ORANGE TEAM 2019

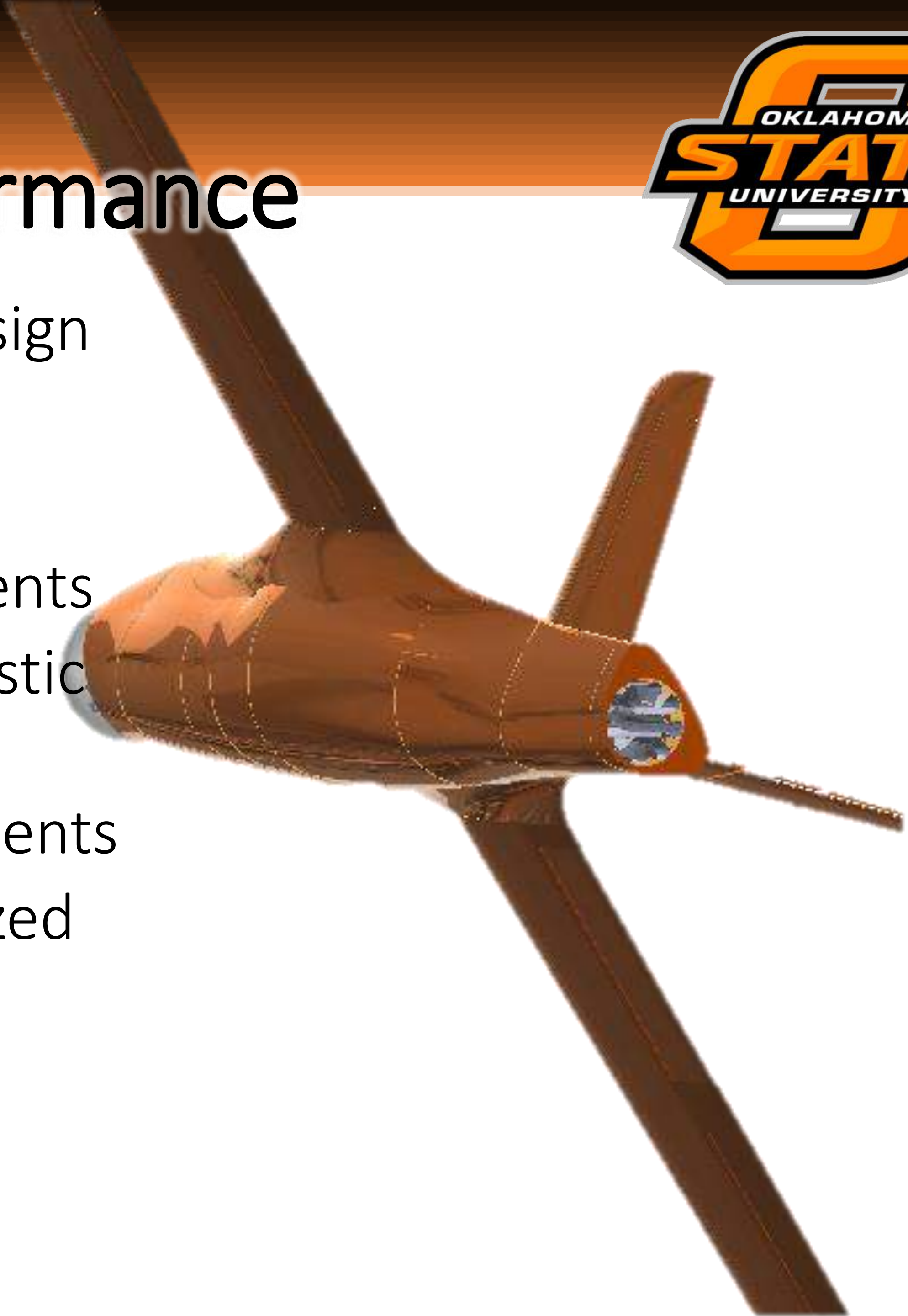
Critical Design Review (CDR)
20 February 2019

Overview

1. Overall Timeline and Goals for Phase 3
2. Overview of Concept
3. Manufacturing Timeline
4. Structures: Manufacturing and Materials
5. Structures: Aircraft Configurations
6. Ground Equipment
7. Launch and Recovery
8. Aerodynamics
9. Propulsion
10. Review
11. Backup Slides

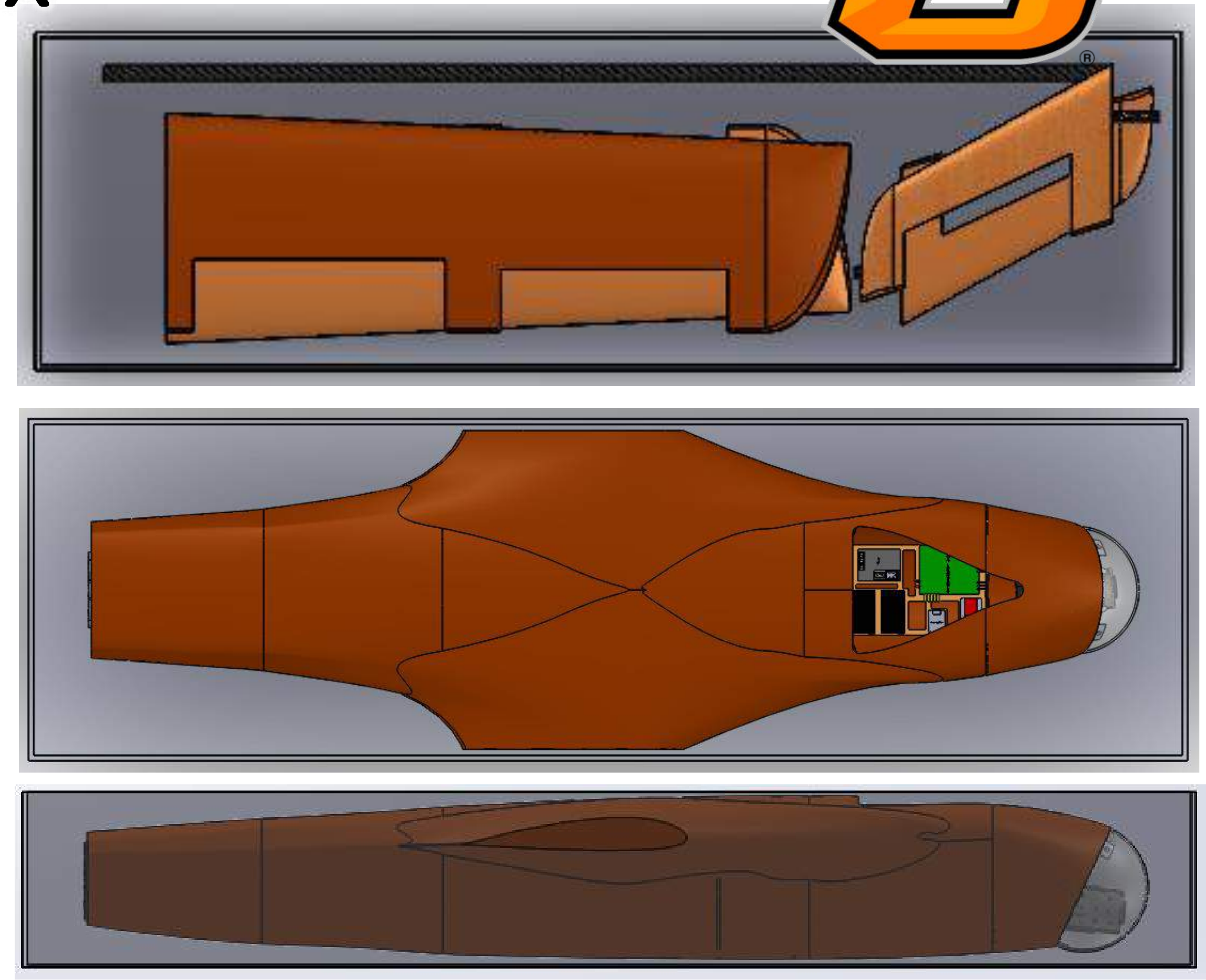
Overview: HawkEye Performance

- Small, compact, and high speed design
- 25% static margin
- Max GTOW = 17.9lb
- Ground launched, meets requirements
- Lobed exhaust and K-wool for acoustic cancellation
- Meets all range and loiter requirements
- 30x optical zoom with 3-axis stabilized gimbal
  - Long range targeting
  - Low acoustic signature at distance



HawkEye: Inside the Box

- Small, compact, and high speed design
- Aircraft fits in 2 designated Pelican Cases
- Third case used for ground equipment



HawkEye: Basic Figures

- Max Thrust: 15.5lb
- Max Speed: 132 ~ 151 kts
- Max GTOW: 17.9lb
  - Empty Weight: 10.96lb
- SM: 18.6%
  - CG @ 22.1 in from nose
  - Quarter Cord @ 24 in

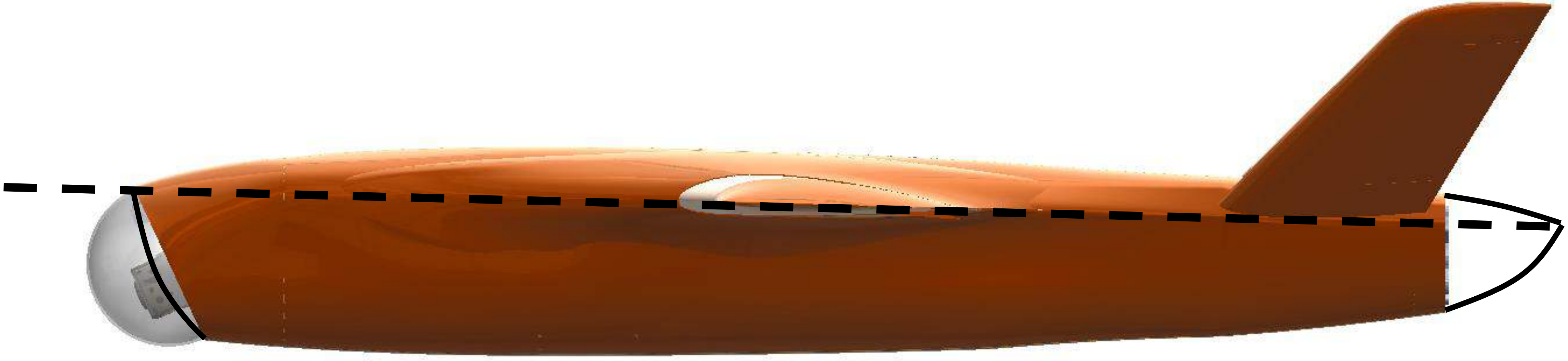
STRUCTURAL DESIGN AND MANUFACTURING

Tasks Accomplished Since PMR

- Finalized wing and tail attachment structure
- CDR Specific Tasks
  - Takeoff/landing strategies
  - Molding strategy
  - Fuselage skin layup and weight estimations
  - Internal components, electronics, camera and bulkhead configuration
  - Inlet and hatch integration
  - Camera and acrylic dome integration
  - Specified skin weights and C.G. calculations

Aircraft Molding Strategy

- Top-bottom molds for both fuselage body and wings
- Left-right mold for V-tail



Core Option 1: Balsa Wood

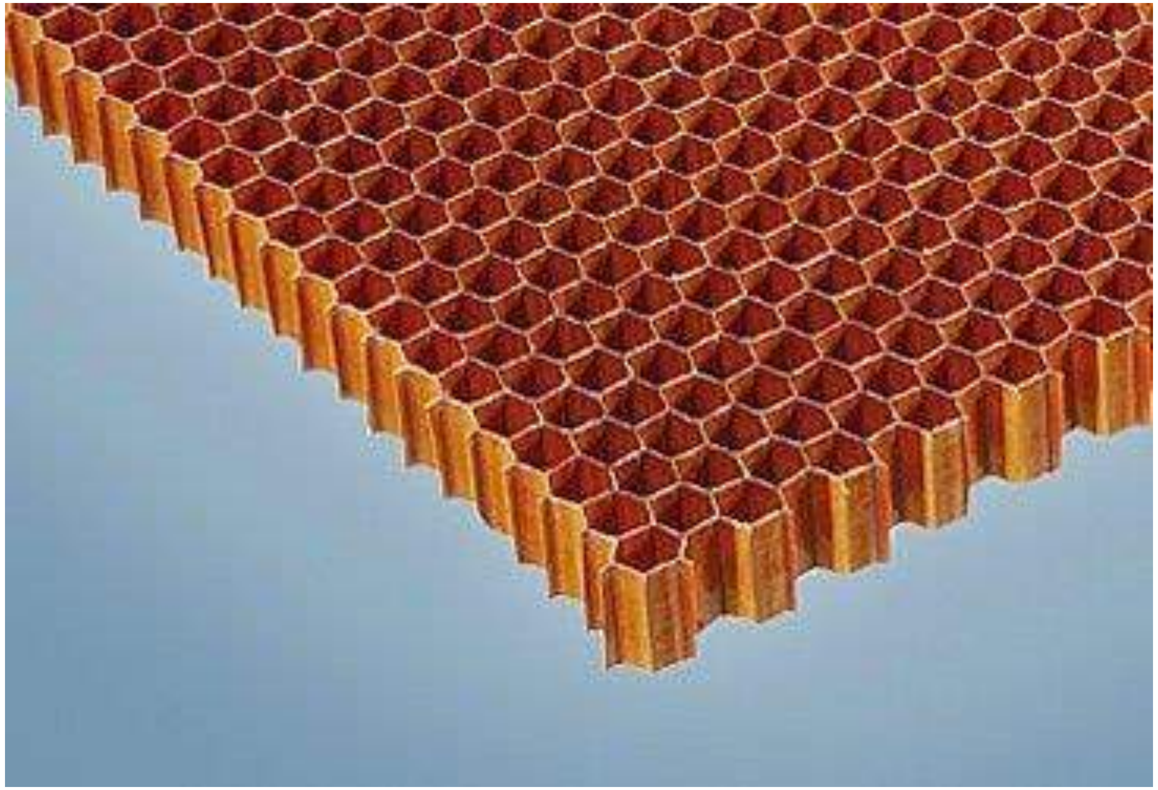
- Thickness: 1/16”
  - Density: 6~10 lb/ft^3
- Has traditionally been used in past Speedfest aircraft
- Easy to mold to shape of aircraft

Core Option 2: Divinycell Foam

- Thickness: 1/8”
  - Thicker foam available
  - Density: 3lb/ft^3
  - Also is available in 5 lb/ft^3
- Easy to mold to shape of mold
- More simple to repair than balsa

Core Option 3: Honeycomb

- ~~Thickness: 0.20-0.25 inches~~
  - Density: 3 lb/ft^3
  - Available in 1.8 lb/ft^3; considered too weak
- Different strength properties based on direction of loading
- Best strength-weight ratio

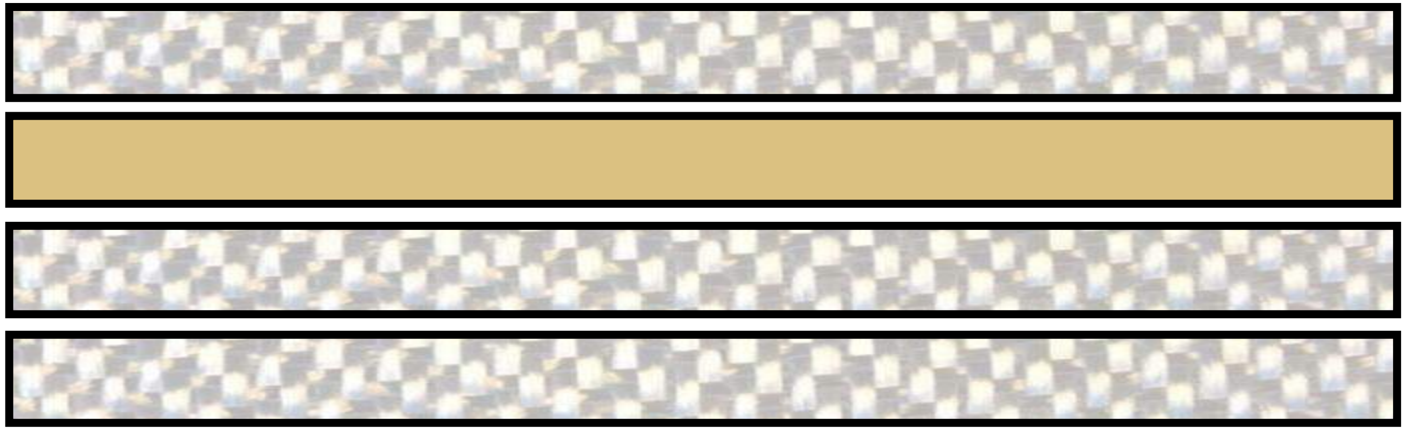


Skin Selection

- Core selection:
  - **Divinycell 1/8" foam core chosen**
- 2 oz., 1610 fiberglass:
  - Allows for extremely lightweight structure
  - Does not carry flight loads sufficiently unless multiple layer layup
- **3 oz., 120 fiberglass:**
  - 4 harness weave allows for easier contoured layups than plain weave
- 4 oz., 1522 fiberglass:
  - Structurally sufficient; could use fewer layers of fabric

Skin Layup

- Semi-monocoque structure
- Skin carrying torsional loads during flight
- Carbon tow implemented along high stress areas



45° bias, 3 oz. fiberglass

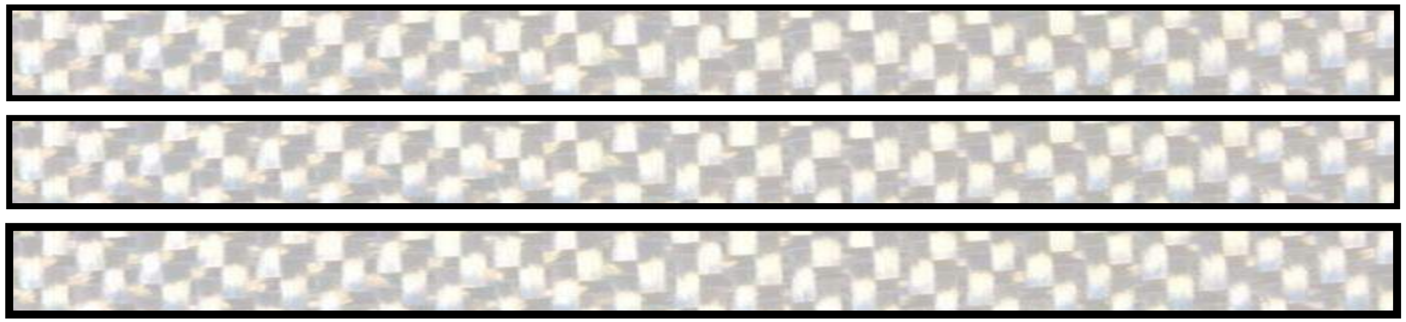
1/8” Divinycell Foam Core

90° bias, 3 oz. fiberglass

45° bias, 3 oz. fiberglass

Customized Composite Fuel Tank

- Top-bottom mold for customized fuel tanks
- Tooling glass will be used
- 400/215 epoxy mixture



45° bias, 9.6 oz. fiberglass

90° bias, 9.6 oz. fiberglass

45° bias, 9.6 oz. fiberglass

Skin Weight (Best Case)

1:1 Fiberglass to epoxy ratio

3 lb/ft^3 Divinycell foam

- 2 layers fiberglass - foam - 1 layer fiberglass
- Total Skin Weight: 2.441 lb.

5 lb/ft^3 Divinycell foam

- 2 layers fiberglass - foam - 1 layer fiberglass
- Total Skin Weight: 2.742 lb.

Skin Weight (Worst Case)

1:1.5 Fiberglass to epoxy ratio

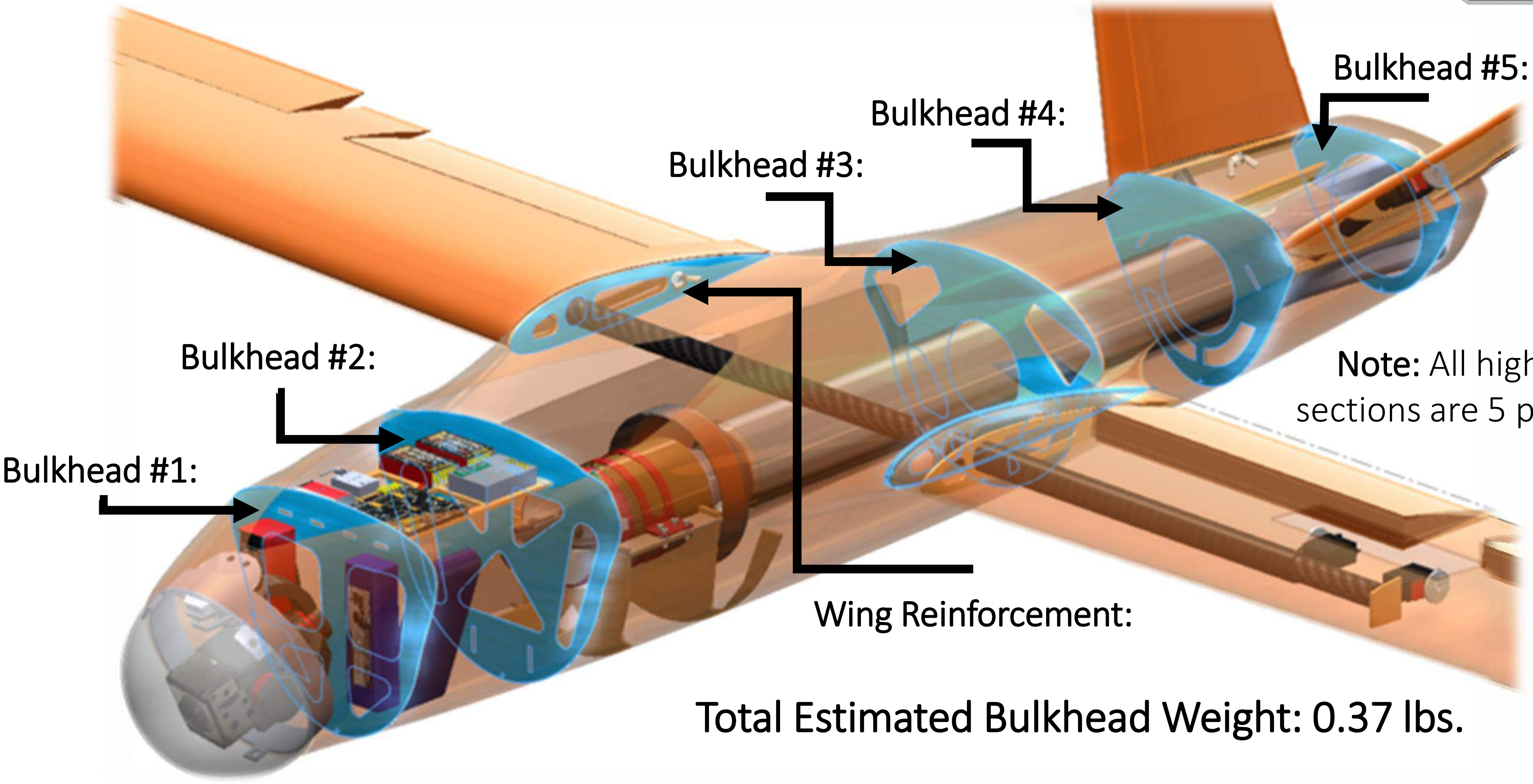
3 lb/ft^3 Divinycell foam

- 2 layers fiberglass - foam - 1 layer fiberglass
- Total Skin Weight: 2.938 lb.

5 lb/ft^3 Divinycell foam

- 2 layers fiberglass - foam - 1 layer fiberglass
- Total Skin Weight: 3.239 lb.

Bulkhead Configuration



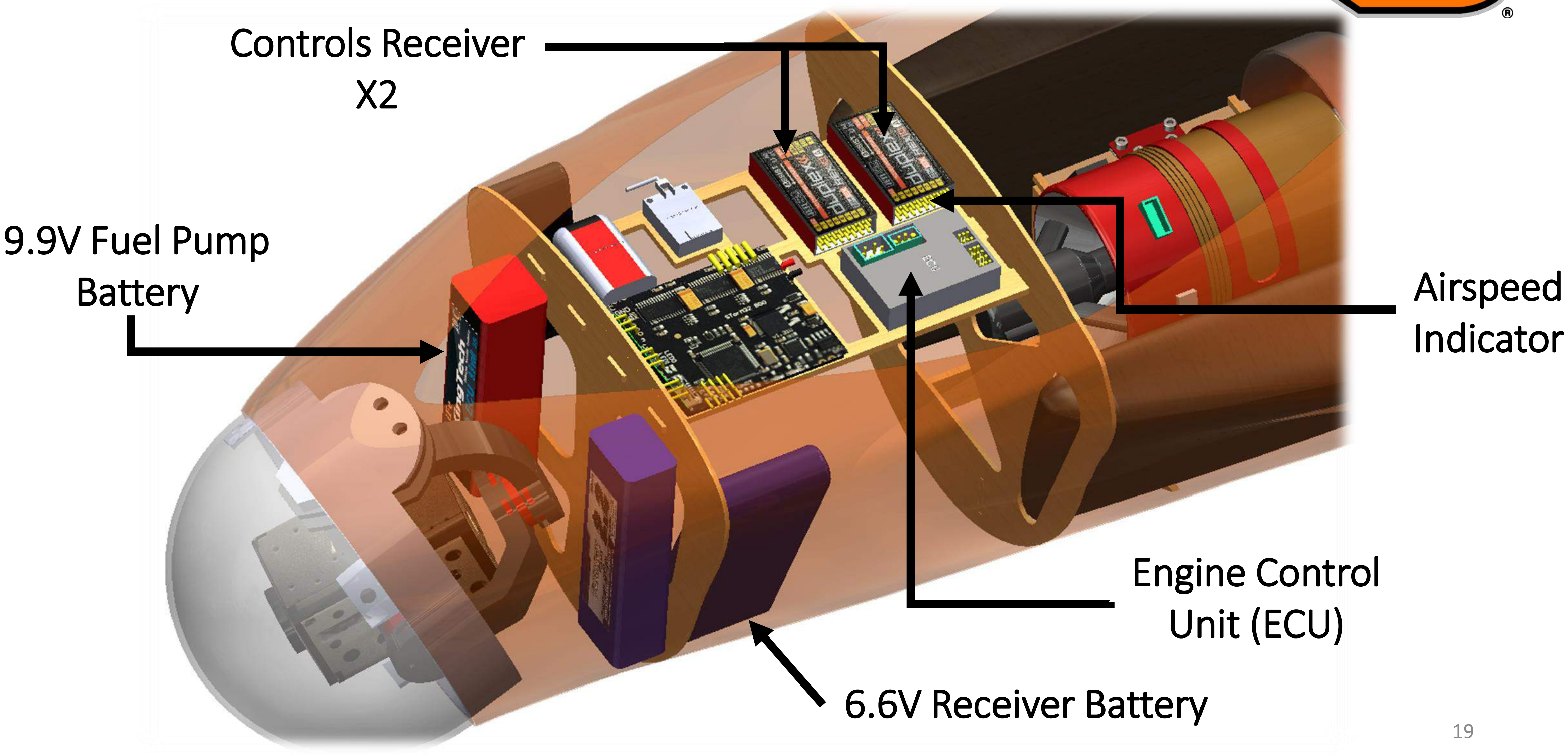
Note: All highlighted sections are 5 ply Aeroply

Total Estimated Bulkhead Weight: 0.37 lbs.

