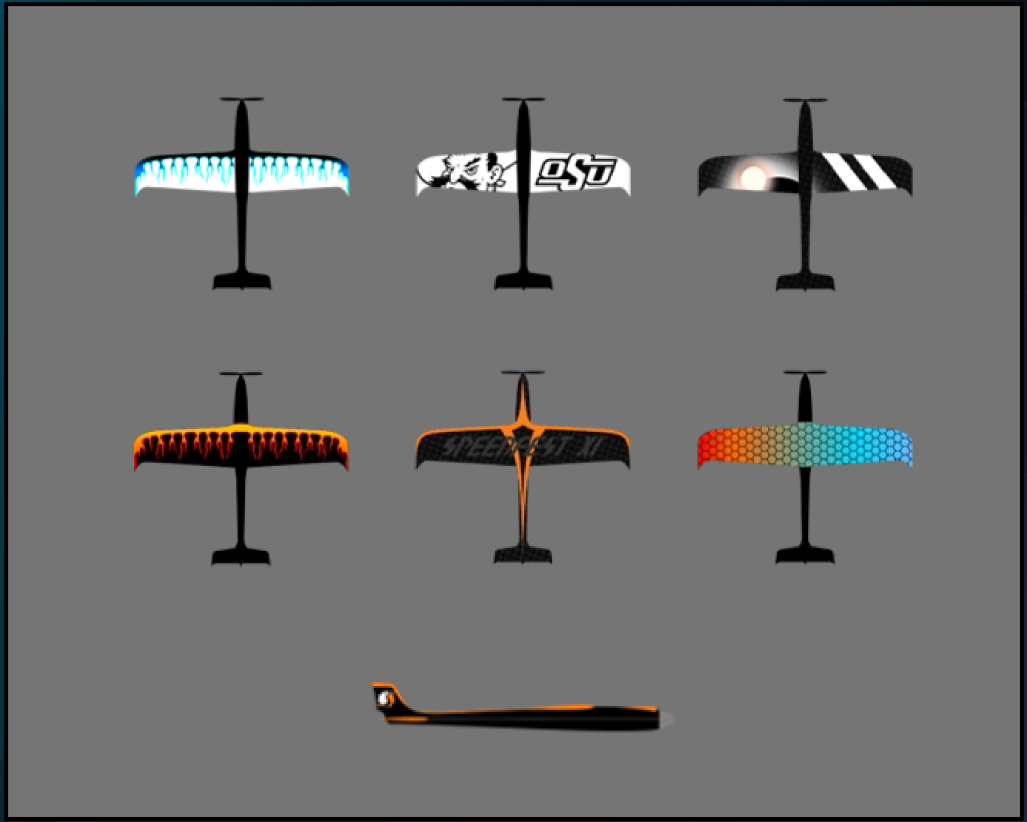
- Creative paint schemes
- Carbon fiber accents

Optimize for acceleration without sacrificing extreme speed

Compliment excellent manufacturing with exquisite artistic design (We made our own font)