Bulk Heads Materials

- Material: Birch Aircraft Plywood (aero-ply)
- Sizes: 5-ply (0.028lb/in^3) and 3-ply (0.023lb/in^3)
- Light weight and strong for application
- Has been successfully used on previous OSU Speedfest aircraft
- 5 ply used for bulk head/wing attachments and engine mount structure
- 3 ply used for remaining ribs and internal wing structure

Avionics Bay Configuration



Electronics Bay Component Costs

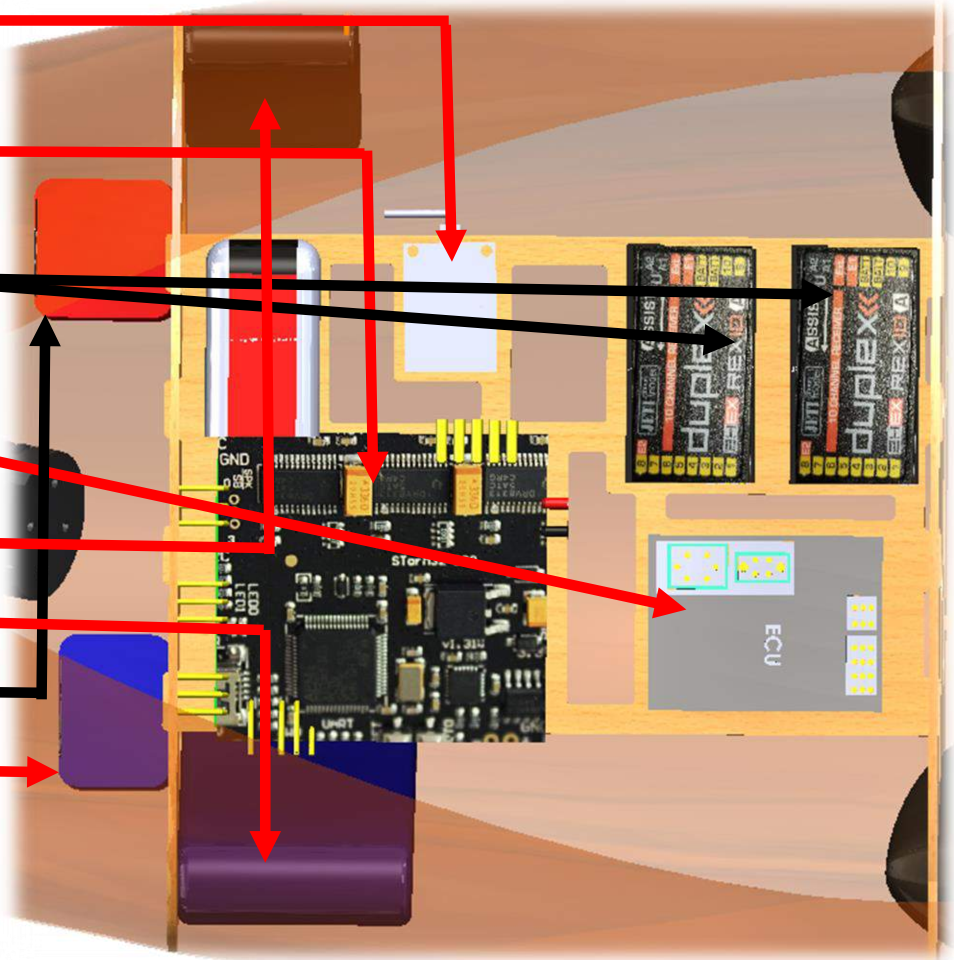
Video Transmitter – Wolfwhoop T86P 5.8gHz $13.00

Brushless Gimbal Controller - Storm 32 BGC $35

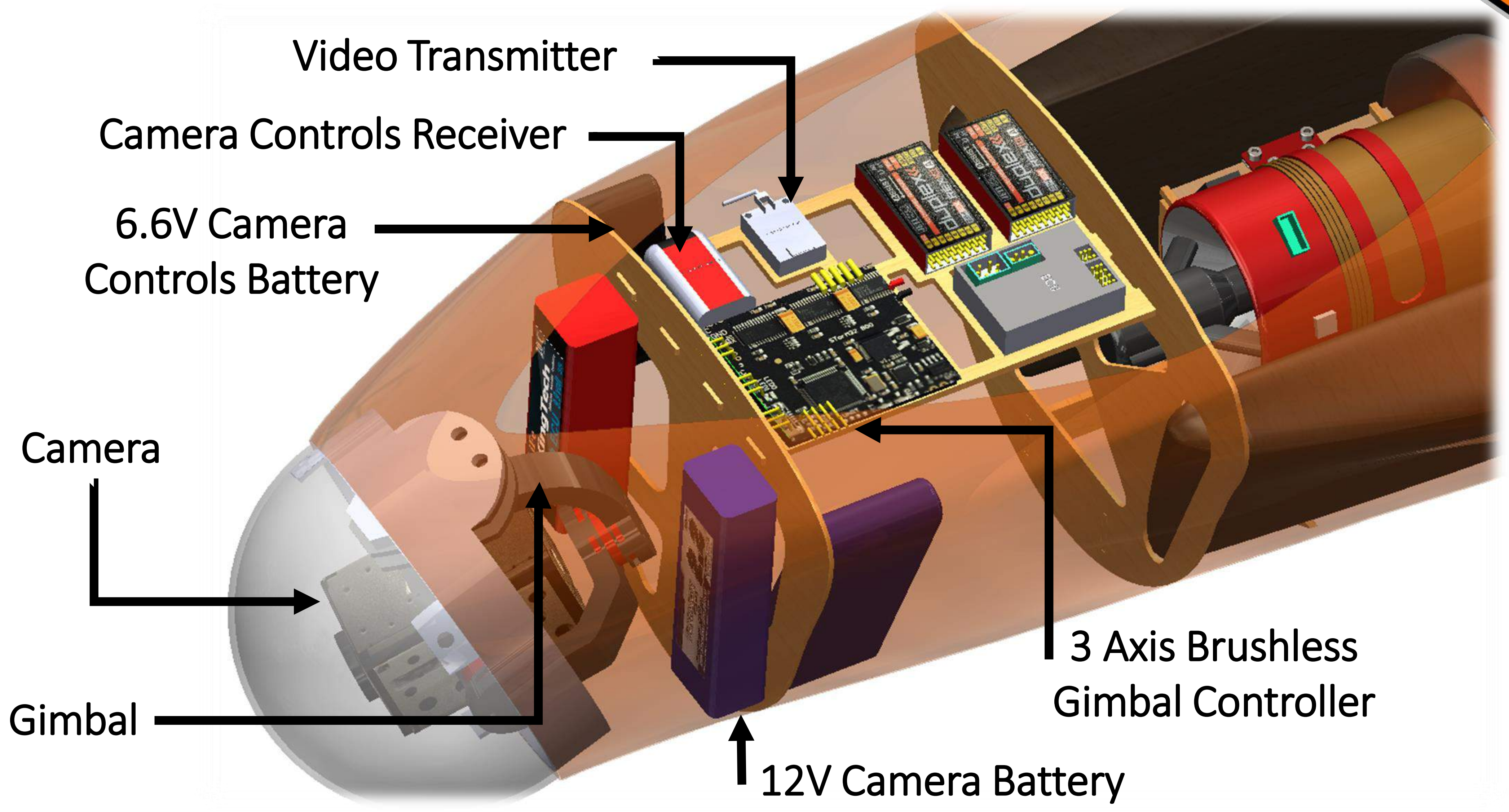
Aircraft Controls Reciever – 2 Jeti Duplex $175 *2

Engine Control Unit – Included in the K70

Batteries – Venom 850mAh 6.6v $24.44
Nano-tech 2000mAh 2S $13.78
Kingtech 2100mAh 9.9v $48
Turnigy 2200mAh 3S Lipo Pack $11

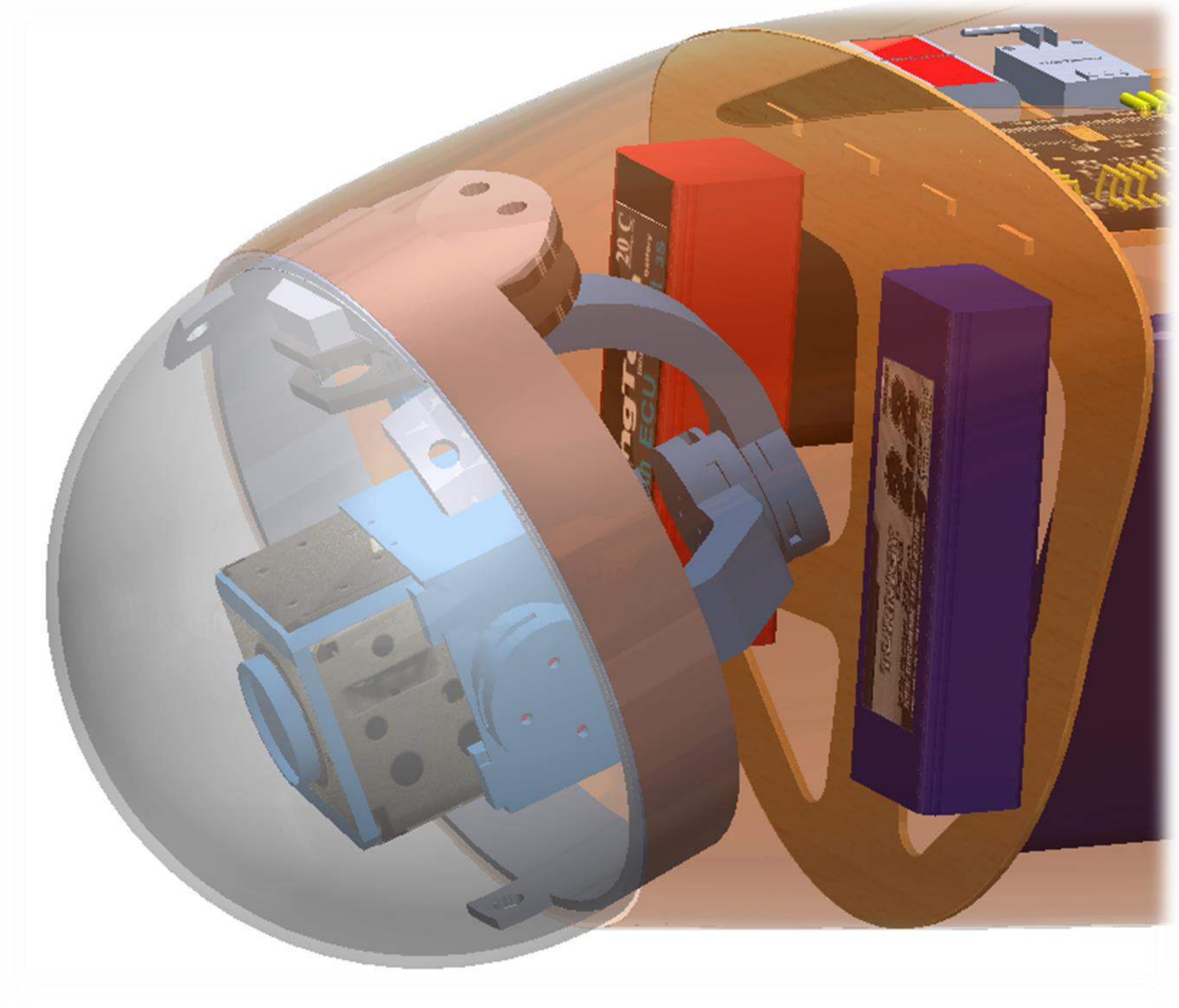


Optics Configuration

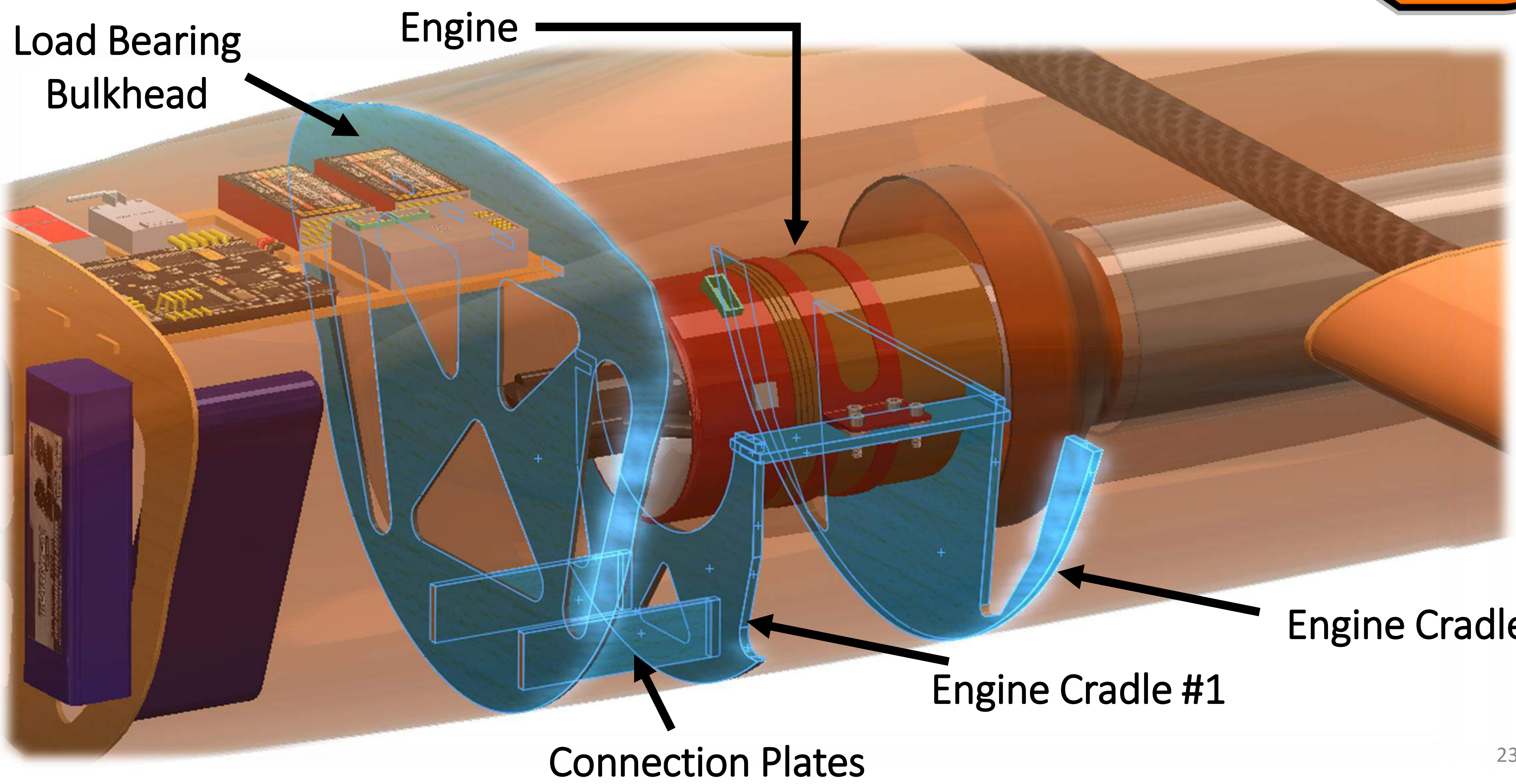


Optics Component Costs

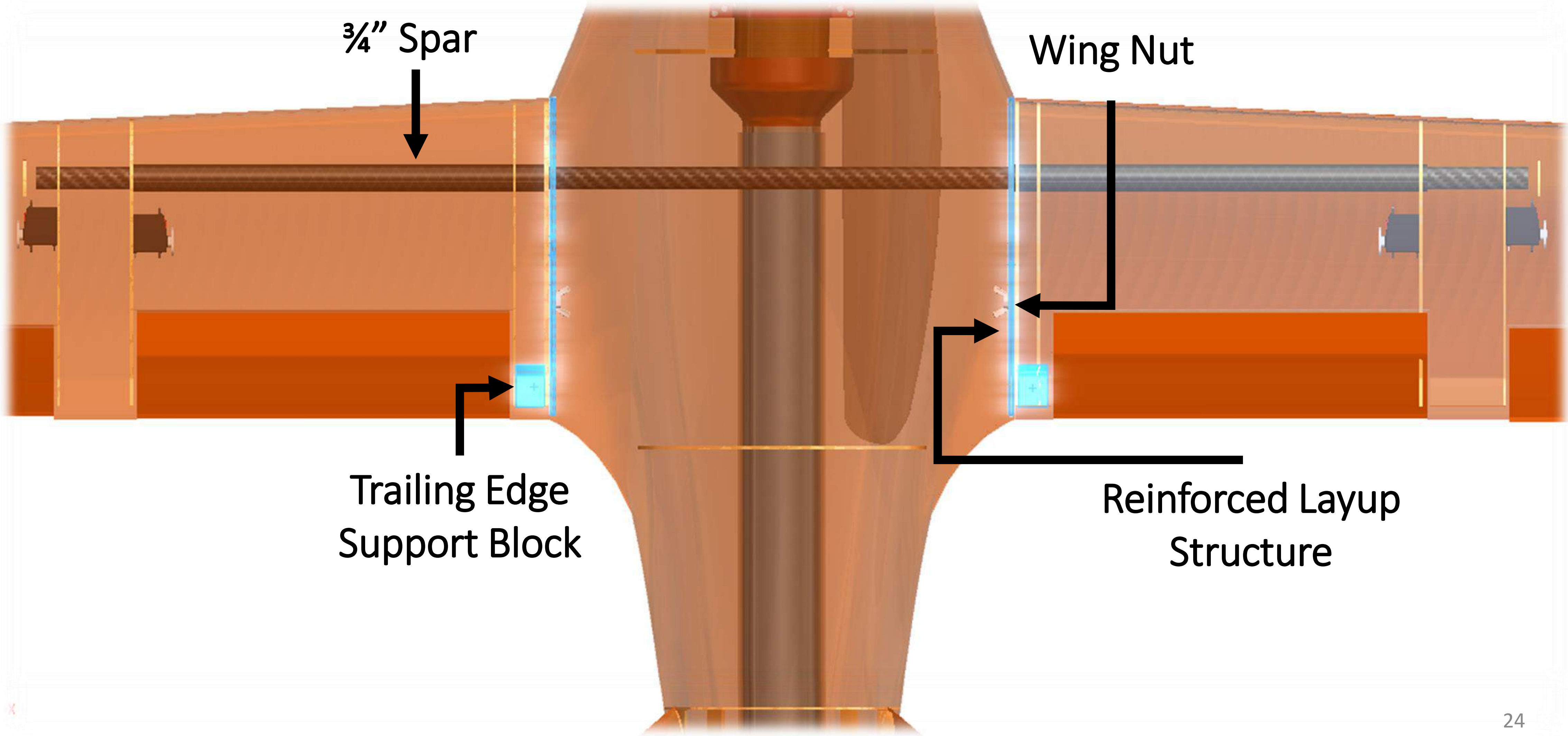
- Camera
  - 17.5° view horizontal
  - 13° view vertical
- Brushless Custom Gimbal
- Two Flight Operators
  - ECO-ABS
- Total Cost: $206



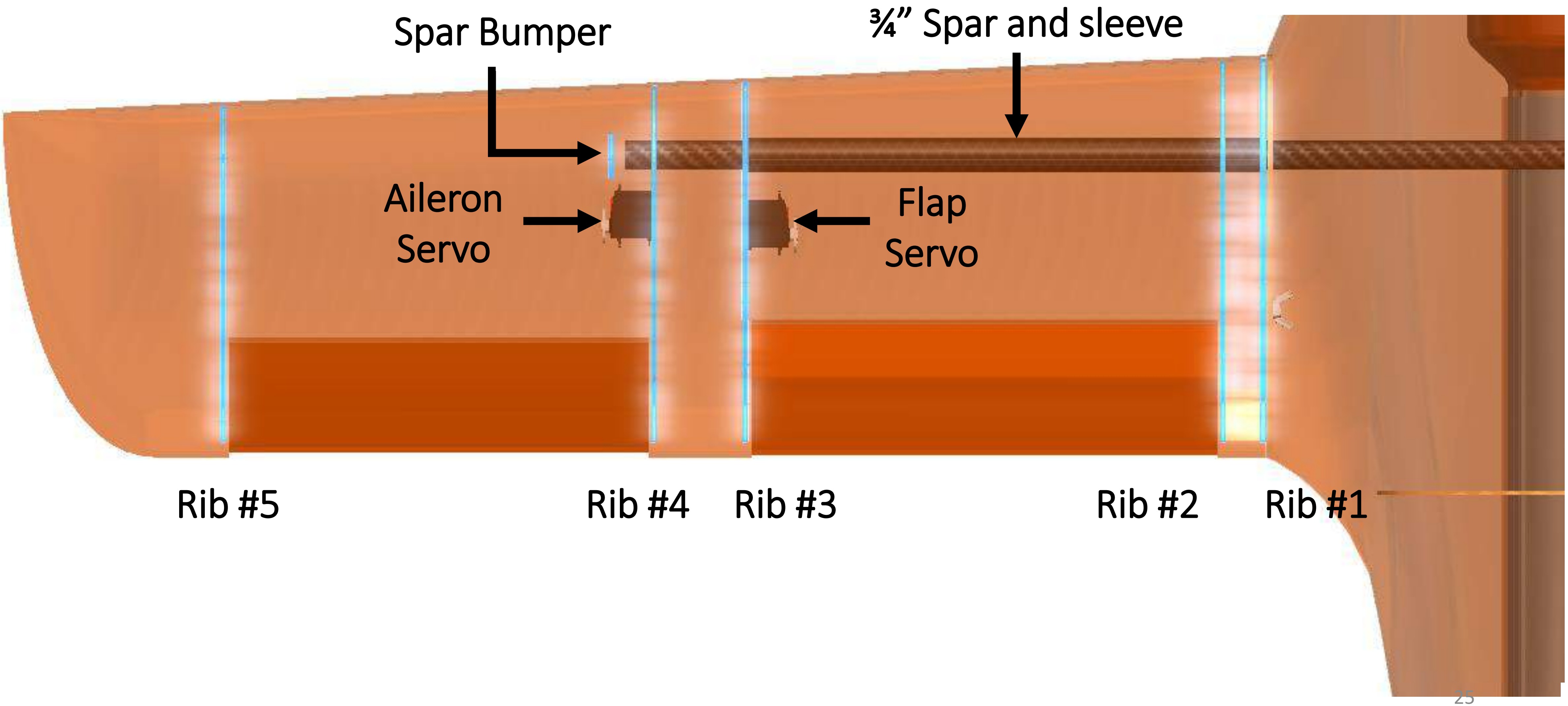
Engine Attachment Configuration



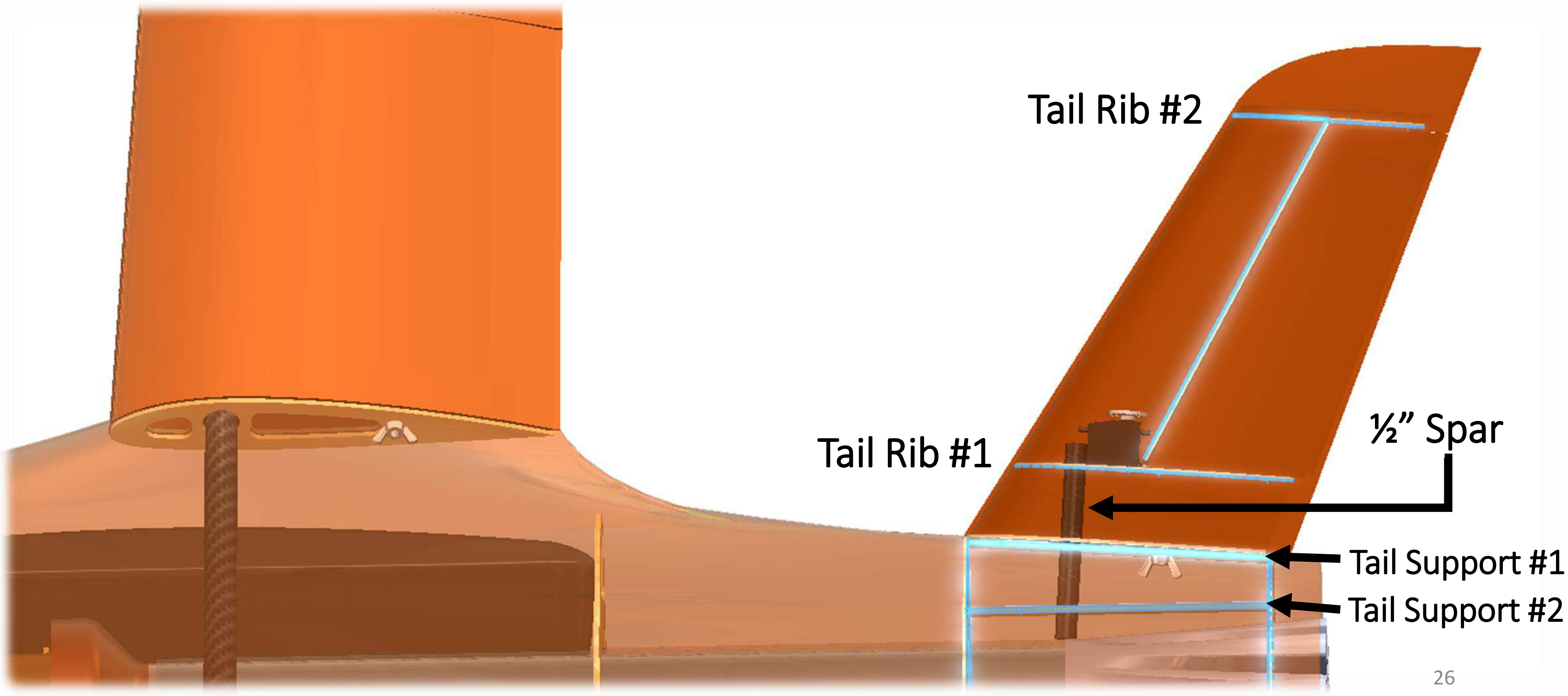
Wing Attachment Configuration



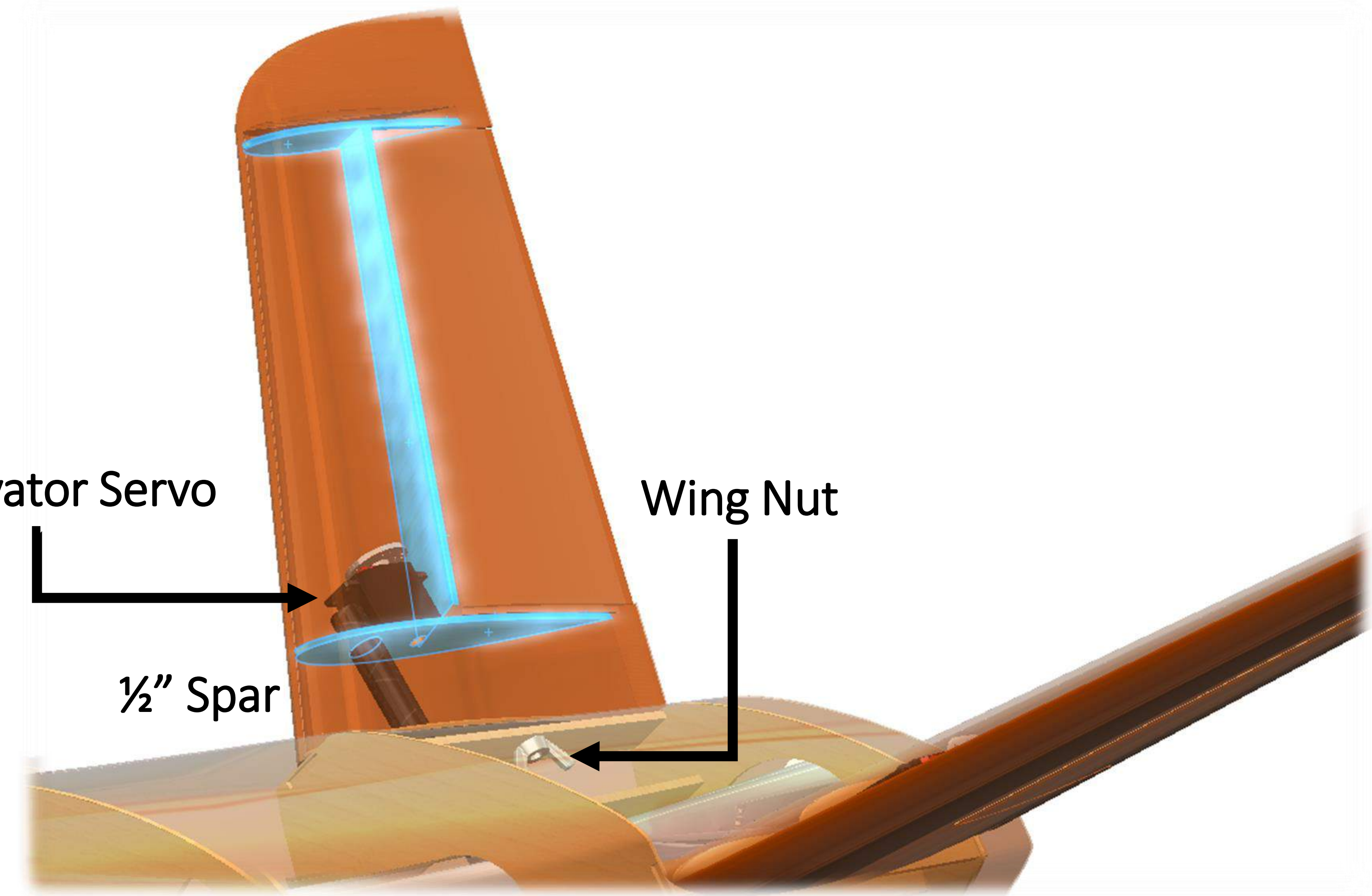
Internal Wing Configuration



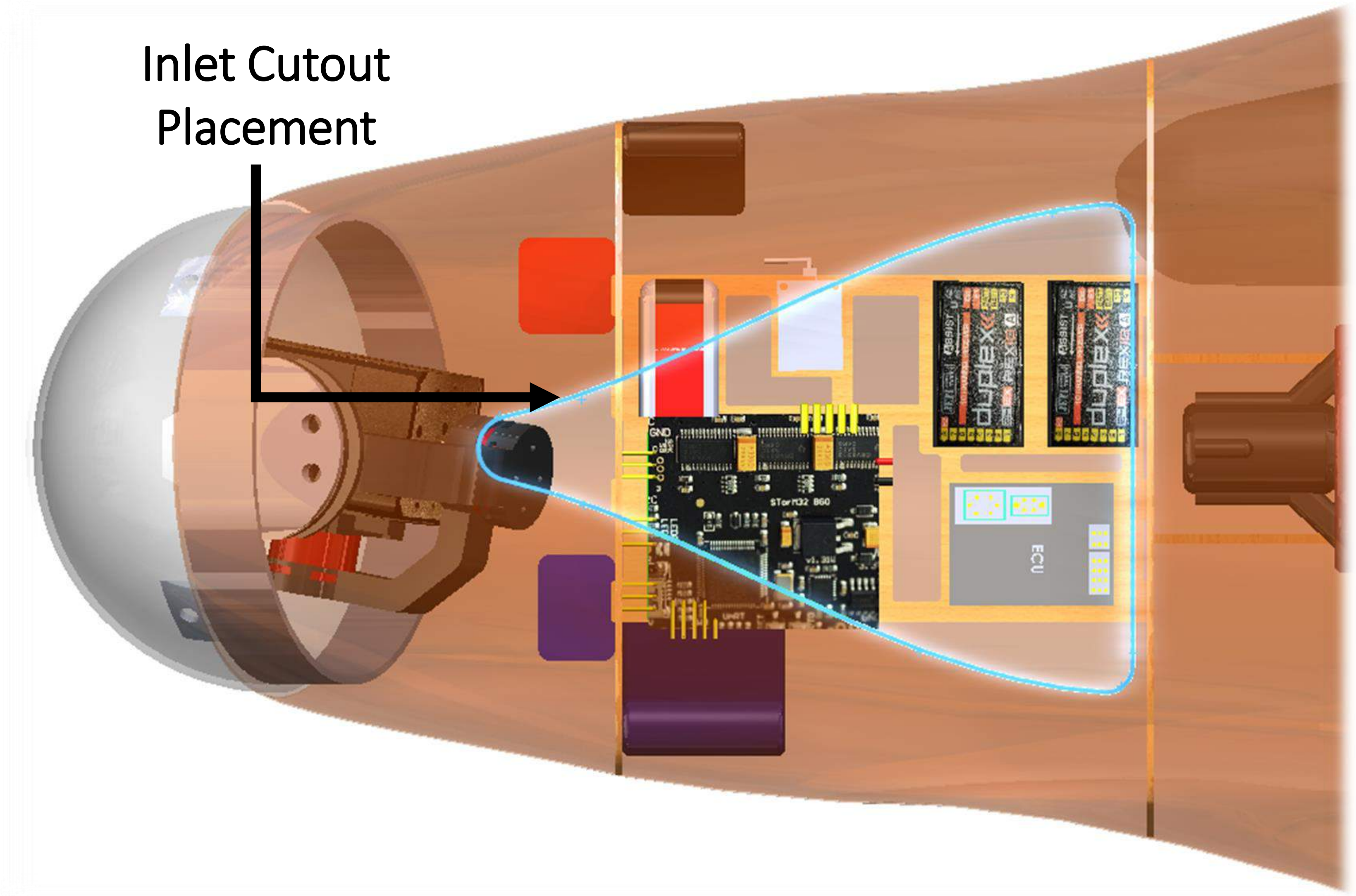
Tail Attachment Configuration



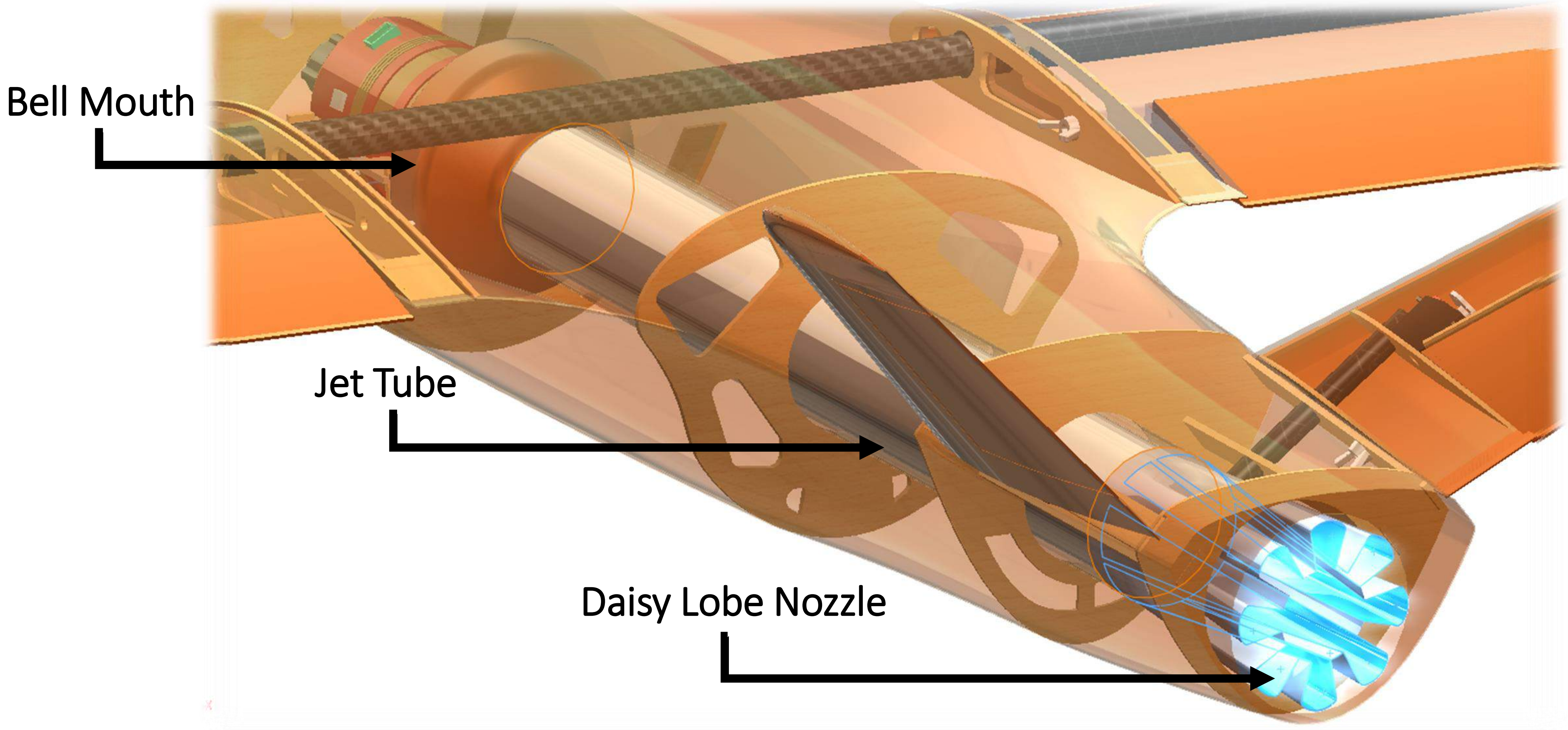
Internal Tail Configuration



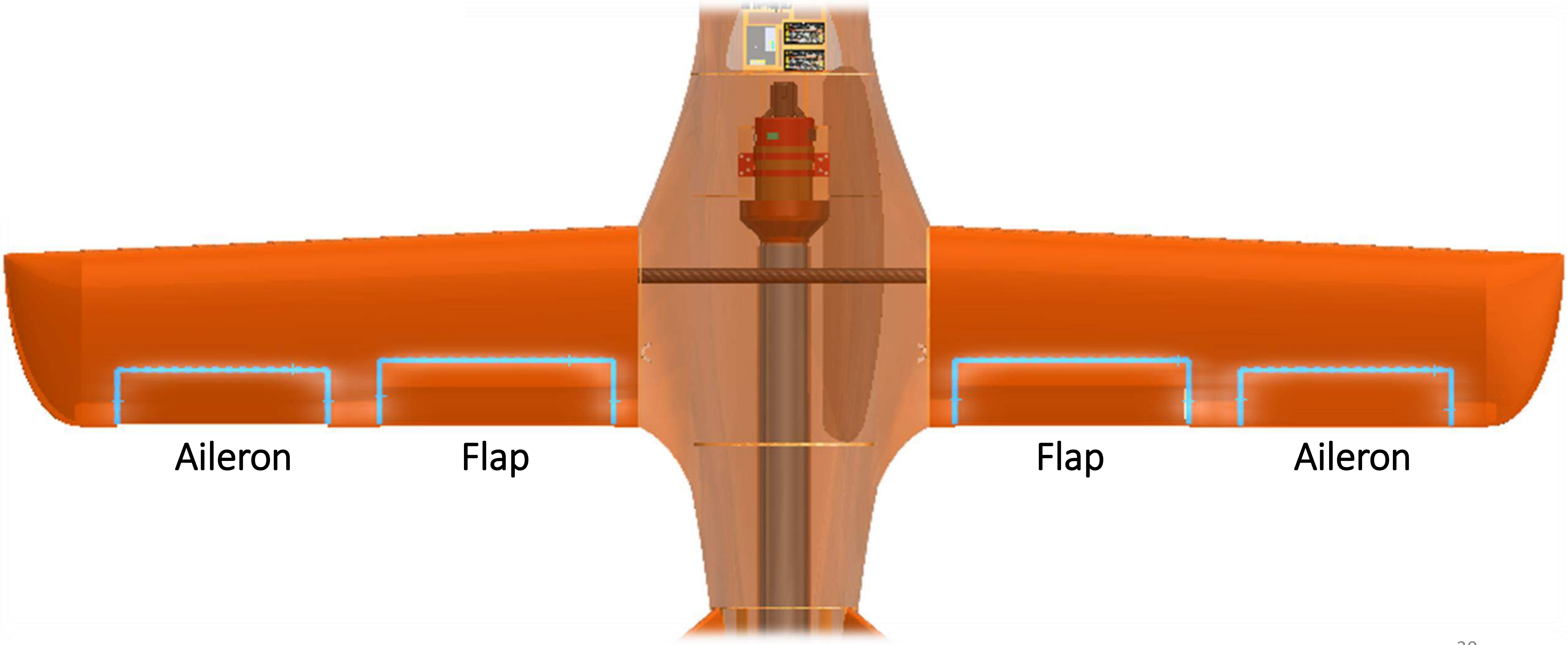
Inlet Integration



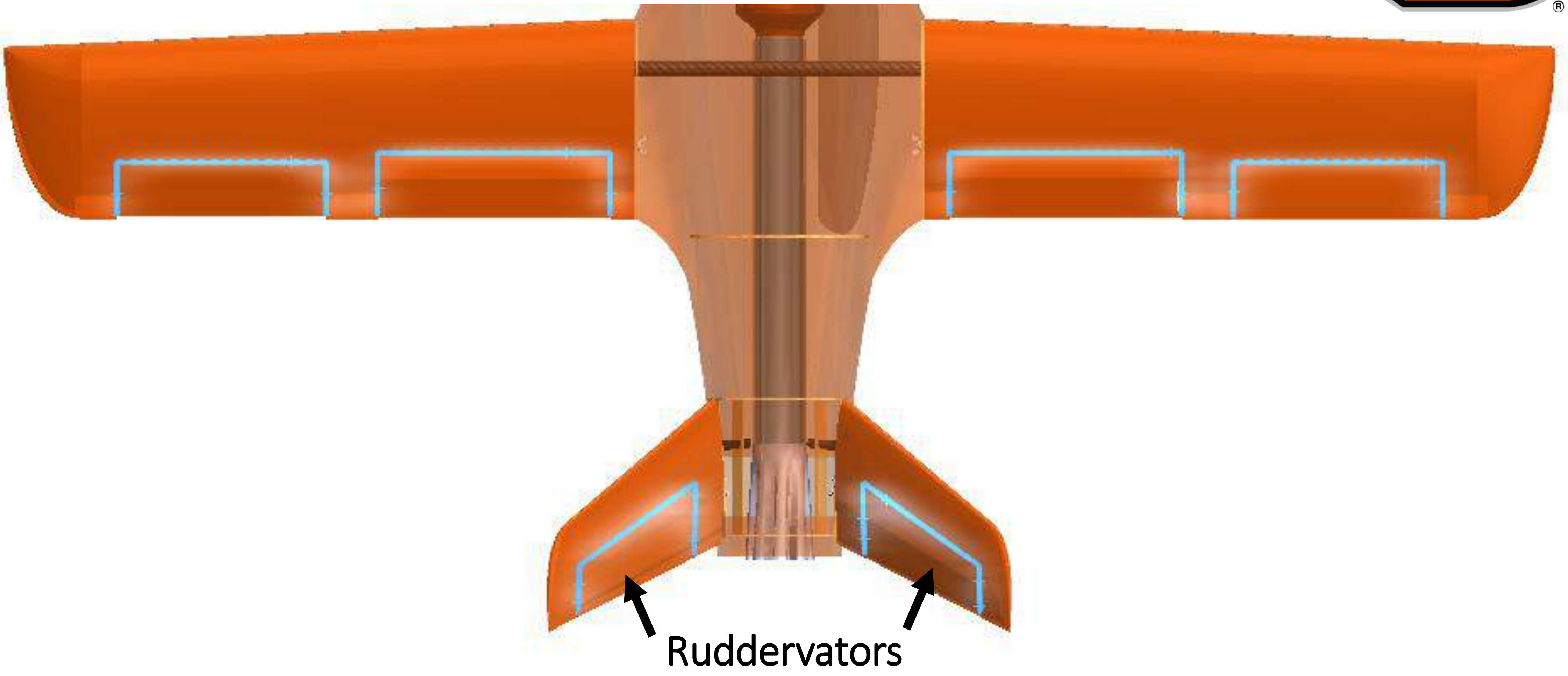
Propulsion Configuration



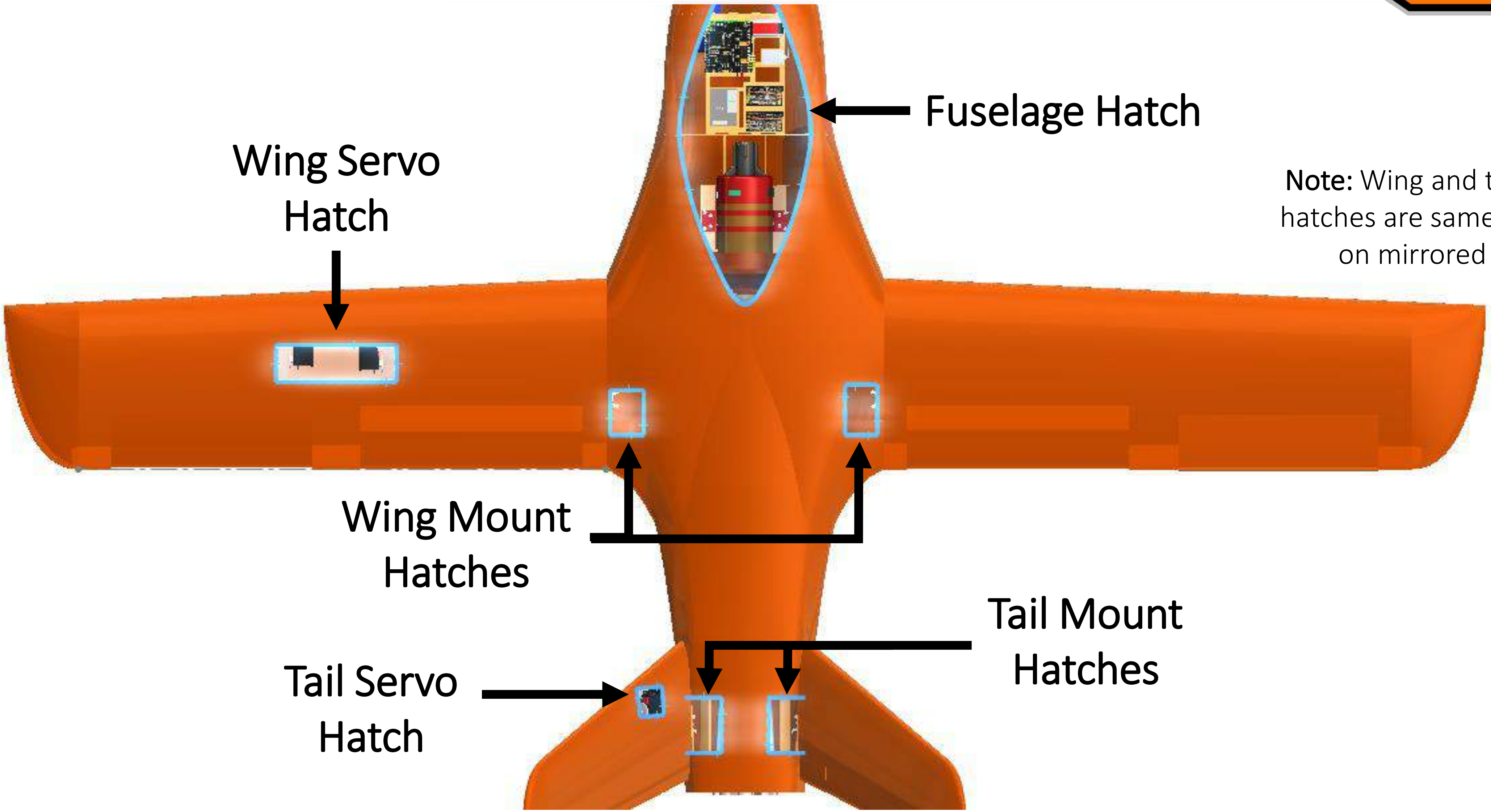
Wing Control Surfaces



Tail Control Surfaces

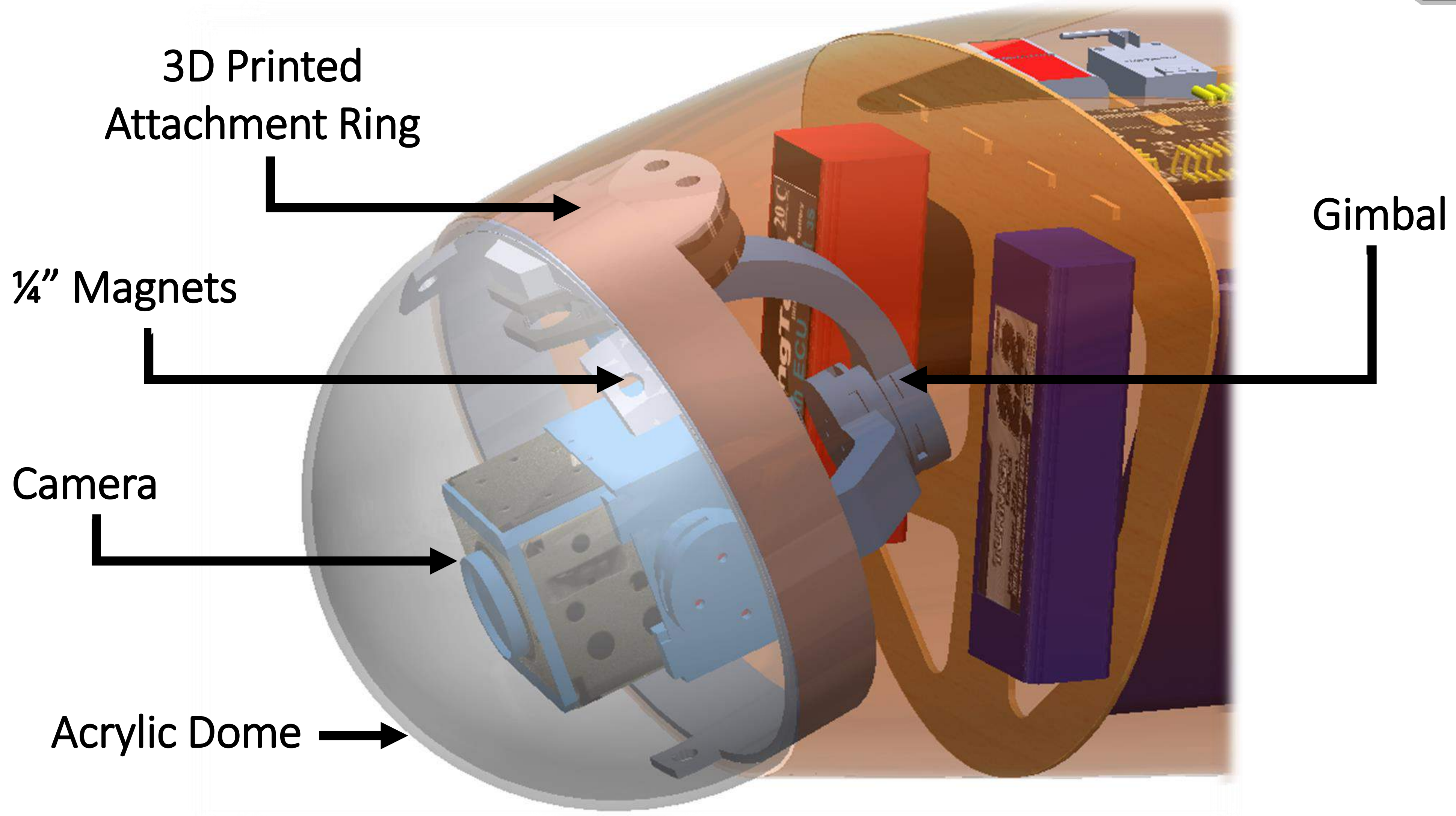


Hatch Integration & Placement



Note: Wing and tail servo hatches are same location on mirrored side

Acrylic Dome Integration



Weight and C.G: Best Case

- No fuel weight
- Weight of aircraft: 10.96 lb
- CG Location: 21.54 in from nose
- **Static margin: 25%**