Create a professional website that emphasizes performance

★ Produce professional quality marketing video

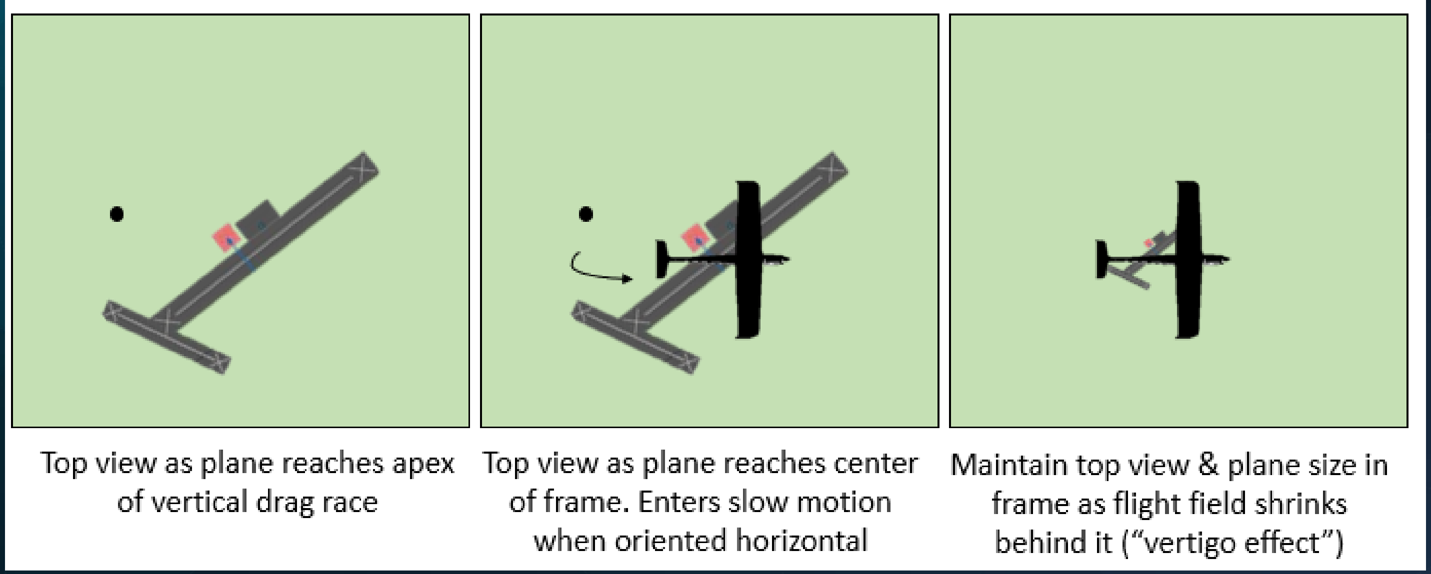


Marketing: Video

Reviewed past SpeedFest videos to determine preferred format & additions

Plan to devote frames to unique aspects of plane—as well as the name of the plane (TBD)

- Outrunner motor (possible)
- Light & small design
- Speed
- Horizontal & vertical missions
- Electric propulsion system



Storyboard of video opening shots

Questions?

appendix

Schedule

Speedfest Operational Hours (Pre CDR)
- Monday – Friday: 10 -3
- Saturday: 12 – 3

2022 FEBRUARY

Critical Day – Operations will be 24/7

SUN	MON	TUE	WED	THU	FRI	SAT
		1 Materials & Structural Design; Sizing & Aero Analysis	2	3	4	5
6	7	8 Final Propulsion System Selection	9 All Final Dimensions given to CAD	10 Start CFD	11	12
13	14 Mock CDR 1	15 Mock CDR 2	16 CDR; Plug, PB sent to CNC. (ALL CAD FINALIZED)	17 Marketing Team Forms; Fit plug to parting board	18	19 Epoxy plug halves together (24 hr. cure)
20 Priming and Sanding the Plug	21 Priming and Sanding the PB and Dams	22	23	24 Start making the molds	25	26
27	28					

Speedfest Operational Hours (Pre CDR)
- Monday – Friday: 10 -3
- Saturday: 12 – 3
- 24/7 Structures Shifts

2022 MARCH

Critical Day – Operations will be 24/7

SUN	MON	TUE	WED	THU	FRI	SAT
		1 Mold Construction Continues	2	3 Molds are complete	4 Plane 1 Layup Prep	5
6 Plane 1 Layup 1 (hatches, Htail)	7	8 Plane 1 Layup 2 (Wing, Fuselage, Htail)	9	10	11	12 P1: Bonding Halves, Control Surfaces
13 P2 Layup Prep	14 P1: Integration & Avionics; Plane 2 Layup 1 (hatches, Htail)	15 P1 Complete	16 First Flight Test; Plane 2 Layup 2 (Wing, Fuselage, Htail)	17	18 Marketing Orders In (shirts, stickers)	19
20	21 P2: Bonding Halves, Control Surfaces	22 P2: Integration & Avionics	23 P3 Layup Prep	24	25 P2 Complete; Flight Test Day?	26 Buffer day
27 Buffer day	28 P3 Layup 1 (hatches, Htail)	29	30 P3 Layup 2 (Wing, fuselage Htail)	31		

Airfoil downselect

- Common airfoils (ex. NACA 2410/2412) chosen as baseline for mission performance and launch
- Between the wing and tail, 24 established and 13 custom-blended airfoils were considered.
    - Thin airfoils didn't generate enough lift during launch/early part of drag races to be selected
    - Thick airfoils were close to thin airfoils in performance during vertical climb and horizontal race

Motor testing: overview

Quadcopter Motors

- None survived testing
- Could not reach 65 A
- Best thrust to weight (≤25)