Weight and C.G: Worst Case

- Full fuel tanks: 6.94 lb of fuel
- Weight of aircraft: 17.9 lb
- CG Location: 22.10 in from nose
- **Static margin: 18.6%**

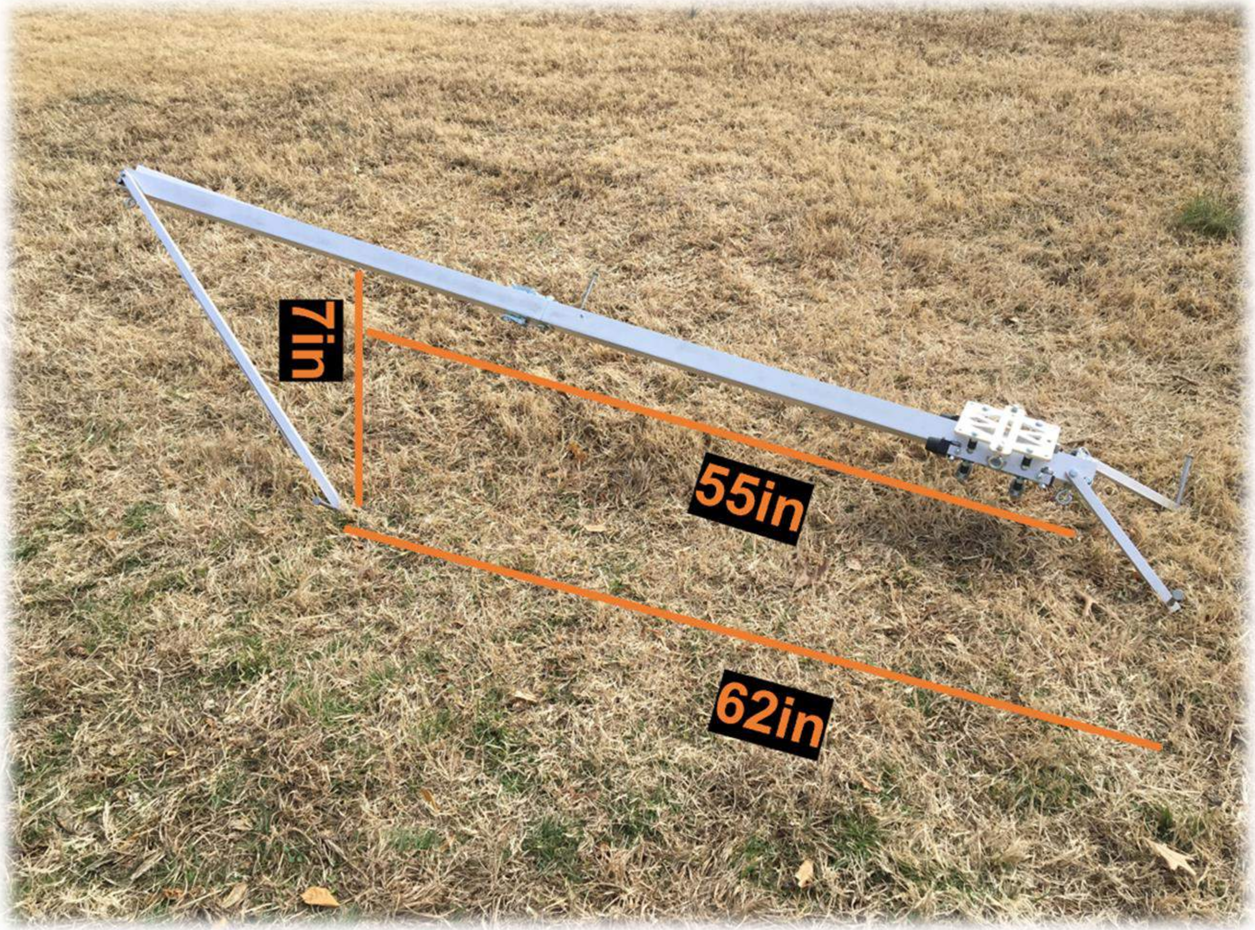
- *Won't need full fuel tanks to complete Speedfest Mission***

Ground Control System

- Skylark Outdoor Highlight FPV Ground Station
- 1000cd/m2 10.4 inch Monitor
- Live video feed
- Mini Joystick will be added to control Gimbal System
- Potentiometer will be added to control camera zoom

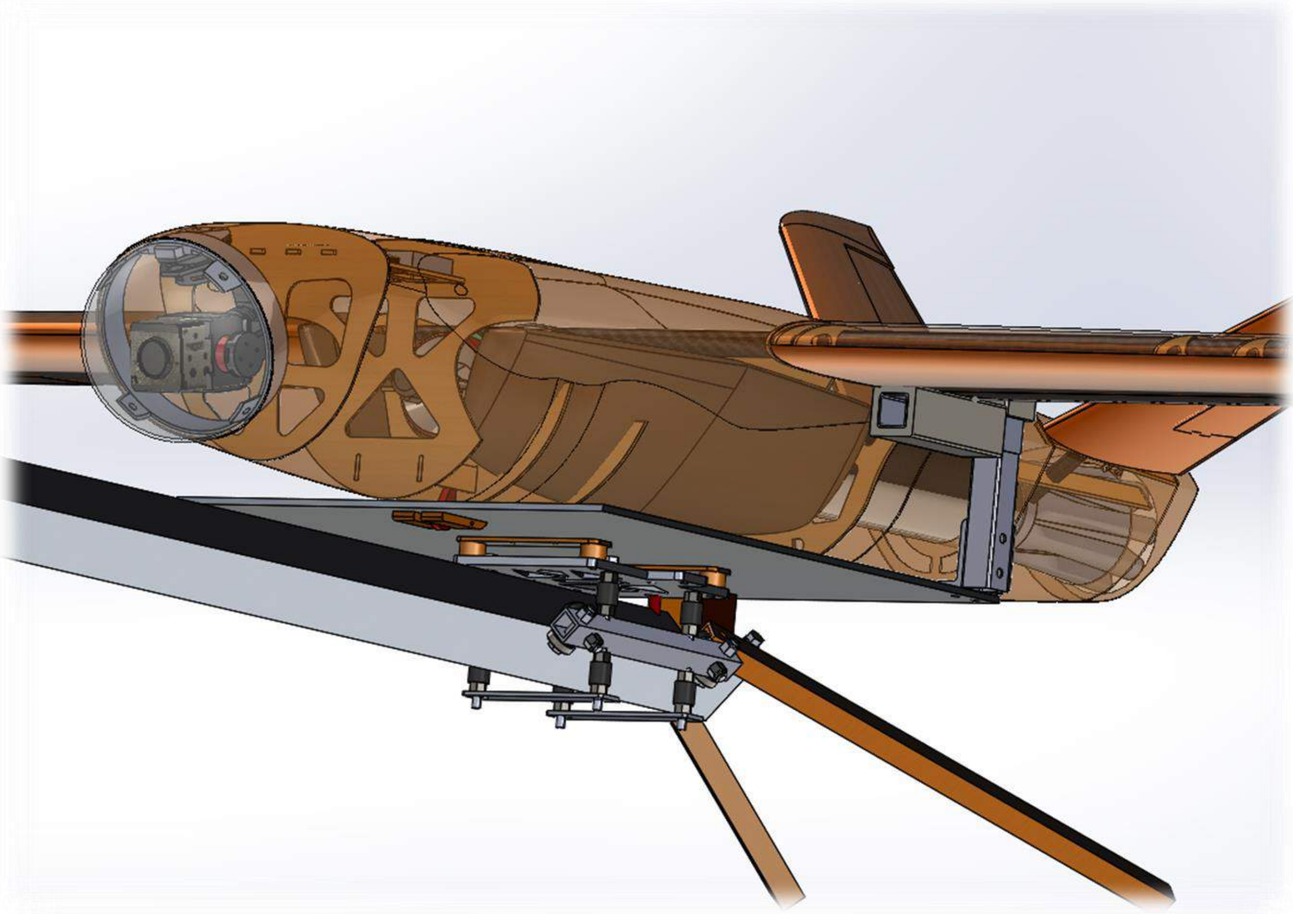
Launching Strategy

- Configured Launch Mechanism
  - 8 foot launcher
  - Legs staked inside required launching area, 6ftx6ft (@ 62 in)
  - 12° launch angle
  - $898.00 Total
    - $225.00 per aircraft



Launching Mechanism Design

- Launch force applied along wing root
- Holding pin implemented in front of C.G. on engine bulkhead
- Foam-filled cutout to store holding pin
  - Reshapes to prevent whistling after pin is released
- Further testing to ensure safety of tail
- Rotating pushers possible



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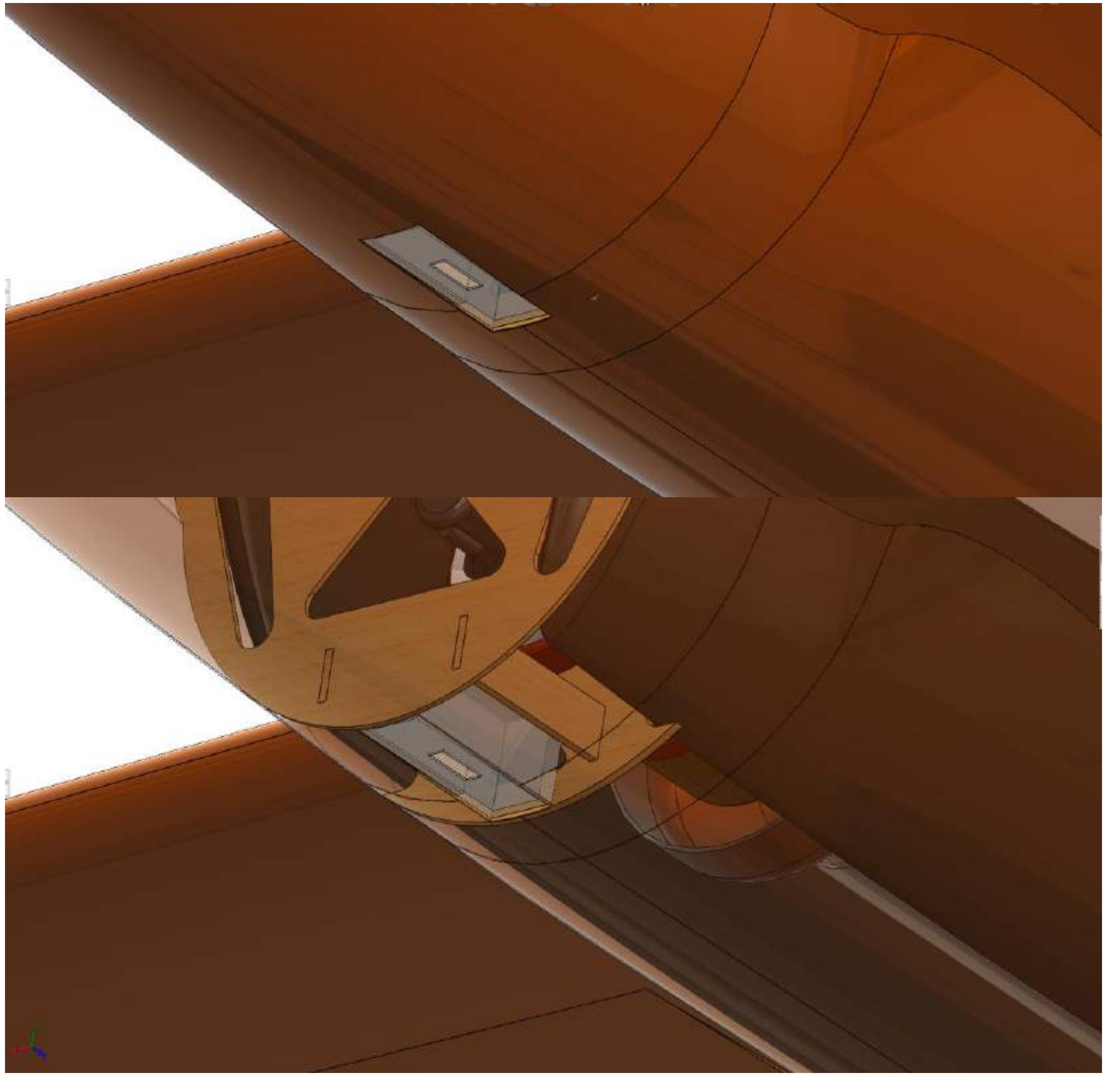
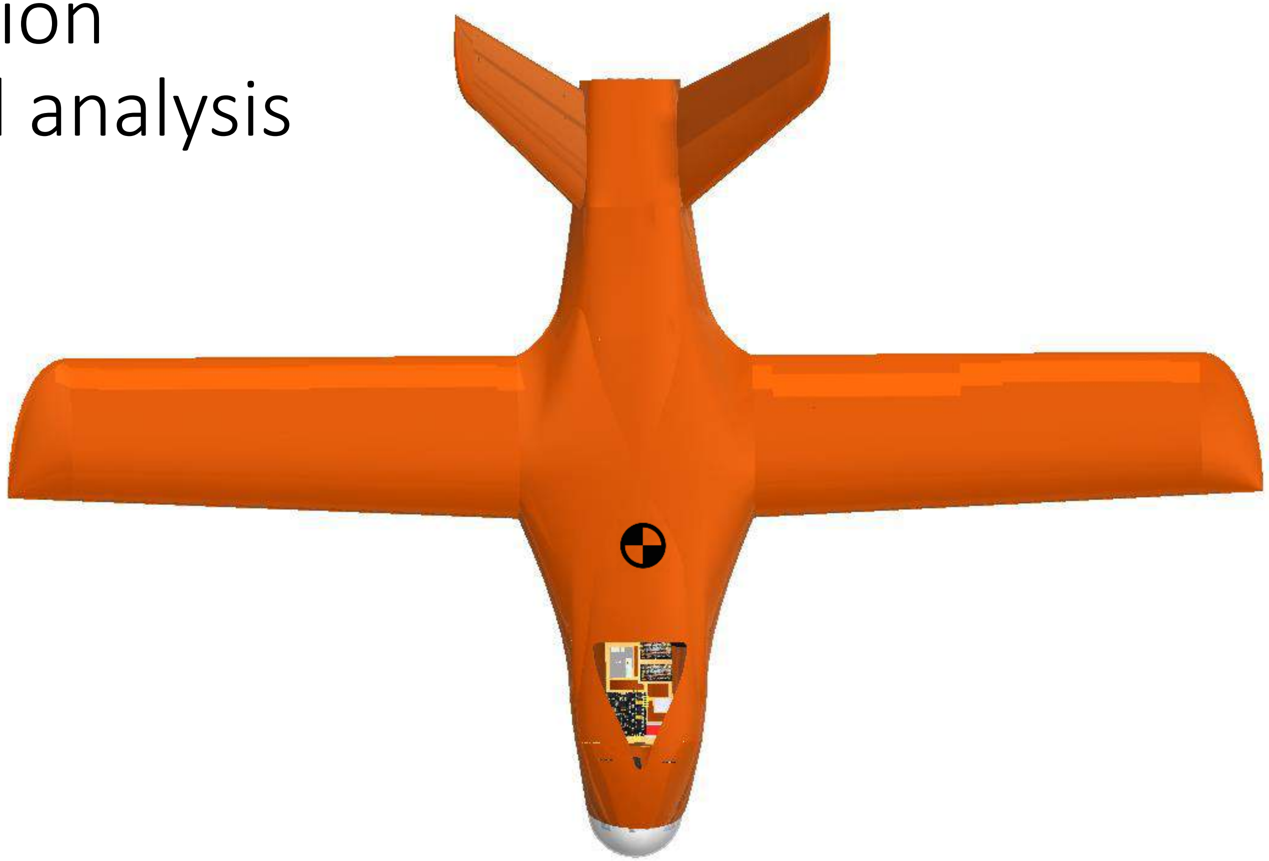


AERODYNAMICS

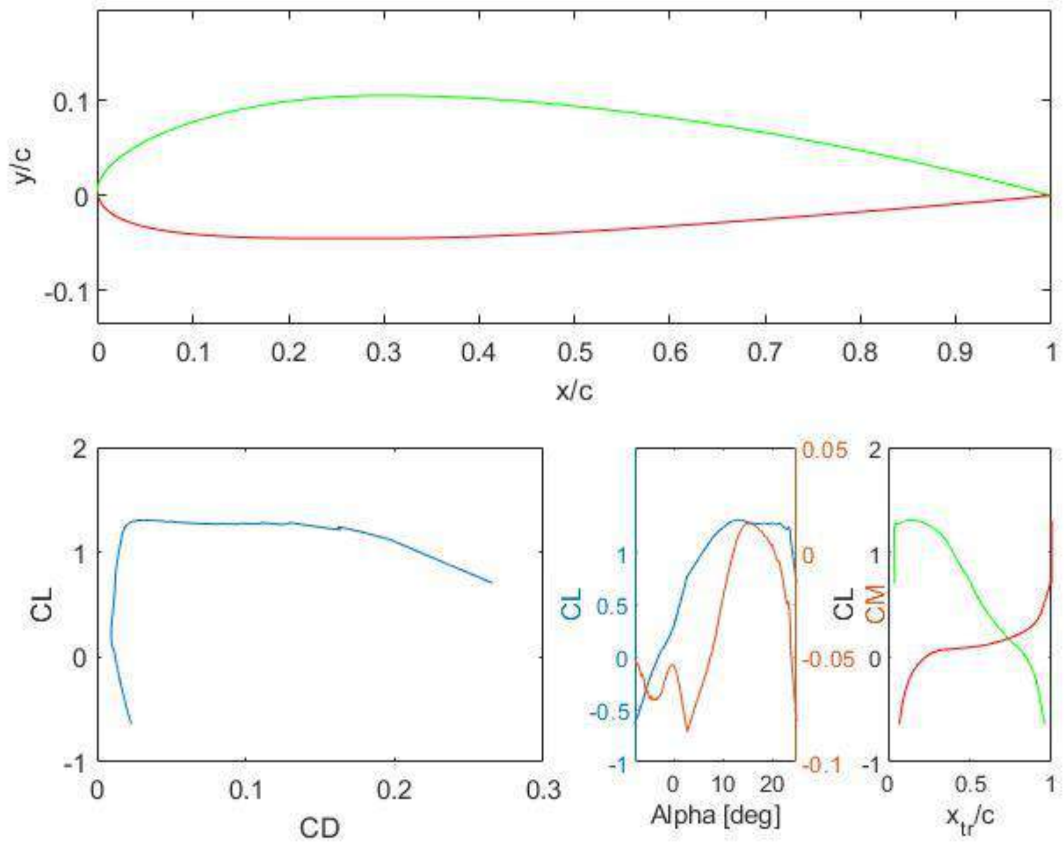
Tasks Accomplished Since PMR

- Airfoil analysis and selection
- Wing Planform sizing and analysis
- Static Stability Analysis
- Tail Sizing
  - V-tail tail volume
  - Control surfaces
- Fuselage analysis



Airfoil Analysis

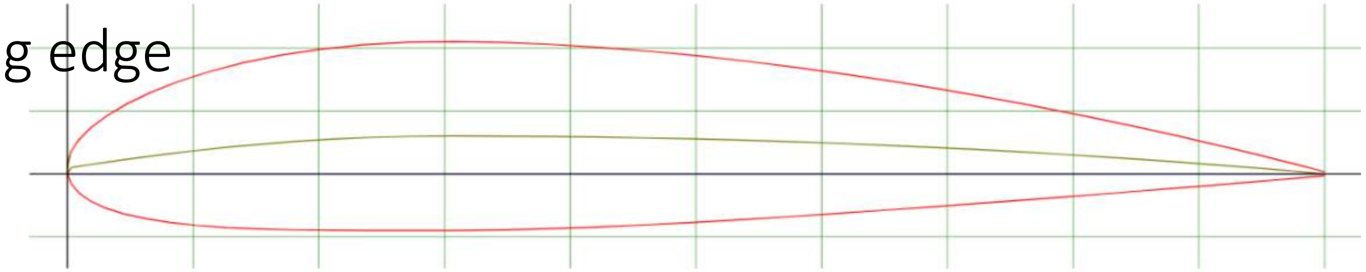
- Analysis tool: MatLab & XFLR5
- Potential airfoil pool:
  - CLARK Y
  - SD 7032
  - NACA 3315
  - SD 7062
  - NACA 4415



NACA 3315 Plots from Matlab-Xfoil Interface

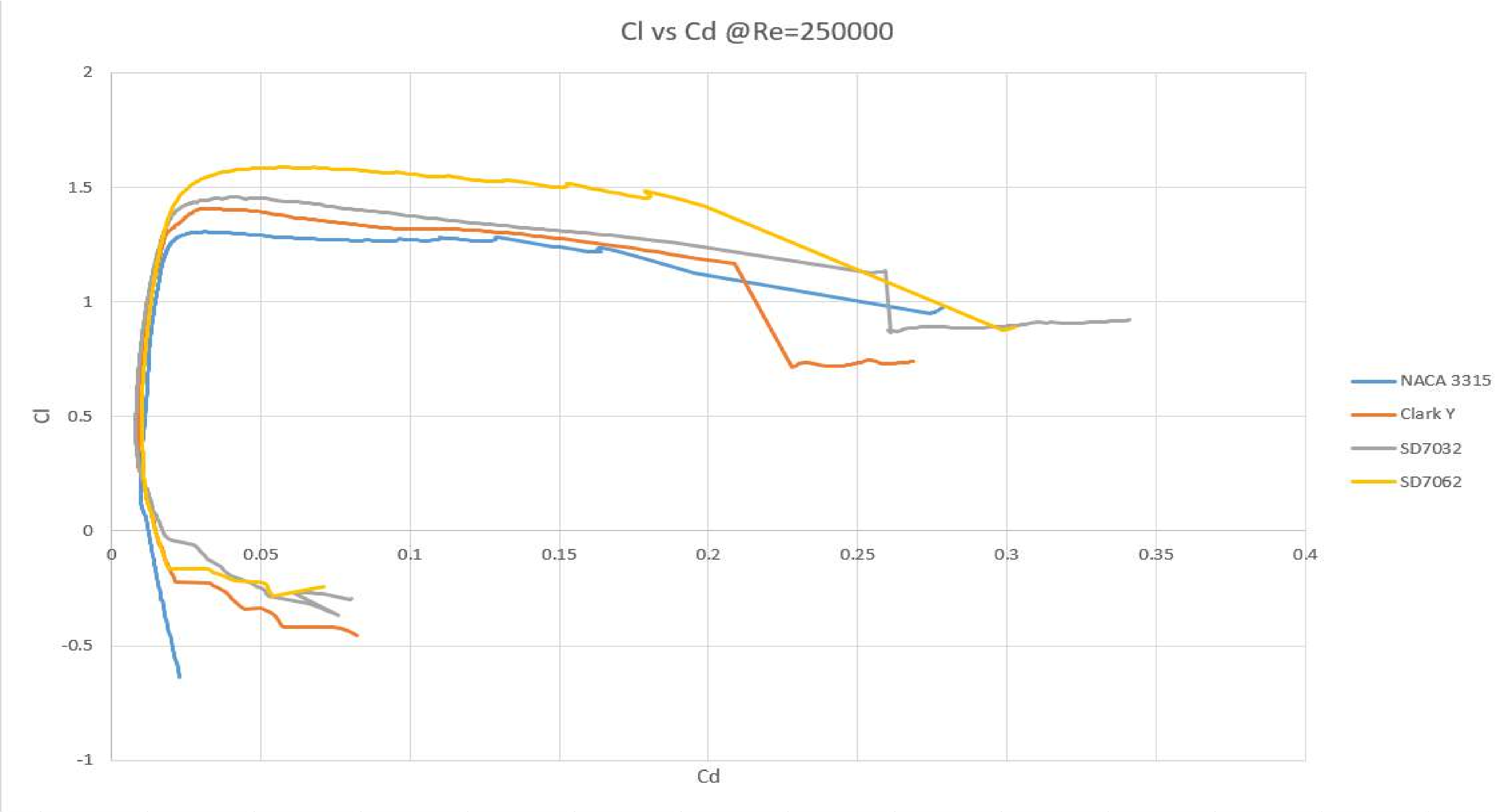
Airfoil Selection

- Wing Selection: NACA 3315
  - SD 7032 & SD 7062: sharp trailing edge
  - CLARK Y: lower Cl at 0 AOA
  - NACA 4415 has higher drag



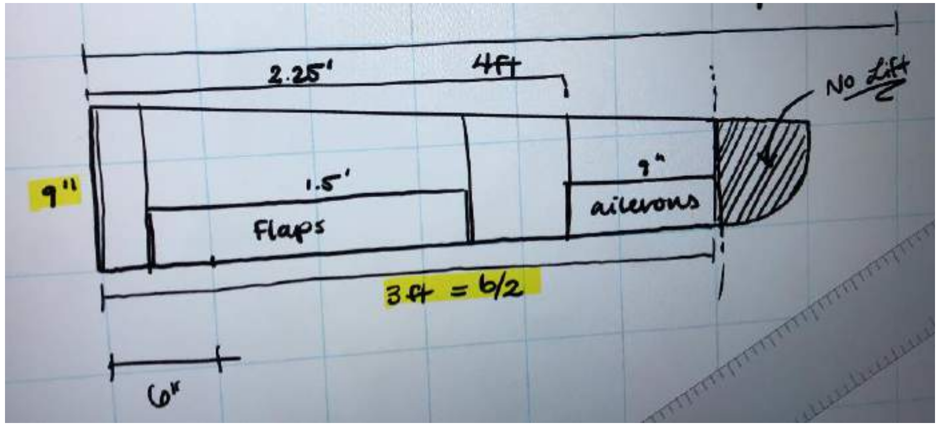
- Tail Selection: NACA 0015
  - Needed symmetric airfoil w/ servo room

C_l v C_d Comparison

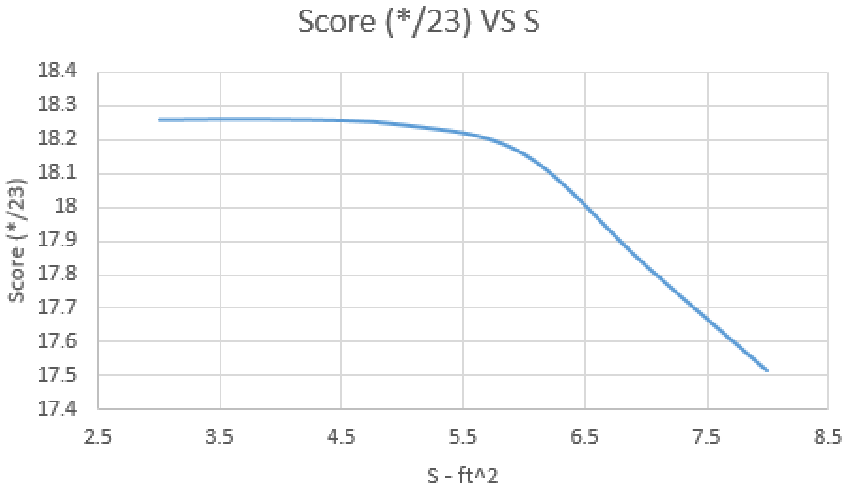


Wing Planform Design

Planform Iteration Start



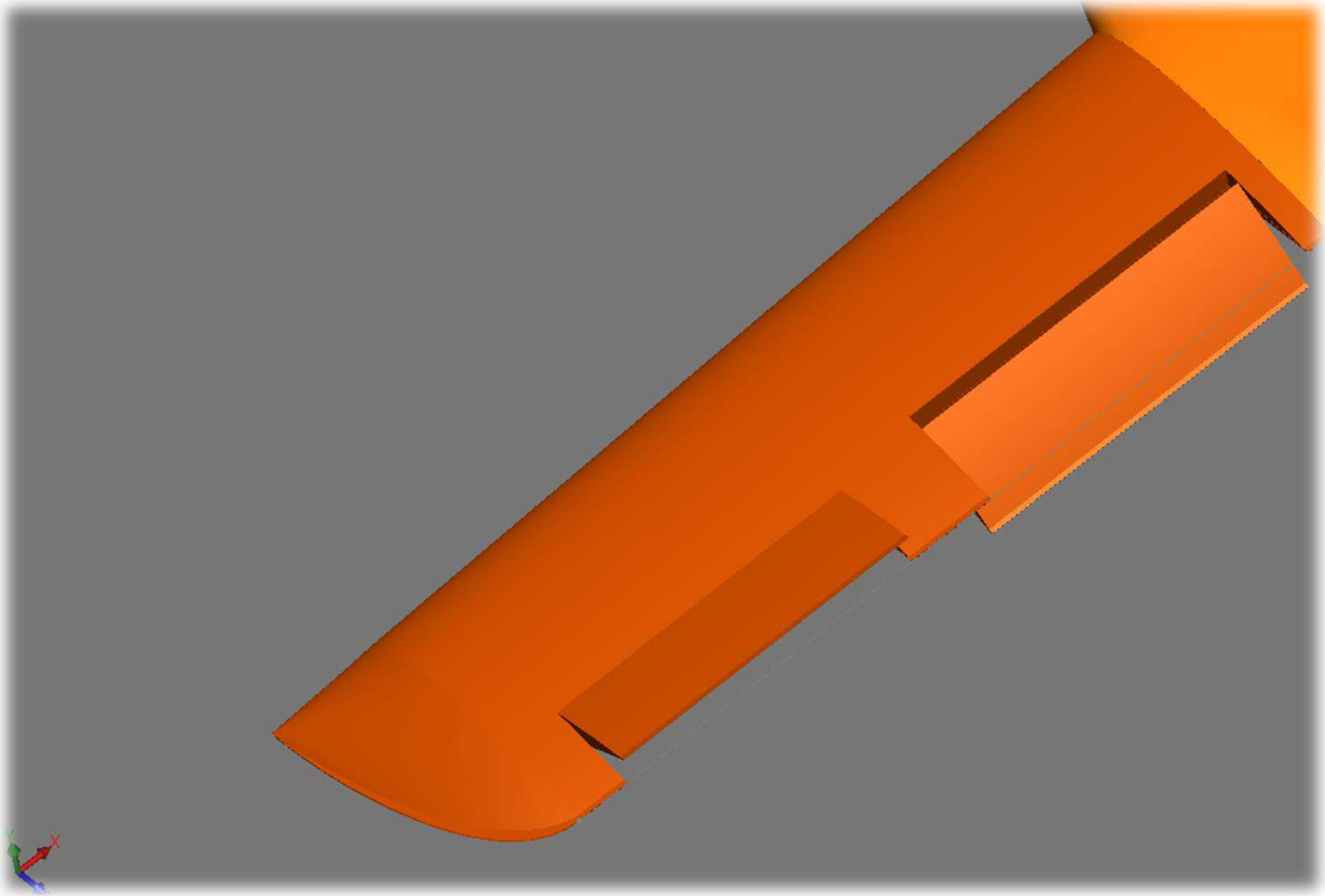
Score Trade-off



- Goals:
  - Keep AR <= 8
  - Estimate score with different wing area
  - Result: S = 5 ft^2, b = 6 ft, MAC = 10 in, λ= 9/11

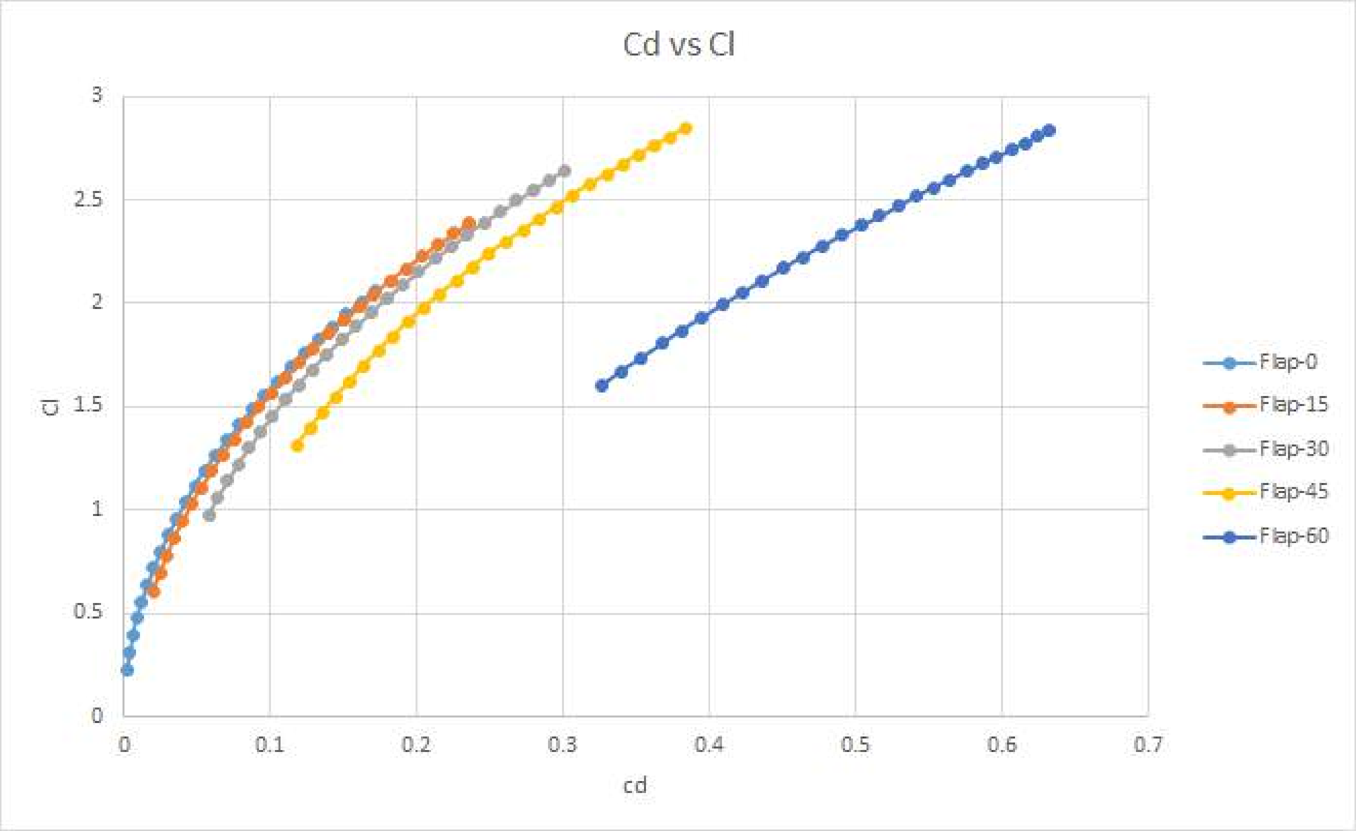
Wing Planform Design

- Results:
  - S = 5 ft^2
  - b= 6 ft
  - MAC = 10 in
  - λ= 9/11

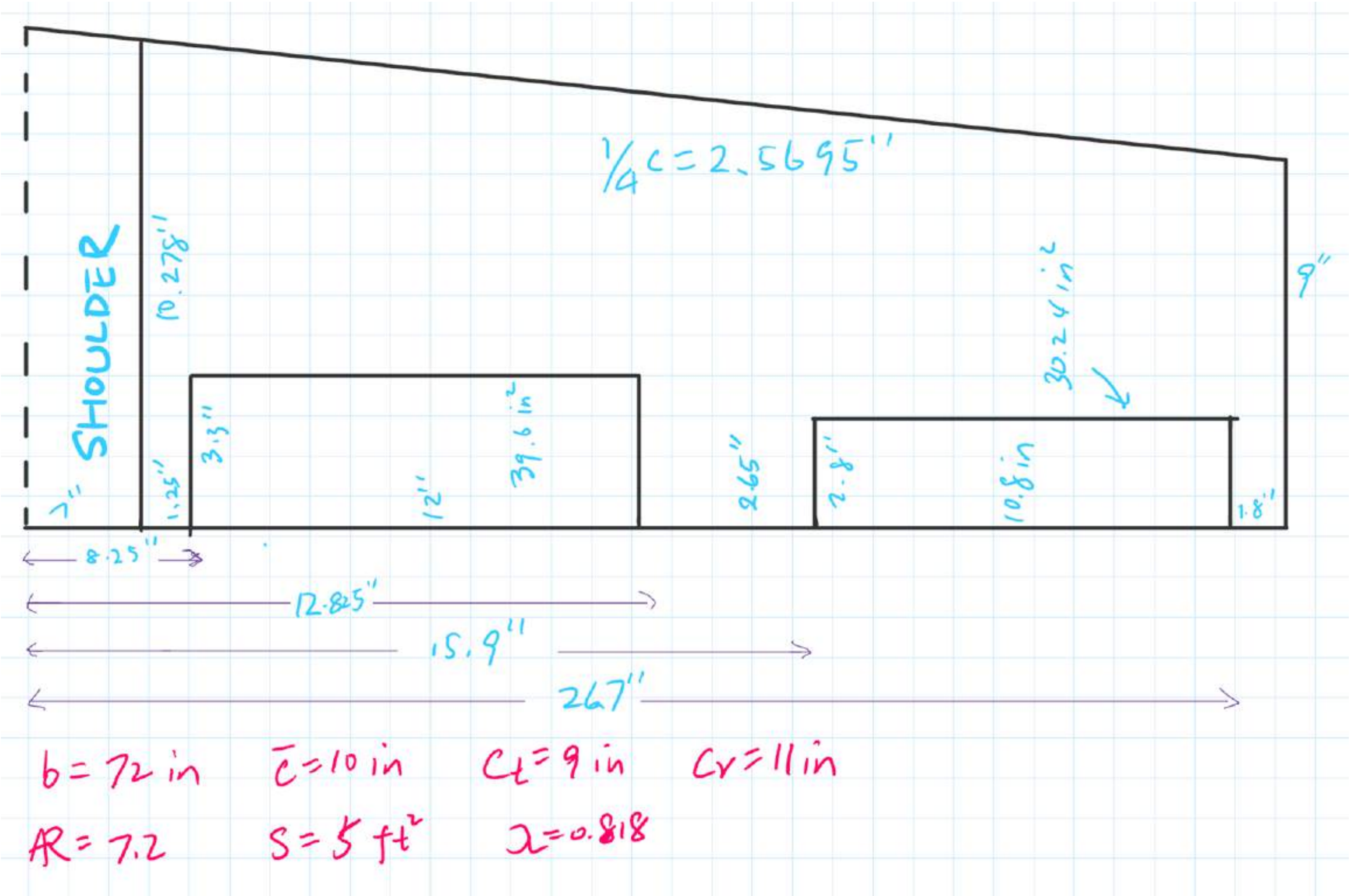


Aileron and Flap Sizing

- Conventional benchmark aileron location, 65%-95% span location
- Adequate roll control @ stall velocity (47 ft/s)
  - Flaps based on benchmarking, verified by XFLR5

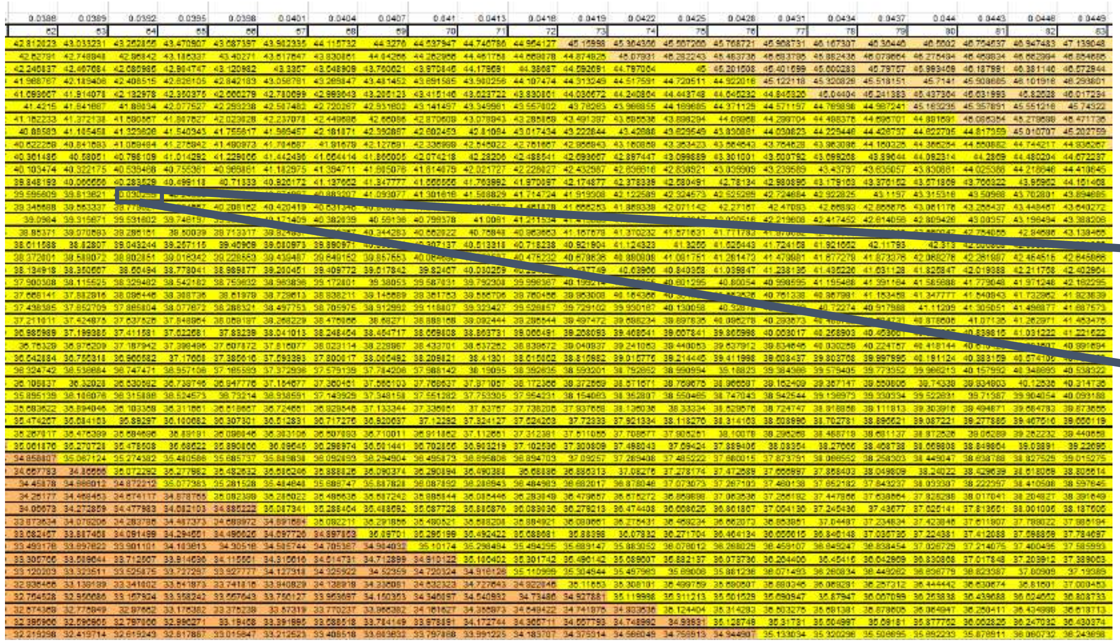


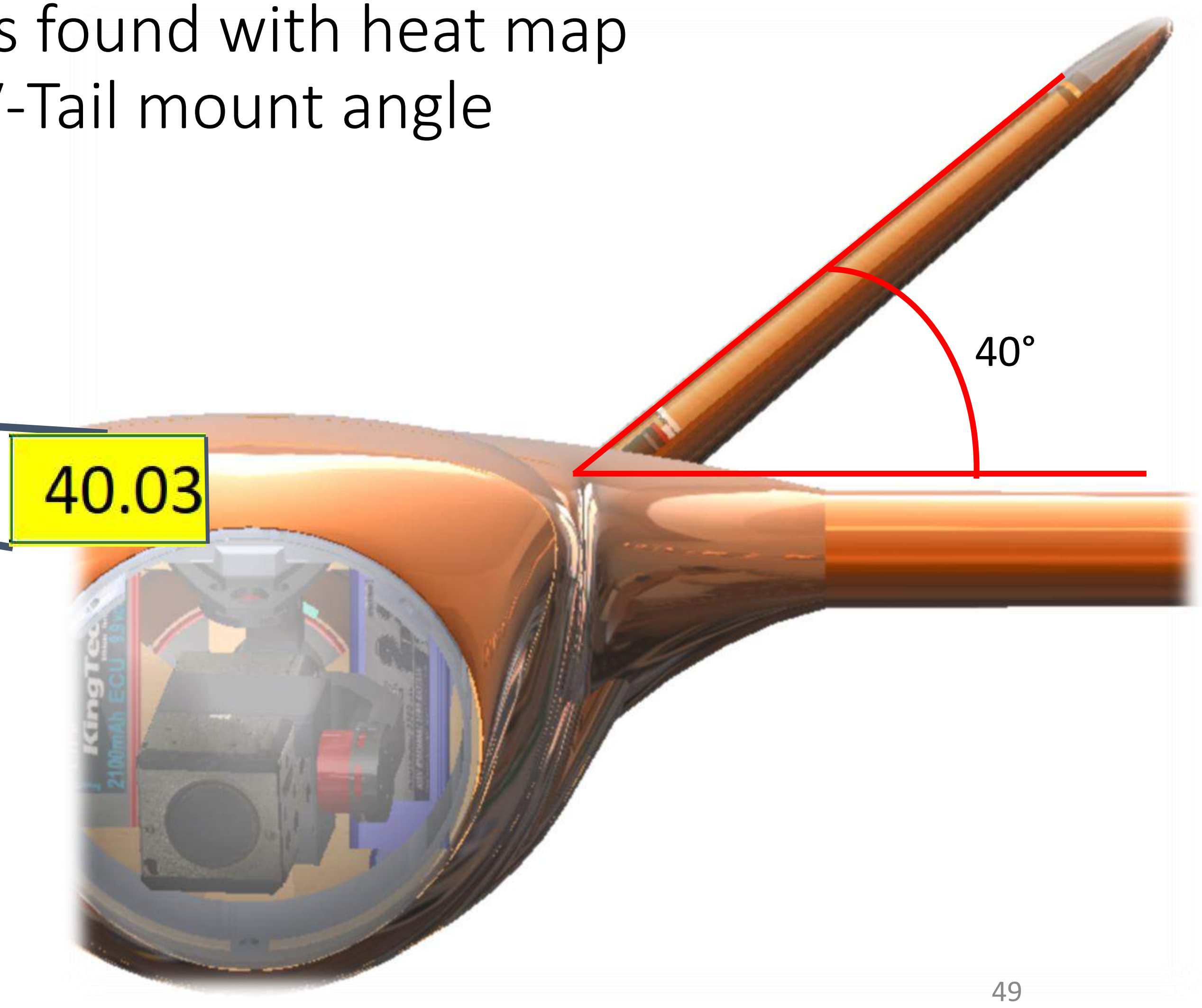
Final Wing Planform



Tail Volume

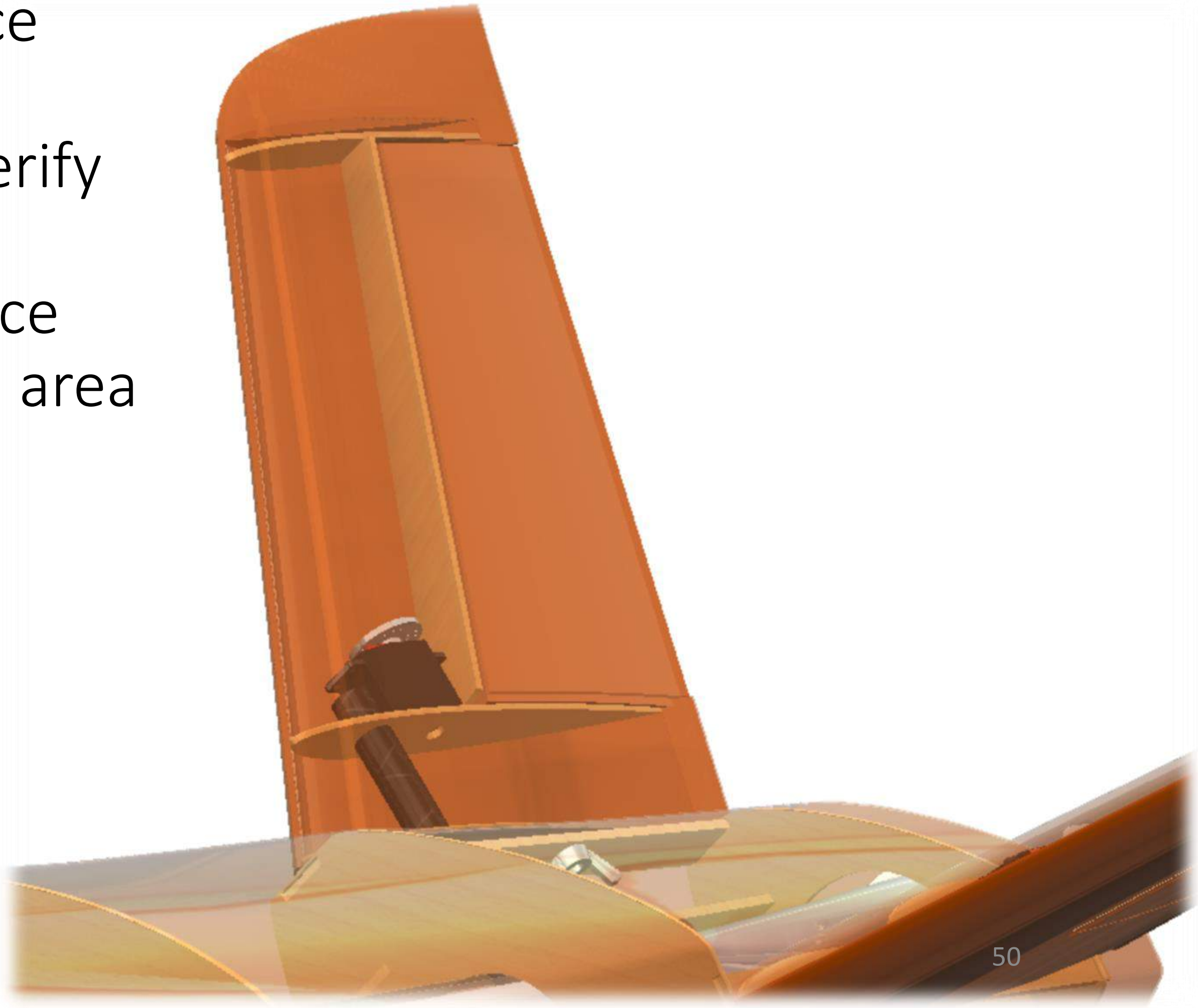
- Range of acceptable V-Tail angles found with heat map
- Tail Volume code gives optimal V-Tail mount angle



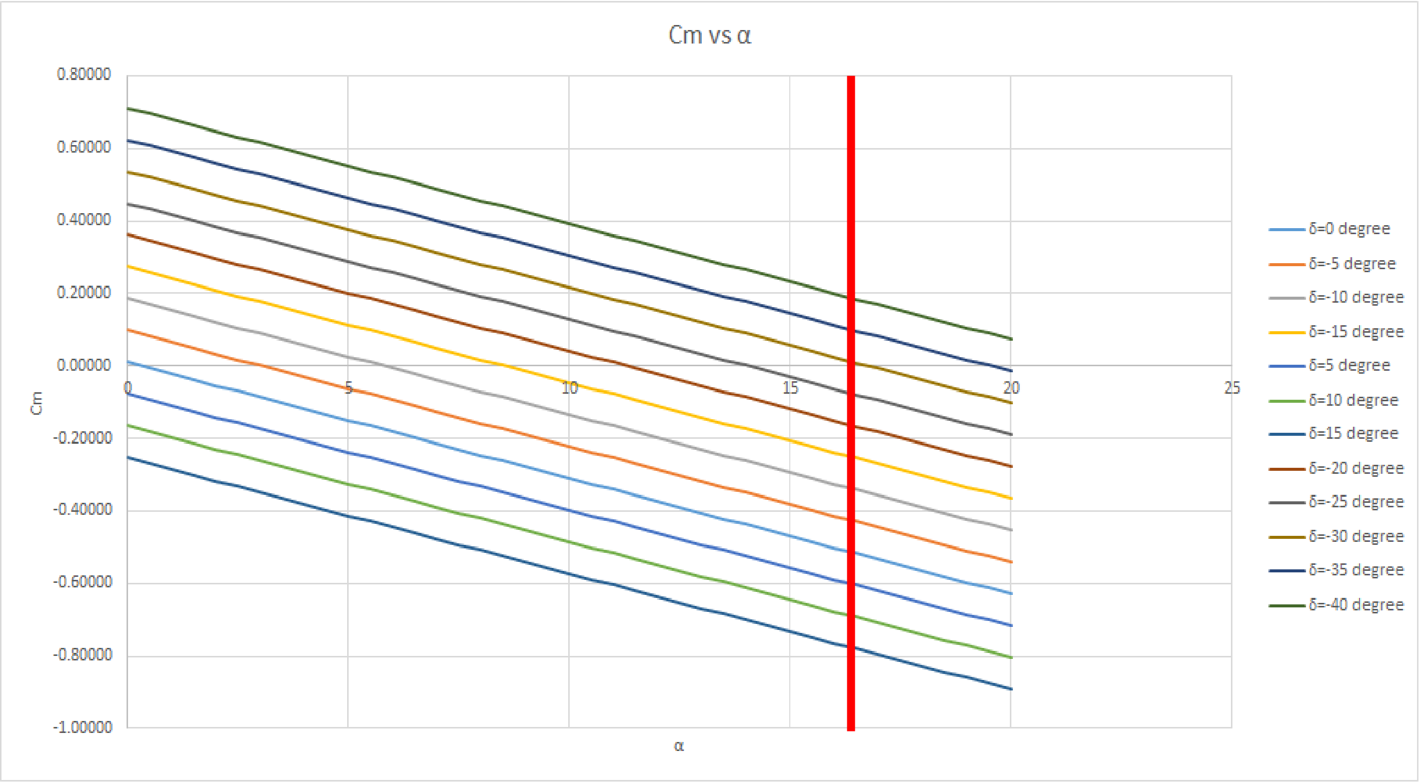


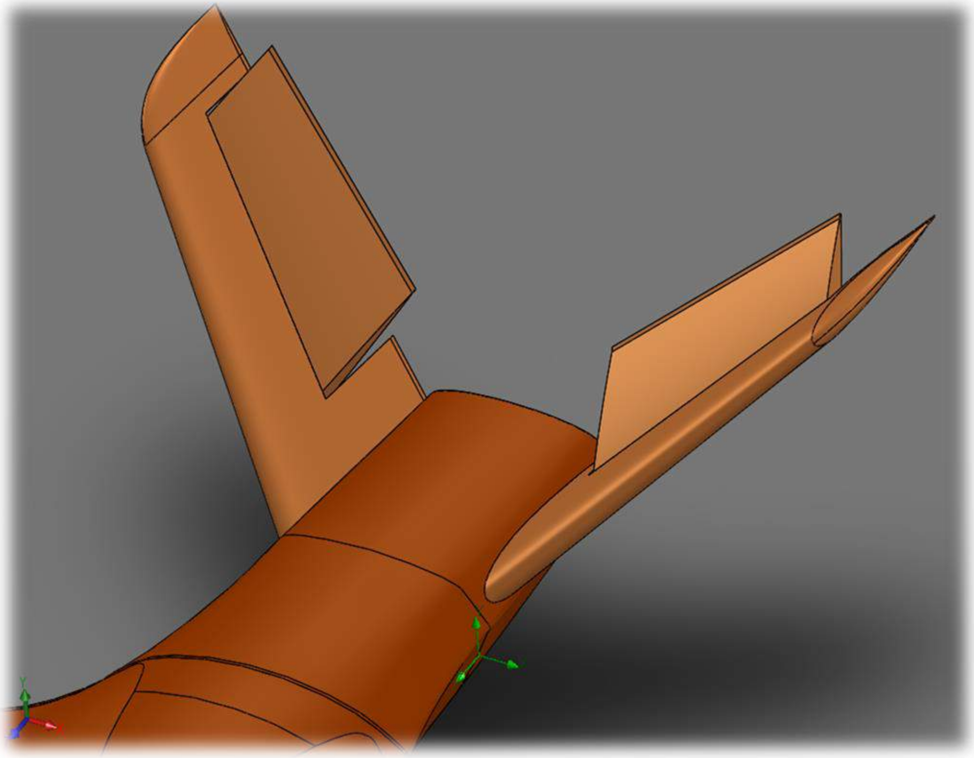
Ruddervator Sizing

- First iteration using 30% surface area benchmark
- Excel and CFD to iterate and verify effectiveness
- Final iteration at 38% tail surface area and oversized for 50% tail area