Inrunner Motors

- Outlasted fuses
- Reached current threshold
- Mediocre thrust to weight (≤11)

BadAss Motors

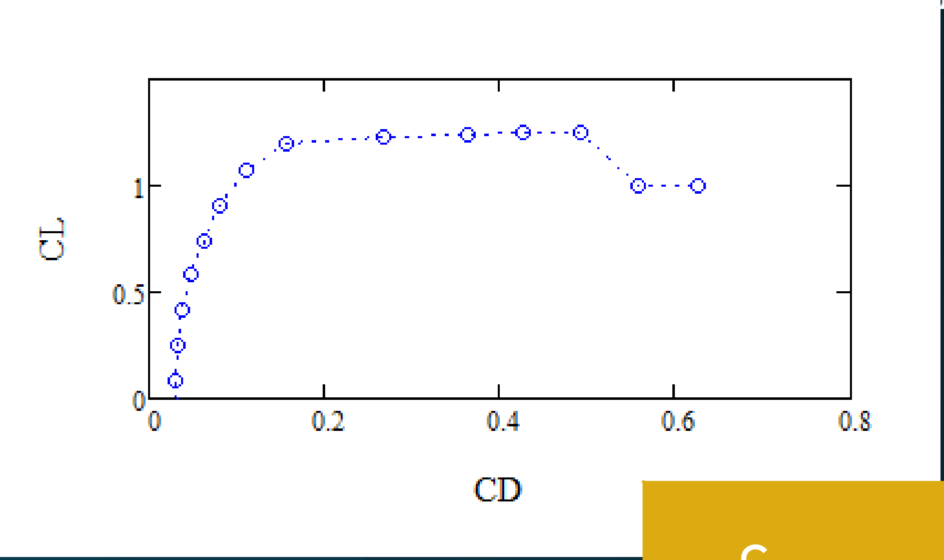
- Outlasted Fuses
- Reached current threshold
- Acceptable thrust to weight (≈17)

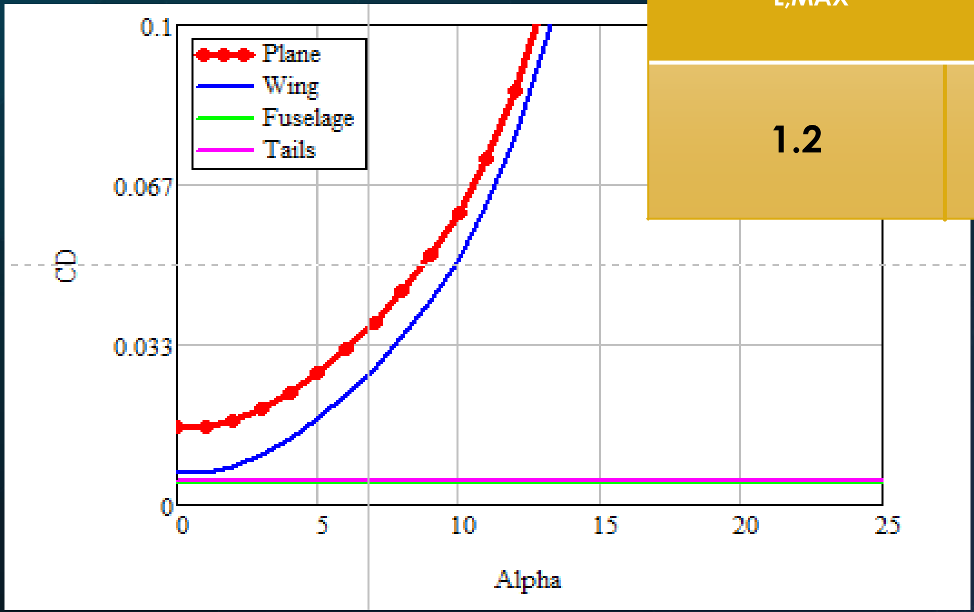
Motor testing: inrunners

- Most reliable
- Smallest thrust-to-weight ratio
- 160-180 grams
- Custom order

Drag breakdown

- Airfoil, near-to-launch airspeed, and aircraft geometry provide aircraft drag polar.
- Total Drag Contributions (Races: Re = 700k, low a)
  - Wing – 46.6%
  - Tail – 28.4%
  - Fuselage – 25%





$C_{L,MAX}$	a_{STALL} (deg)
1.2	13

Aero questions