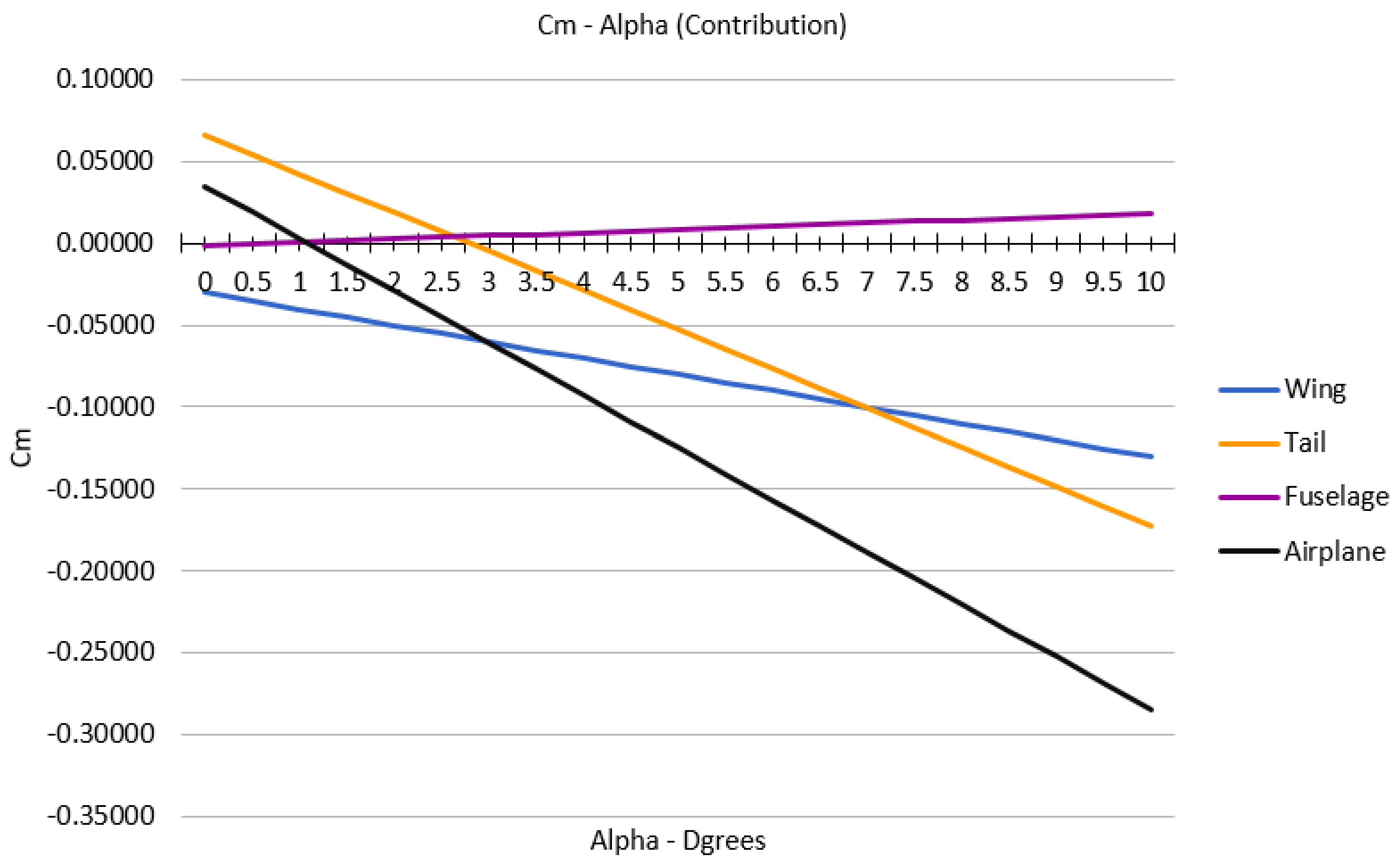
Ruddervator Effectiveness





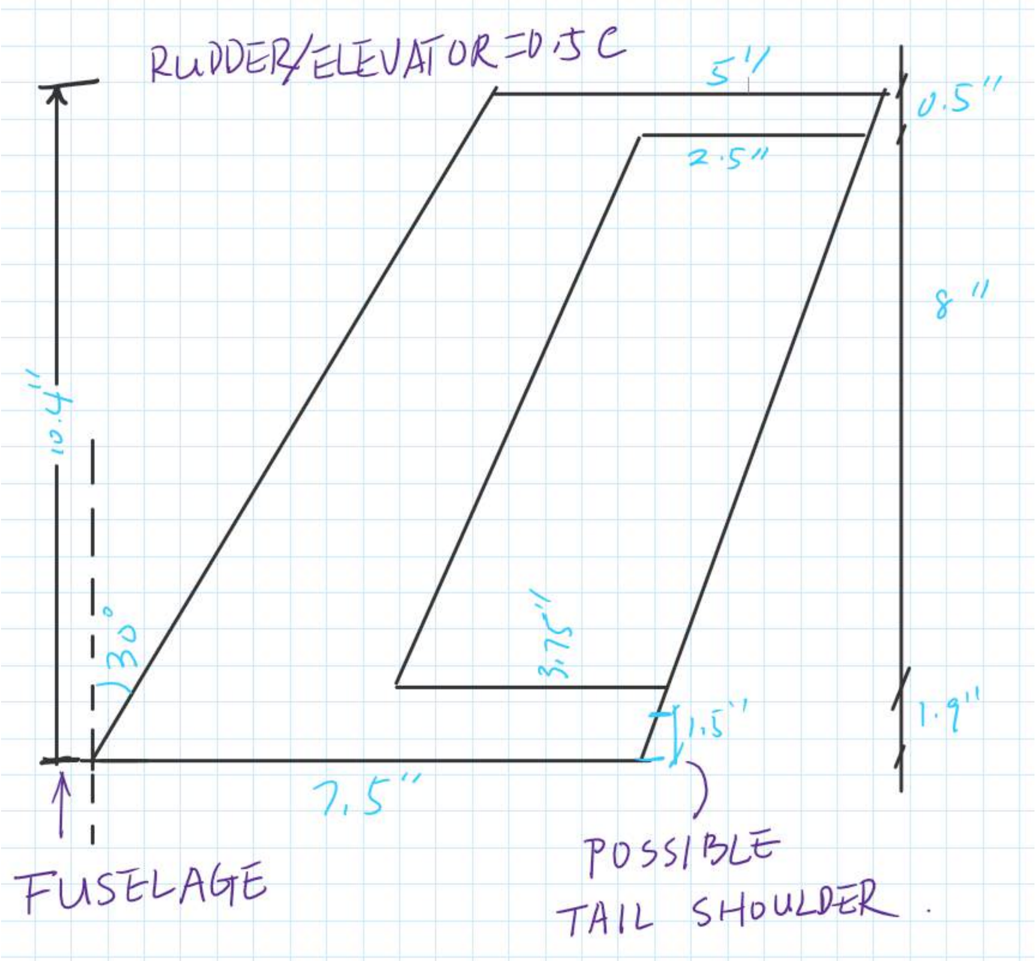
Ruddervator Effectiveness from -40 degree to 15 degree deflection

Fuselage Analysis: Pitching Moment



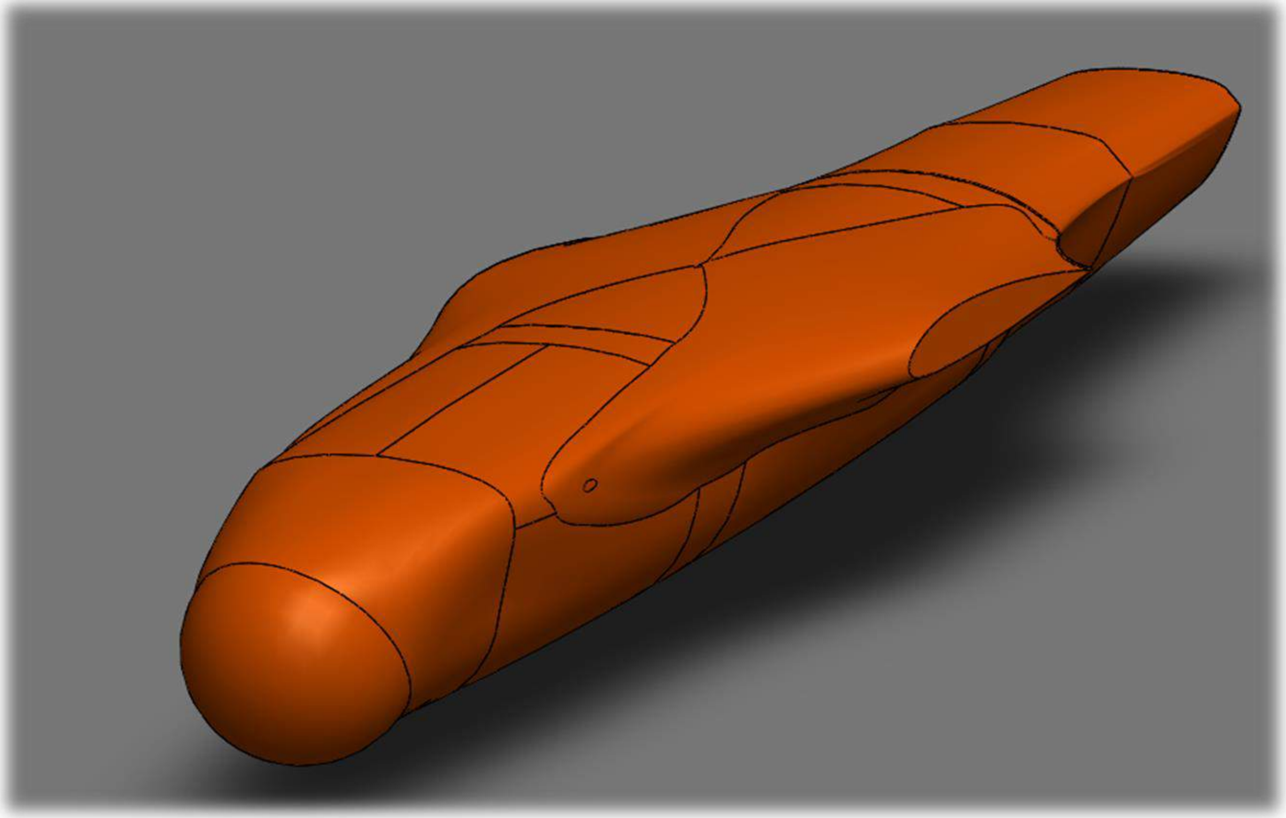
Component contributions to pitching moment

Final Tail Planform



Fuselage Design

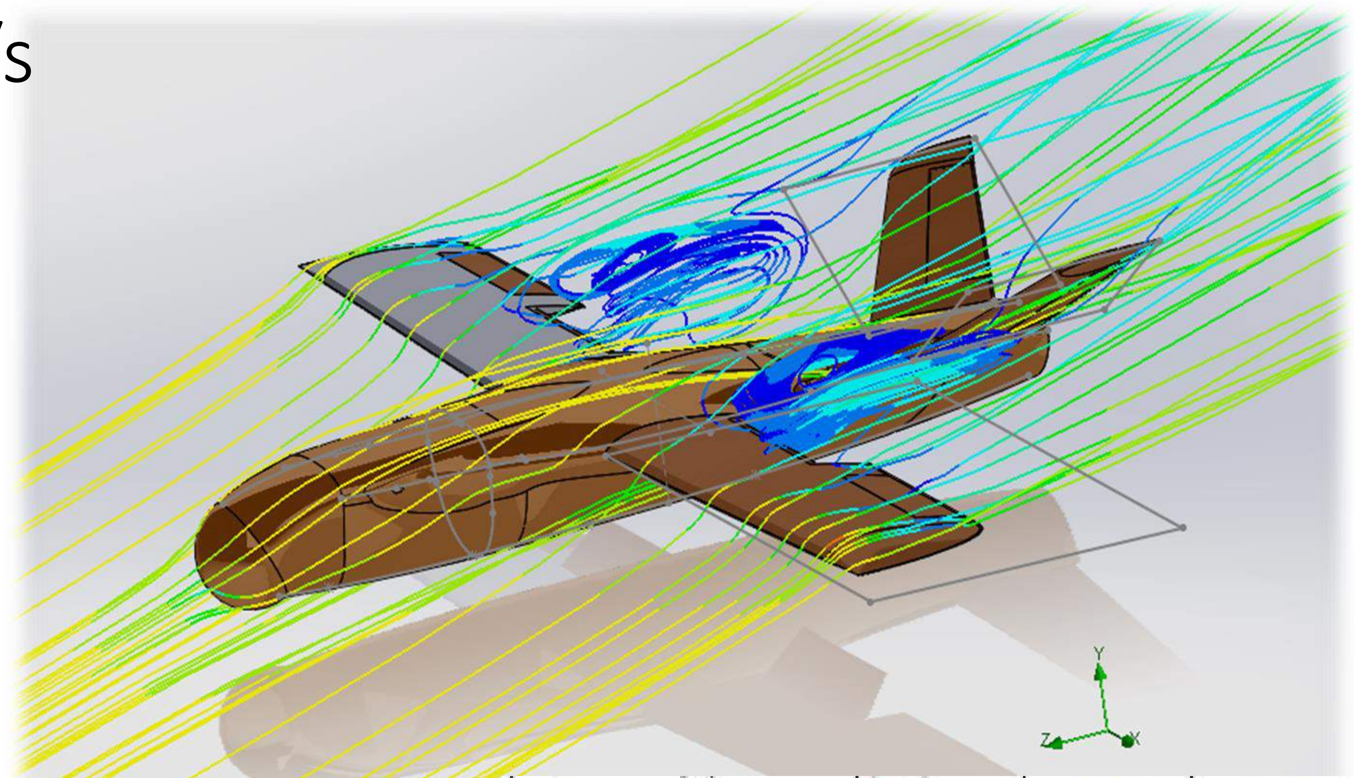
- Designed for high speed and low drag
- Fuselage drag estimated with CFD in combination with all other components



CFD Results

Landing Configuration:

- Landing velocity: 55 ft/s
- Flaps deflection: 40^o
- AoA: 15^o

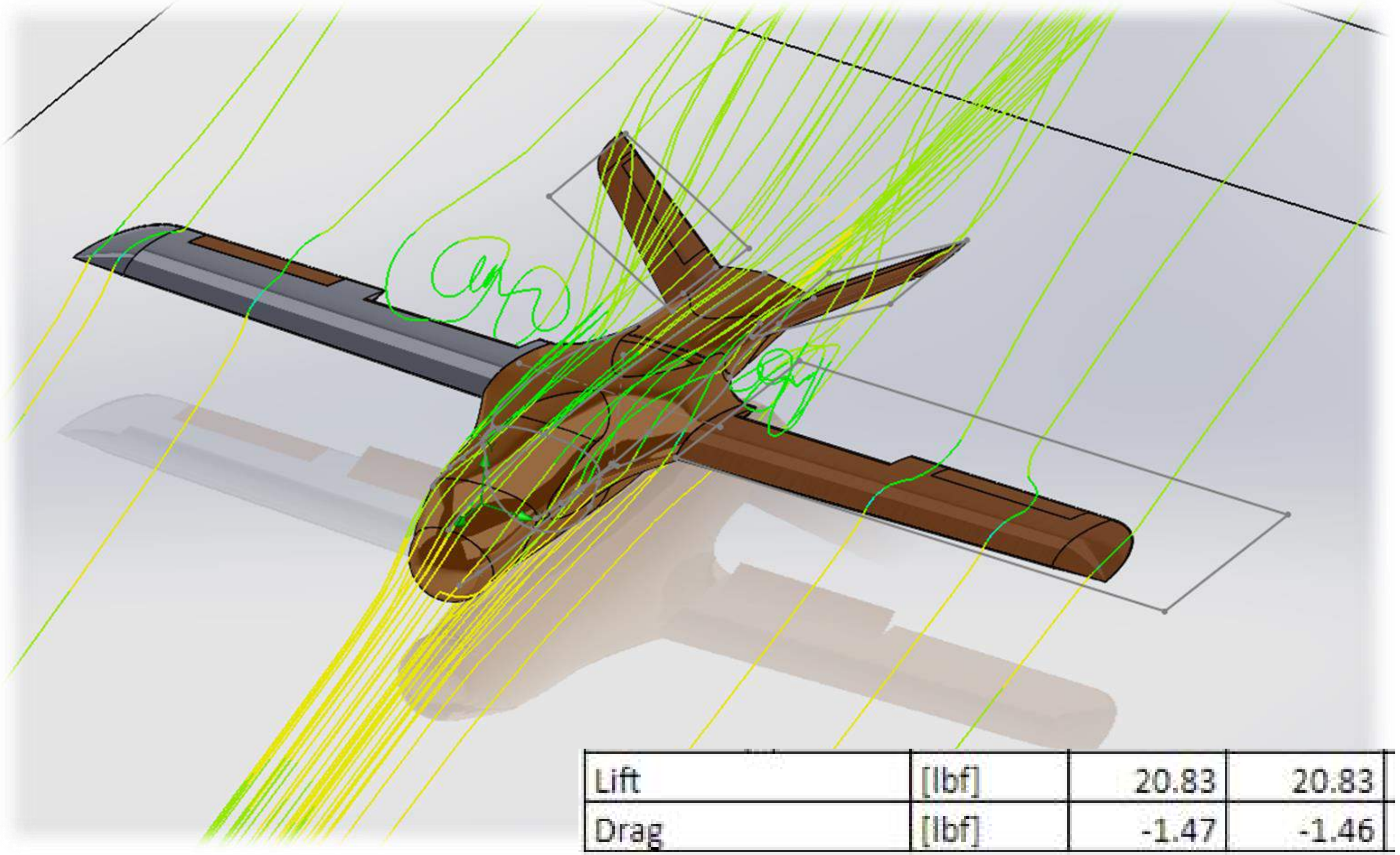


Lift	[lbf]	16.85	16.85
Drag	[lbf]	-0.63	-0.63

CFD Results

Takeoff Configuration

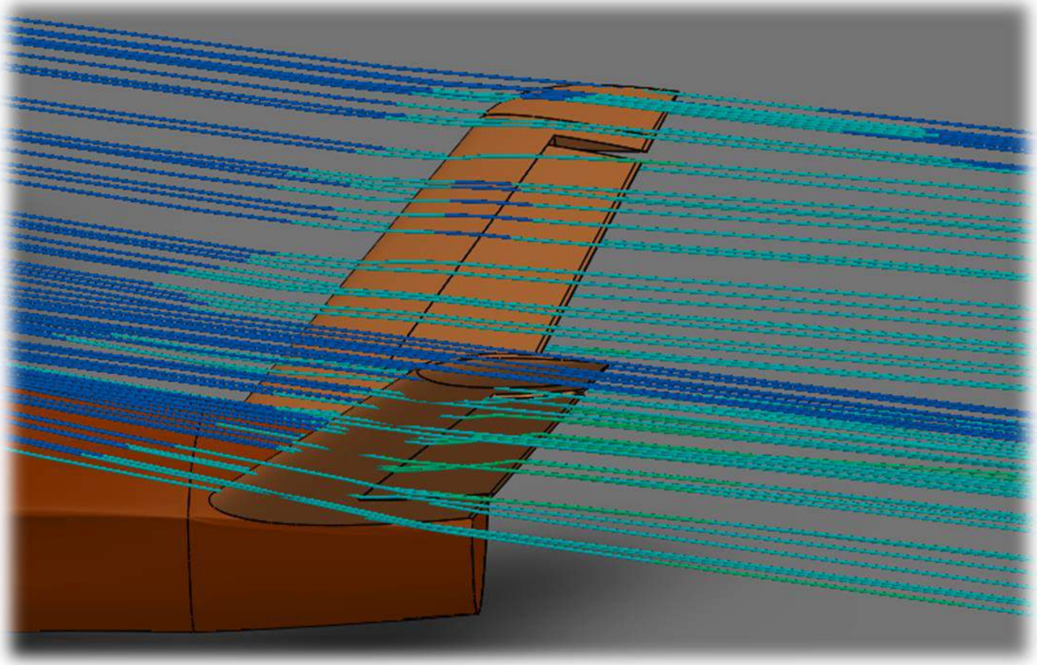
- 50 ft/s
- Flaps 20°
- AoA 17°

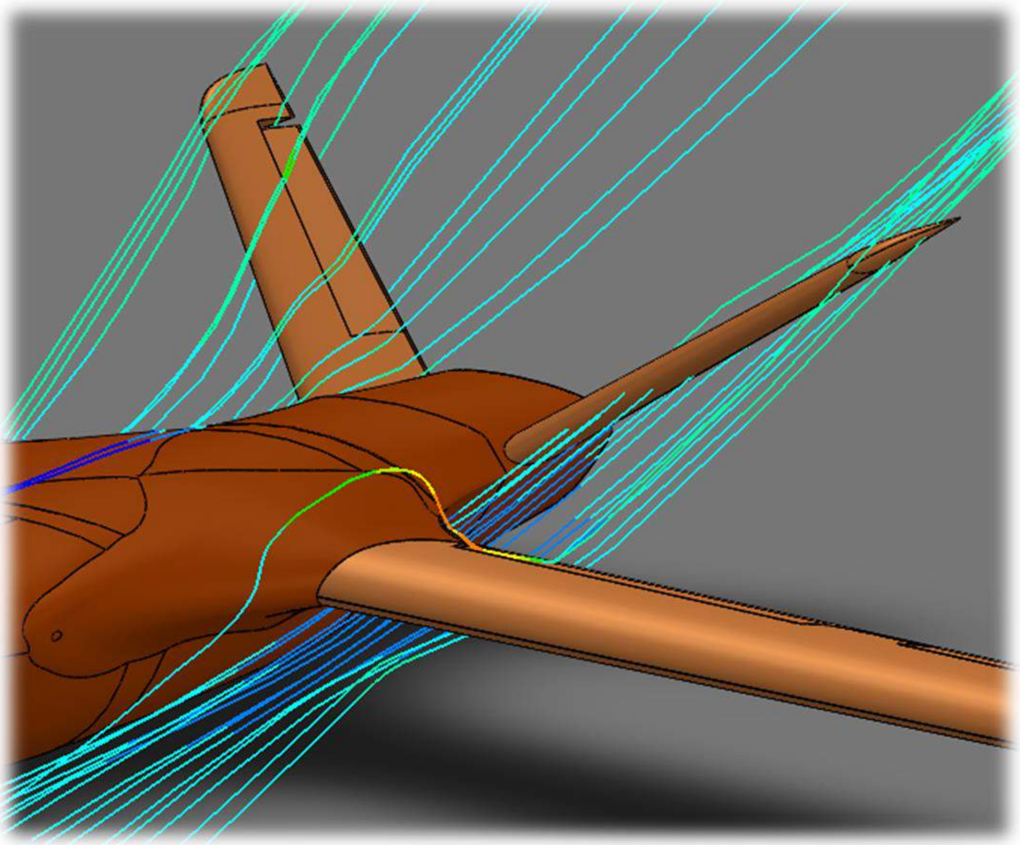


Lift	[lbf]	20.83	20.83
Drag	[lbf]	-1.47	-1.46

CFD Results

- Tail Flow Characteristics
  - CFD @ 17° AOA





PROPULSION

Engine Selection

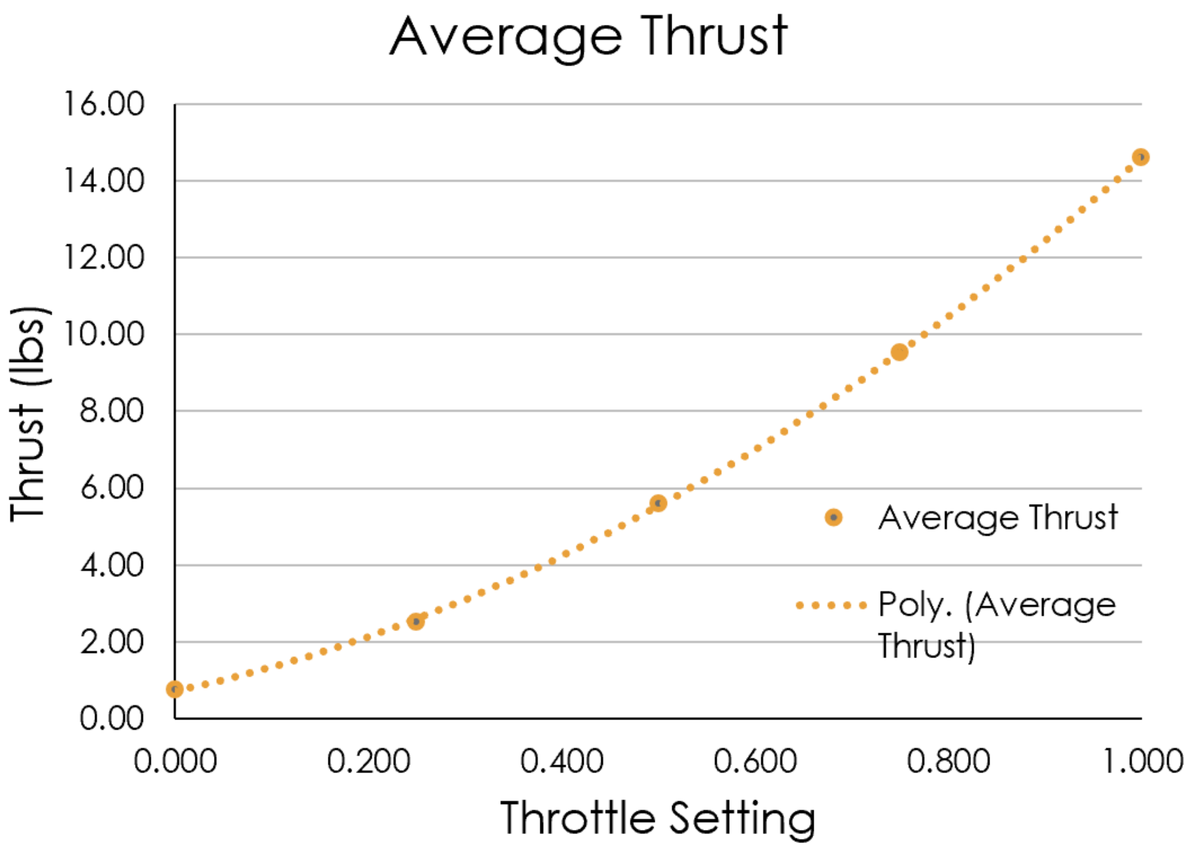
KingTech K-70G2

- Thrust: 15.5 lb @ 15°C
- Cost: $1,650.00
- Weight: 1 lb 9.3 oz
- Fuel Consumption: 8.11 oz/min
- Dimensions (D x L): 2.99” x 7.68”

Previous Engine Testing

Thrust vs. Throttle Setting

- Average thrust at idle: 0.75 lbf @ 60,000 RPM
- Average thrust at full throttle: 14.6 lbf @ 180,000 RPM

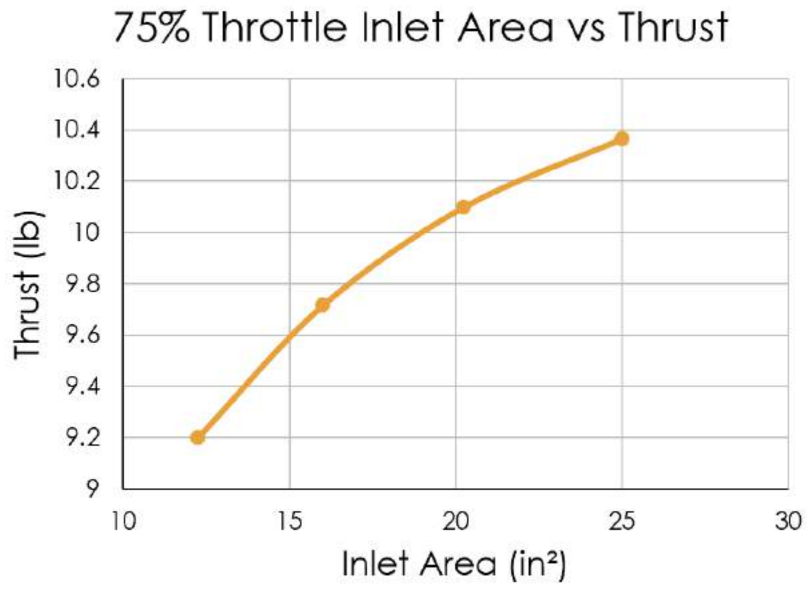


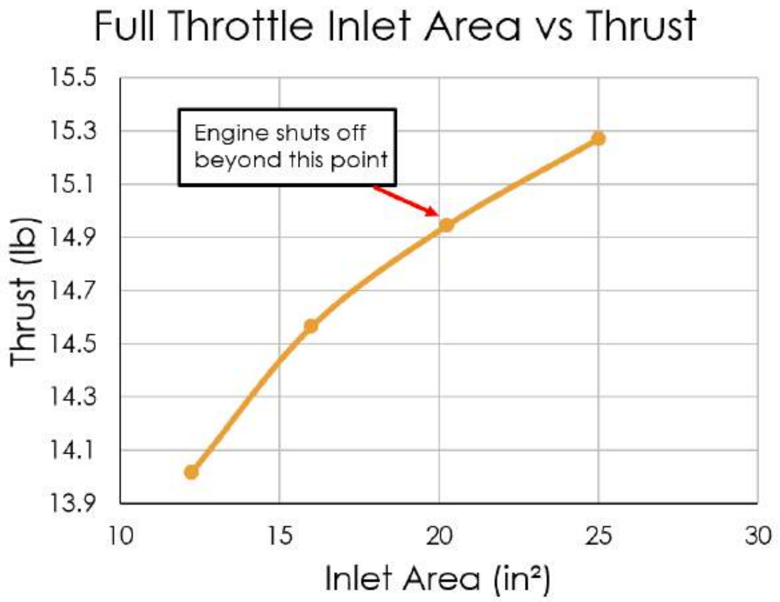
*Engine testing and analysis done by Orange Team 2018

Inlet Sizing

Baseline of at least 25 in^2 inlet area

- Determined based on Orange Team 2018 inlet tests
- Similar K-70G2 engine with thrust tube set-up





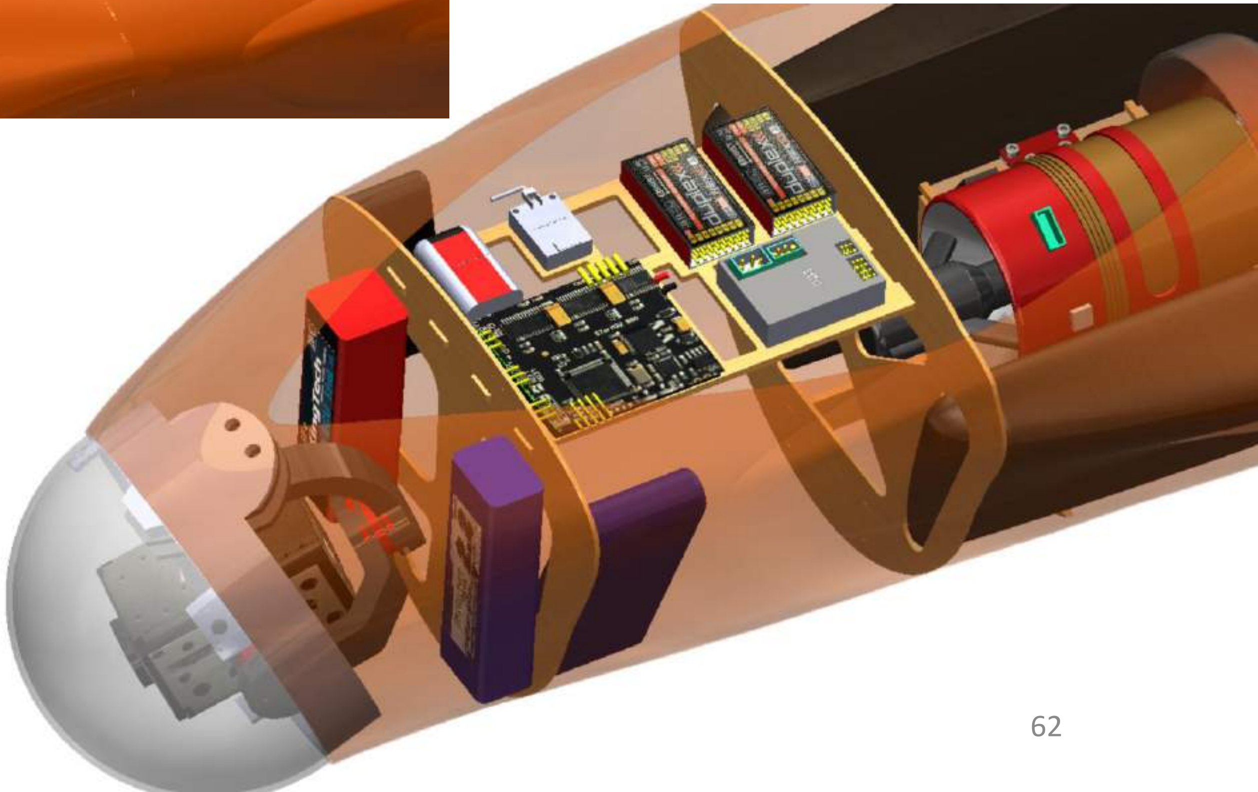
Inlet Design

Size

- NACA Inlet shaped
- Minimum of 25 in^2
- Modeled as approximately 26 in^2

Airflow

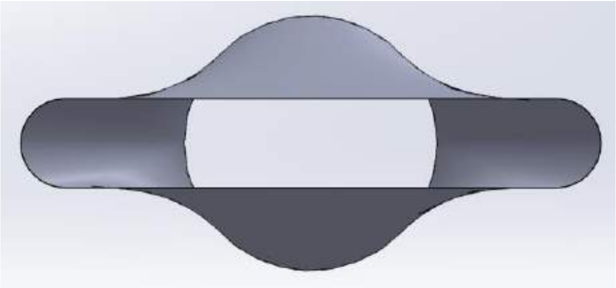
- Cutouts in the bulkheads are at least the same area as inlet
- Flow goes around avionics for cooling

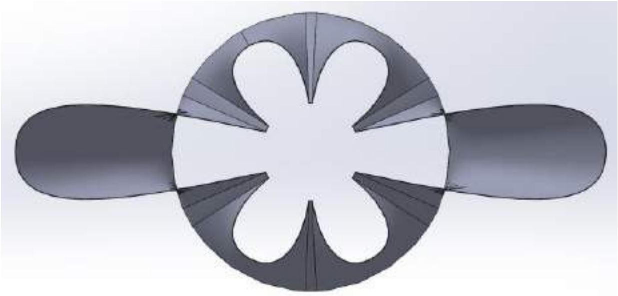


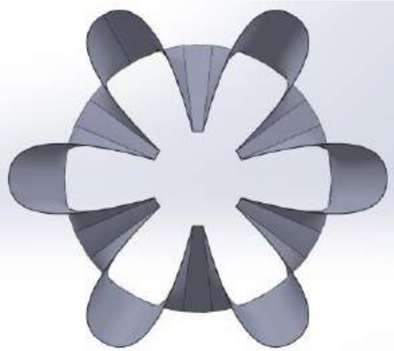
CFD Estimations On Different Nozzles

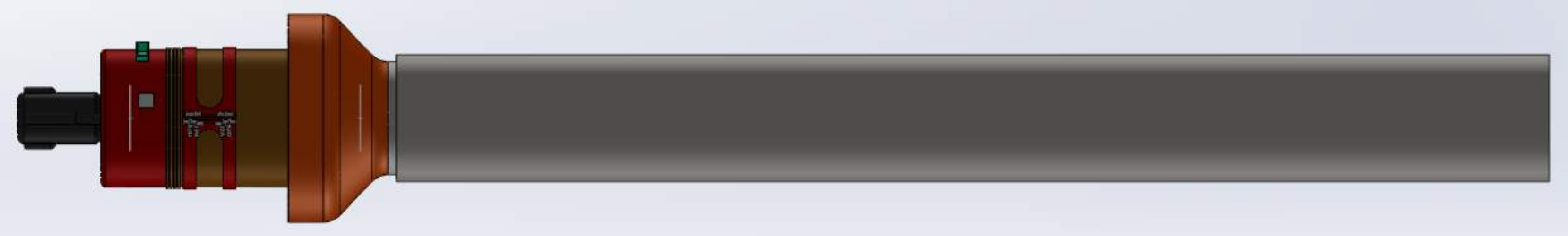
Main Focus of CFD

- Find optimum geometry for decrease in dB while keeping:
  - Constant area at nozzle exit
  - Constant total length from bell mouth to nozzle exit
  - Maximum 7° taper of nozzle
- Geometries being tested:
  - High aspect ratio nozzles
  - Lobed nozzles
  - Combination of the two





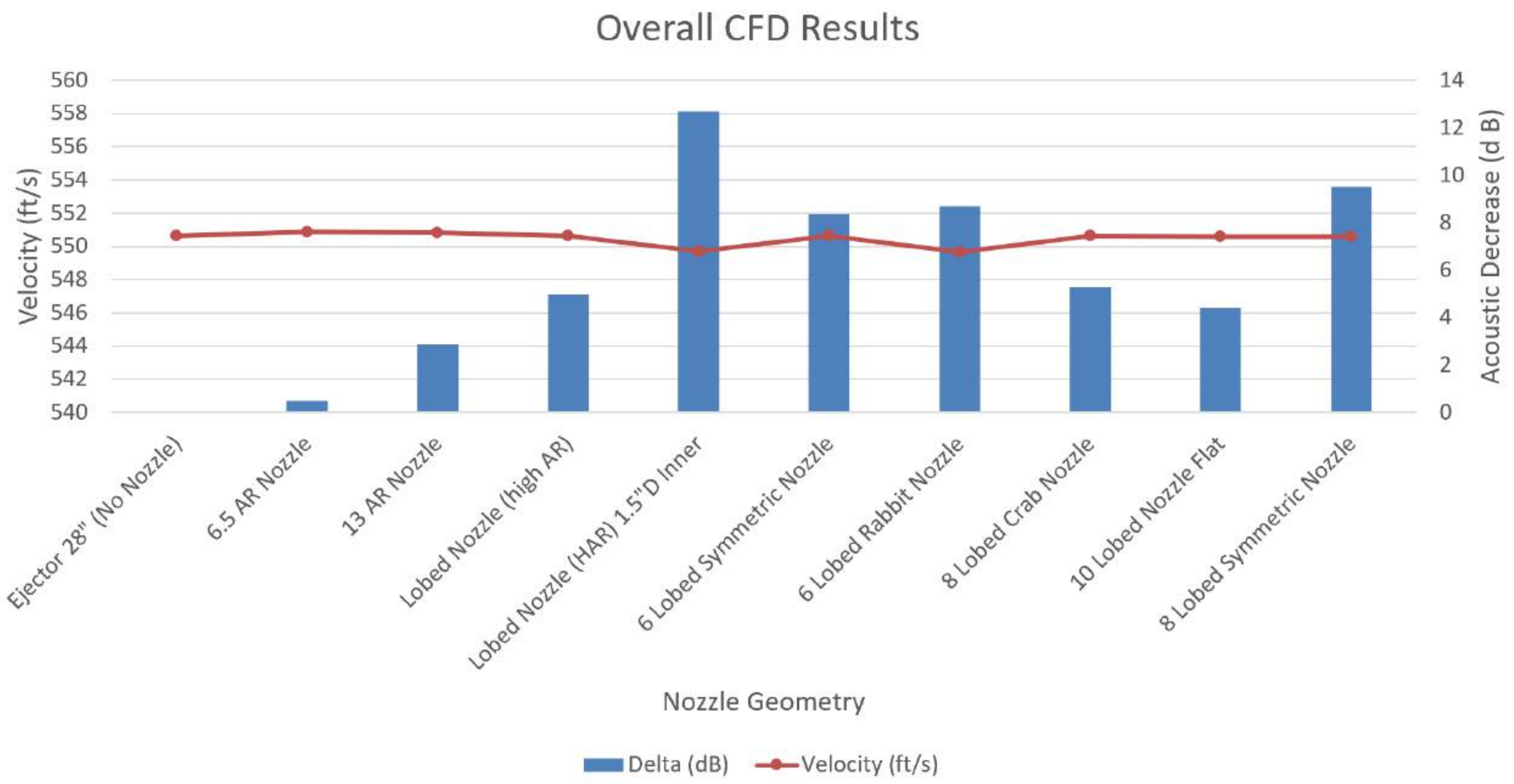




CFD Results

Conclusions

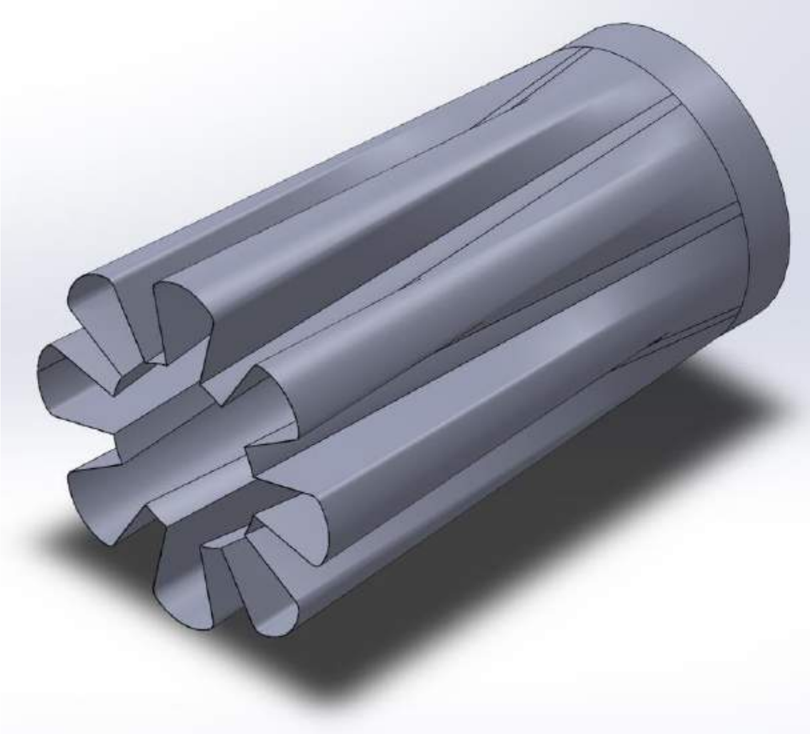
- Average velocity at nozzle exit stays constant with input velocity
- Lobes > High AR
  - Much more surface area



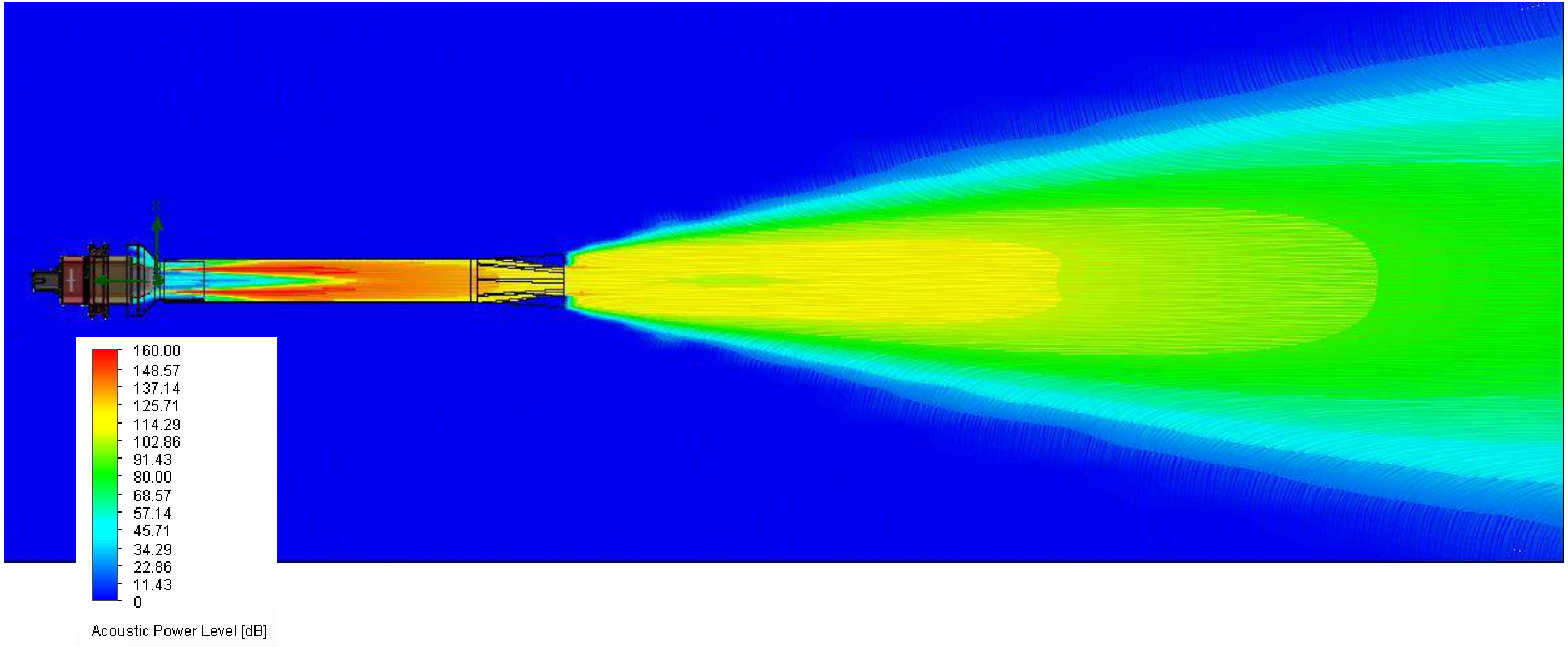
Chosen Nozzle Geometry

8 Lobed Symmetric Nozzle

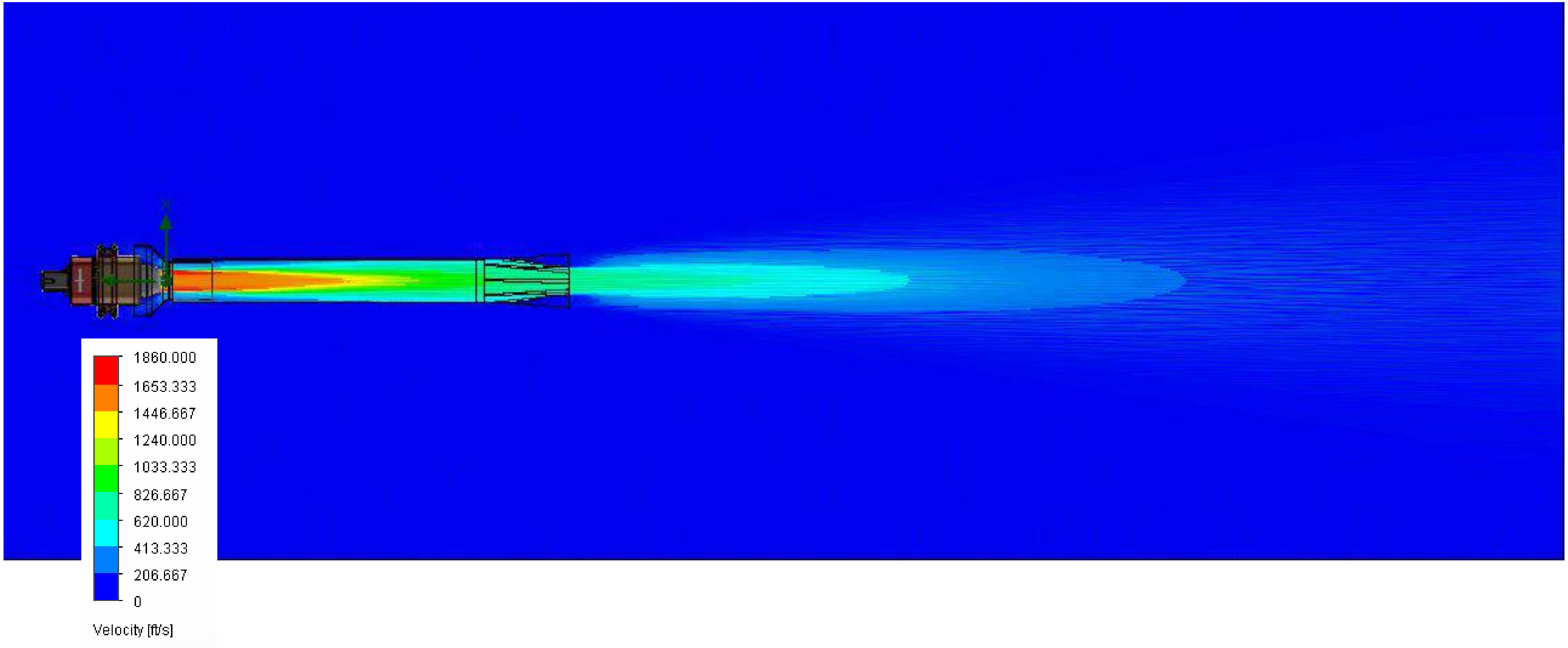
- Length of 5.5”
- Large amount of surface area for more mixing
- 2nd lowest dB delta of tested geometries
- Accommodates structure of V-tail spars



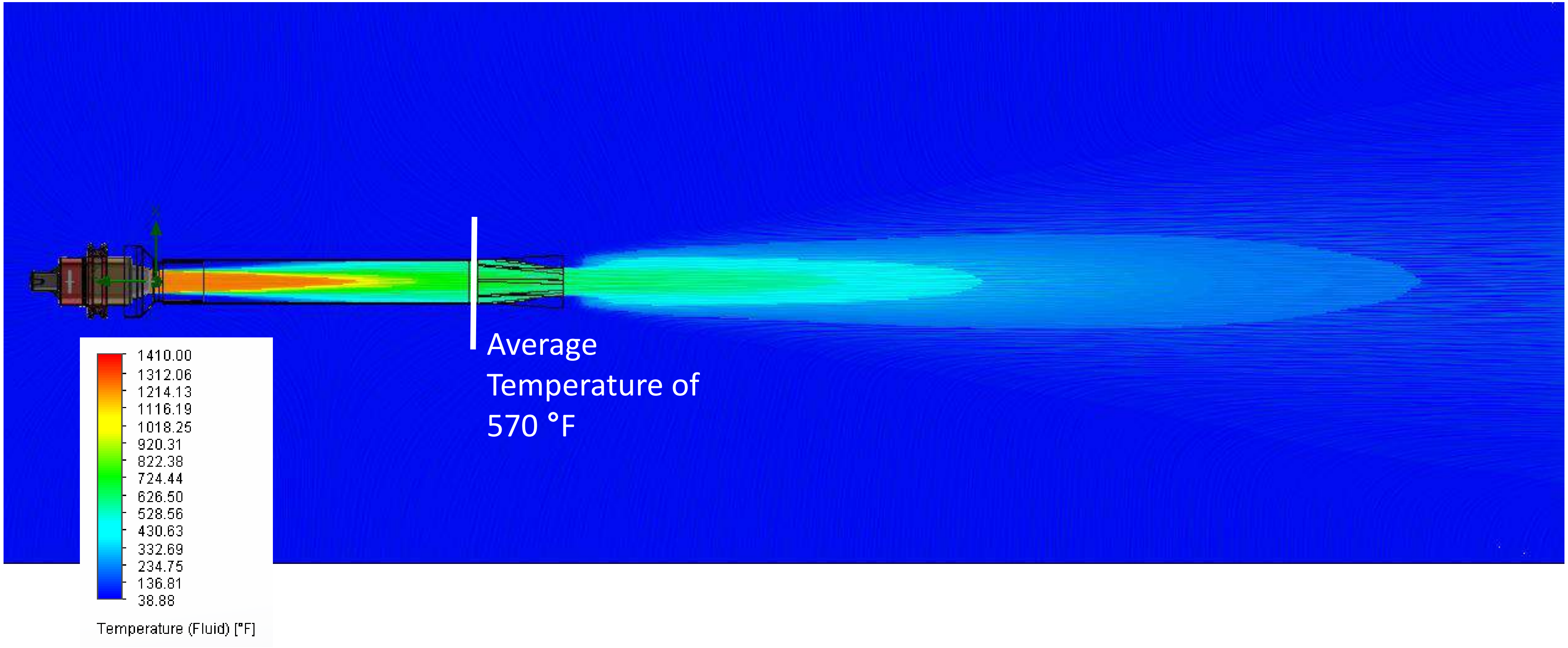
Nozzle Acoustic Power Level



Nozzle Velocity



Nozzle Temperature



Average Temperature of 570 °F

Nozzle Manufacturing

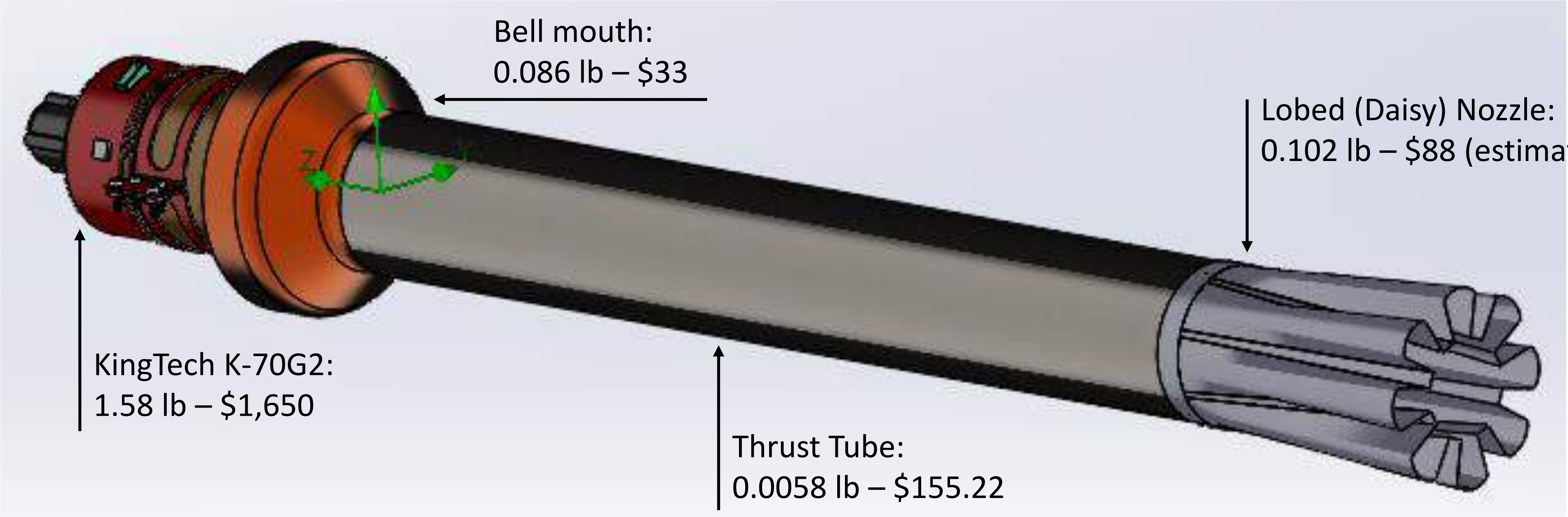
Methods

- 3D printed molds
- Press brake

Material

- Sheet Metal
  - Aluminum
  - Stainless Steel

Component Breakdown



- Possible use of mesh surrounded by K-Wool near bell mouth.
  - Dependent on test results of nozzle (use only if nozzle is insufficient, testing will need to be conducted)

Fuel Required for Cruise and Loiter

Aircraft Estimates

- Empty Weight: 13 lb
- Fuel Weight: ~7 lb
- Wing Area: 5 ft^2
- Wing Span: 6 ft
- Parasite Drag: 0.15

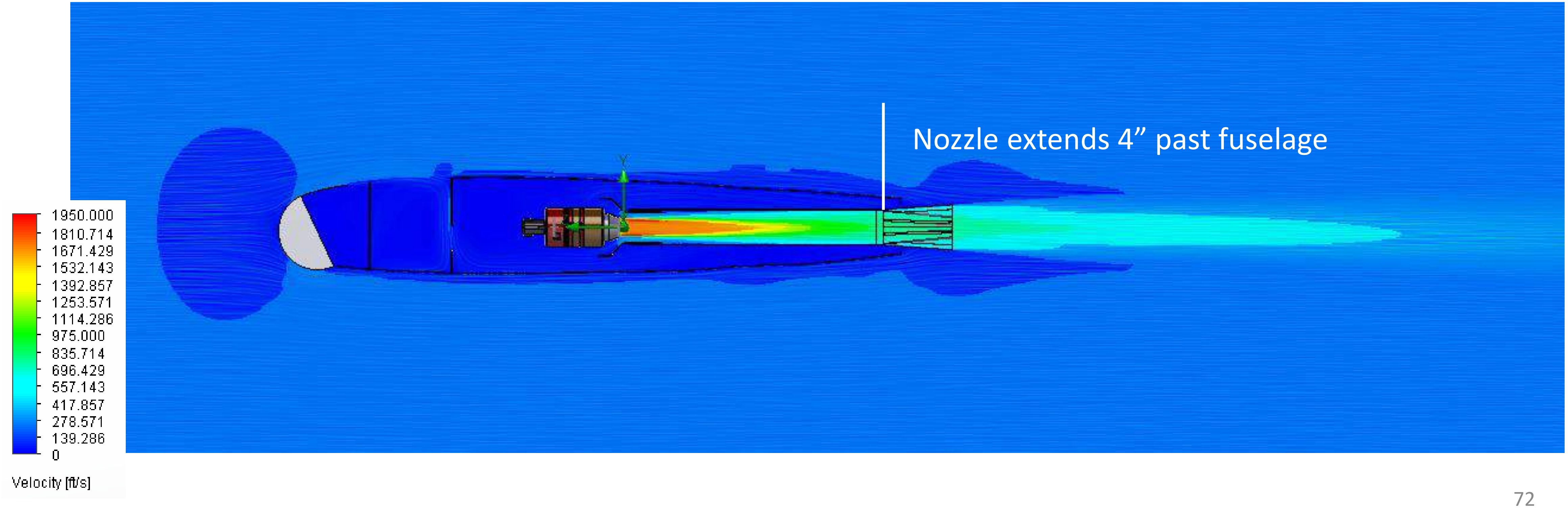
K-70	Cruise Conditions	Loiter Conditions
Throttle Setting (%)	65	20
Average Velocity (kts)	113	63
Time Required (min)	11.2	10
Weight of Required Fuel (lbf)	4.20	2.38
Weight of Required Fuel for Total Mission (lbf)	6.58	

Current Fuel Capacity

- Diesel (6.94 lb/gal)
- 1 gal fuel capacity

Possible Placement Within Aircraft

- Aircraft Velocity and Streamlines
- *Lowers acoustic signature by 7.85 dB (CFD)*
  - *Will be tested in prototype flight tests***



After CDR: Aerodynamics

- Working close with structures and optics with next steps in manufacturing
- Compare results from prototype flight to CFD analysis
- Check aircraft

After CDR: Propulsion

- Work with optics on flight path, find best flying altitude and distance from judges stand
- Layout of fuel lines, fuel pump, and tank attachments
- Optimization of nozzle manufacturing
- Engine testing for nozzle
  - If nozzle isn't sufficient, do testing with mesh and K-wool additions to fuselage

After CDR: Optics and Avionics

- Iterative 3D printing gimbal to make sure it fits
- Camera range
- Fine tune gains on motor controller

- Wiring schematics
- Hooking up and testing complete avionics package
- Tuning stability for Jeti
- Ordering all components

Review

1. Overall Timeline and Goals for Phase 3
2. Overview of Concept
3. Manufacturing Timeline
4. Structures: Manufacturing and Materials
5. Structures: Aircraft Configurations
6. Ground Equipment
7. Launch and Recovery
8. Aerodynamics
9. Propulsion
10. After CDR
11. BFD_cW

BACKUP

Sound dampening back up slides

- Kaowool specs

Acoustical performance per ASTM C-423 A and E-795, Sound Absorption Coefficient

Kaowool Blanket	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	NRC
1"- 4 pcf	0.29	1.00	1.04	0.99	0.98	0.85
1"- 8 pcf	0.50	0.92	0.91	0.91	0.94	0.80
2"- 4 pcf	0.92	1.01	1.01	1.03	1.10	1.00
2"- 8 pcf	0.80	0.72	0.86	0.92	1.02	0.85

- Quiet Batt soundproofing insulation

Acoustic Data:

frequency	125	250	500	1K	2K	4K	NRC*	SAA*
3 inch	.39	.86	.99	.92	.96	1.01	0.95	0.94

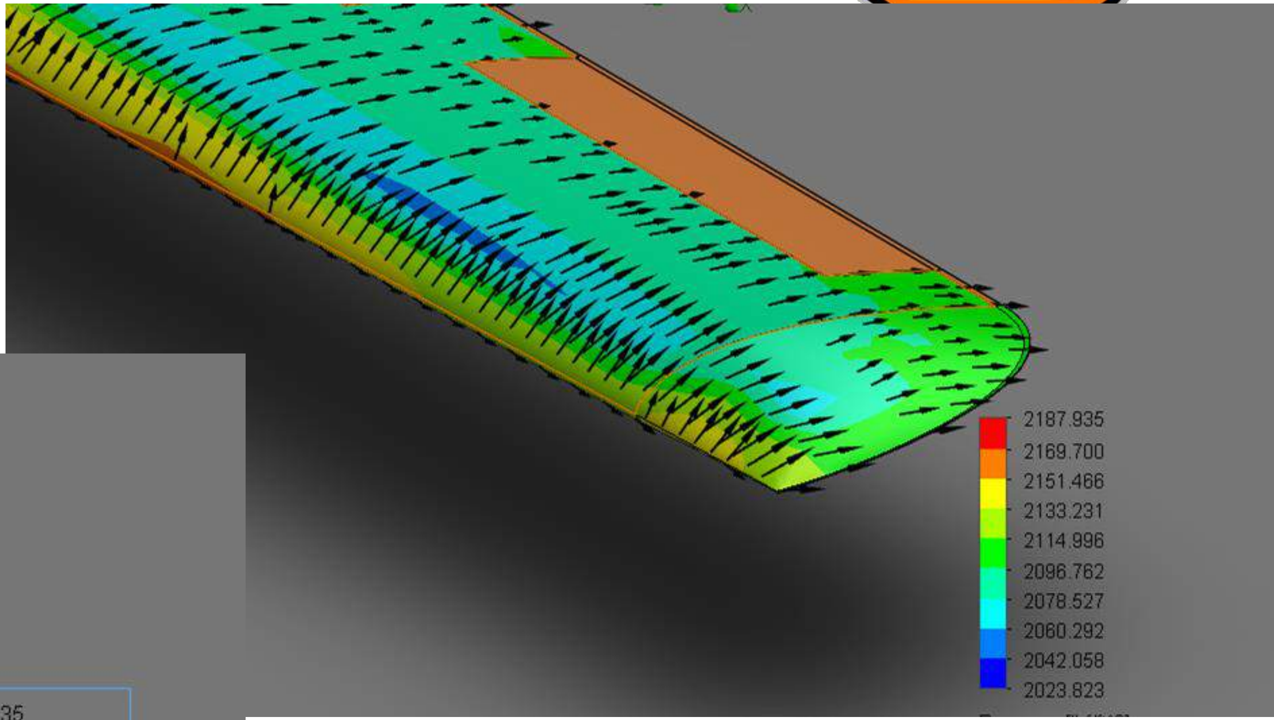
* NRC = noise reduction coefficient

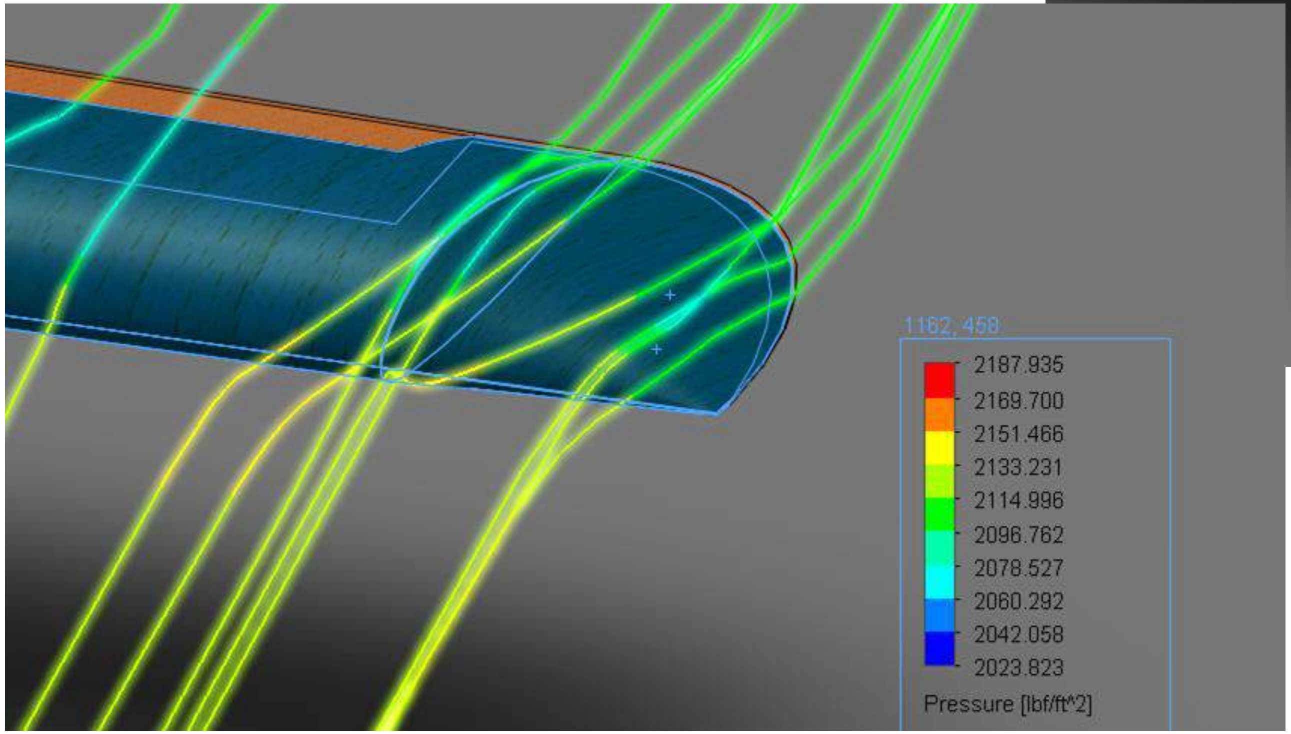
- Auralex StudioFoam Pyramids

	2" Studiofoam Pyramid	4" Studiofoam Pyramid
Overall NRC:	0.70	0.95

CFD Results: Tip Stall

- Tip Stall @ 20° and 200 ft/s, but will effect launch angle considerations





Skin Weight (Foam Core; 1:1; 3oz)

Skin Layup (2 oz, PW) - Assuming 1:1 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.017	0.004	0.246
2	Epoxy	-	0.017	0.002	0.246
3	Fiberglass	90	0.017	0.004	0.246
4	Epoxy	-	0.017	0.002	0.246
5	Divinycell Foam Core (1/8")	-	0.031	0.125	0.452
6	Fiberglass	45	0.017	0.004	0.246
7	Epoxy	-	0.017	0.002	0.246
			Total Skin Weight Estimation (lb)		1.927
			Total Skin Thickness Estimation (in)		0.141

Skin Layup (4 oz, PW) - Assuming 1:1 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.028	0.008	0.405
2	Epoxy	-	0.028	0.004	0.405
3	Fiberglass	90	0.028	0.008	0.405
4	Epoxy	-	0.028	0.004	0.405
5	Divinycell Foam Core (1/8")	-	0.031	0.125	0.452
6	Fiberglass	45	0.028	0.008	0.405
7	Epoxy	-	0.028	0.004	0.405
			Total Skin Weight Estimation (lb)		2.882
			Total Skin Thickness Estimation (in)		0.161

Skin Layup (3 oz, 4H) - Assuming 1:1 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.023	0.006	0.331
2	Epoxy	-	0.023	0.003	0.331
3	Fiberglass	90	0.023	0.006	0.331
4	Epoxy	-	0.023	0.003	0.331
5	Divinycell Foam Core (1/8")	-	0.031	0.125	0.452
6	Fiberglass	45	0.023	0.006	0.331
7	Epoxy	-	0.023	0.003	0.331
			Total Skin Weight Estimation (lb)		2.441
			Total Skin Thickness Estimation (in)		0.152

Skin Layup (9 oz, 8H) - Assuming 1:1 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.063	0.012	0.911
2	Epoxy	-	0.063	0.006	0.911
3	Fiberglass	90	0.063	0.012	0.911
4	Epoxy	-	0.063	0.006	0.911
5	Divinycell Foam Core (1/8")	-	0.031	0.125	0.452
6	Fiberglass	45	0.063	0.012	0.911
7	Epoxy	-	0.063	0.006	0.911
			Total Skin Weight Estimation (lb)		5.919
			Total Skin Thickness Estimation (in)		0.179

Skin Weight (Foam Core; 1:1.5; 3oz)

Skin Layup (2 oz, PW) - Assuming 1:1.5 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.017	0.004	0.246
2	Epoxy	-	0.026	0.002	0.369
3	Fiberglass	90	0.017	0.004	0.246
4	Epoxy	-	0.026	0.002	0.369
5	Divinycell Foam Core (1/8")	-	0.031	0.125	0.452
6	Fiberglass	45	0.017	0.004	0.246
7	Epoxy	-	0.026	0.002	0.369
			Total Skin Weight Estimation (lb)		2.296
			Total Skin Thickness Estimation (in)		0.141

Skin Layup (4 oz, PW) - Assuming 1:1.5 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.028	0.008	0.405
2	Epoxy	-	0.042	0.004	0.607
3	Fiberglass	90	0.028	0.008	0.405
4	Epoxy	-	0.042	0.004	0.607
5	Divinycell Foam Core (1/8")	-	0.031	0.125	0.452
6	Fiberglass	45	0.028	0.008	0.405
7	Epoxy	-	0.042	0.004	0.607
			Total Skin Weight Estimation (lb)		3.489
			Total Skin Thickness Estimation (in)		0.161

Skin Layup (3 oz, 4H) - Assuming 1:1.5 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.023	0.006	0.331
2	Epoxy	-	0.034	0.003	0.497
3	Fiberglass	90	0.023	0.006	0.331
4	Epoxy	-	0.034	0.003	0.497
5	Divinycell Foam Core (1/8")	-	0.031	0.125	0.452
6	Fiberglass	45	0.023	0.006	0.331
7	Epoxy	-	0.034	0.003	0.497
			Total Skin Weight Estimation (lb)		2.938
			Total Skin Thickness Estimation (in)		0.152

Skin Layup (9 oz, 8H) - Assuming 1:1.5 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.063	0.012	0.911
2	Epoxy	-	0.095	0.006	1.367
3	Fiberglass	90	0.063	0.012	0.911
4	Epoxy	-	0.095	0.006	1.367
5	Divinycell Foam Core (1/8")	-	0.031	0.125	0.452
6	Fiberglass	45	0.063	0.012	0.911
7	Epoxy	-	0.095	0.006	1.367
			Total Skin Weight Estimation (lb)		7.286
			Total Skin Thickness Estimation (in)		0.179

Skin Weight (Foam Core; 1:1; 5oz)

Skin Layup (2 oz, PW) - Assuming 1:1 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.017	0.004	0.246
2	Epoxy	-	0.017	0.002	0.246
3	Fiberglass	90	0.017	0.004	0.246
4	Epoxy	-	0.017	0.002	0.246
5	Divinycell Foam Core (1/8")	-	0.052	0.125	0.753
6	Fiberglass	45	0.017	0.004	0.246
7	Epoxy	-	0.017	0.002	0.246
			Total Skin Weight Estimation (lb)		2.229
			Total Skin Thickness Estimation (in)		0.141

Skin Layup (4 oz, PW) - Assuming 1:1 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.028	0.008	0.405
2	Epoxy	-	0.028	0.004	0.405
3	Fiberglass	90	0.028	0.008	0.405
4	Epoxy	-	0.028	0.004	0.405
5	Divinycell Foam Core (1/8")	-	0.052	0.125	0.753
6	Fiberglass	45	0.028	0.008	0.405
7	Epoxy	-	0.028	0.004	0.405
			Total Skin Weight Estimation (lb)		3.183
			Total Skin Thickness Estimation (in)		0.161

Skin Layup (3 oz, 4H) - Assuming 1:1 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.023	0.006	0.331
2	Epoxy	-	0.023	0.003	0.331
3	Fiberglass	90	0.023	0.006	0.331
4	Epoxy	-	0.023	0.003	0.331
5	Divinycell Foam Core (1/8")	-	0.052	0.125	0.753
6	Fiberglass	45	0.023	0.006	0.331
7	Epoxy	-	0.023	0.003	0.331
			Total Skin Weight Estimation (lb)		2.742
			Total Skin Thickness Estimation (in)		0.152

Skin Layup (9 oz, 8H) - Assuming 1:1 Ratio of Fabric/Epoxy					
#	Material	Bias	Material Density (lb/ft^2)	Thickness (in)	Weight (lb)
1	Fiberglass	45	0.063	0.012	0.911
2	Epoxy	-	0.063	0.006	0.911
3	Fiberglass	90	0.063	0.012	0.911
4	Epoxy	-	0.063	0.006	0.911
5	Divinycell Foam Core (1/8")	-	0.052	0.125	0.753
6	Fiberglass	45	0.063	0.012	0.911
7	Epoxy	-	0.063	0.006	0.911
			Total Skin Weight Estimation (lb)		6.220
			Total Skin Thickness Estimation (in)		0.179

Wing Servo Option #1

HS-5245MG Servo Specifications

Performance Specifications	
Operating Voltage Range (Volts DC)	4.8V ~ 6.0V
Speed (Second @ 60°)	0.15 ~ 0.12
Maximum Torque Range oz. / in.	61 ~ 76
Maximum Torque Range kg. / cm.	4.4 ~ 5.5
Current Draw at Idle	3 mA
No Load Operating Current Draw	300 mA
Stall Current Draw	1,200 mA
Dead Band Width	4 µs
Physical Specifications	
Dimensions (Inches)	1.27 x 0.66 x 1.21
Dimensions (Metric)	32.4 x 16.8 x 30.8
Weight (Ounces)	1.12
Weight (Gram)	32.0
Circuit Type	G1 Programable Digital
Motor Type	3 Pole Metal Brush Ferrite
Gear Material	Metal
Bearing Type	Dual Ball Bearing
Output Shaft (type / Ømm)	Standard 24
Case Material	Plastic
Dust / Water Resistance	N / A
Connector Gauge (AWG) / Strand Count	25 / 40

Tail Servo

HS-5070MH Servo Specifications

Performance Specifications	
Operating Voltage Range (Volts DC)	6.0V ~ 7.4V
Speed (Second @ 60°)	0.14 ~ 0.12
Maximum Torque Range oz. / in.	42 ~ 52
Maximum Torque Range kg. / cm.	3.0 ~ 3.7
Current Draw at Idle	3 mA
No Load Operating Current Draw	240 mA
Stall Current Draw	1,300 mA
Dead Band Width	2 µs
Physical Specifications	
Dimensions (Inches)	0.92 x 0.45 x 1.14
Dimensions (Metric)	23.6 x 11.6 x 28.1
Weight (Ounces)	0.50
Weight (Gram)	14.2
Circuit Type	G1 Programable Digital
Motor Type	3 Pole Metal Brush Neodymium
Gear Material	Metal
Bearing Type	Top Ball Bearing
Output Shaft (type / Ømm)	Micro 23
Case Material	Plastic
Dust / Water Resistance	N / A
Connector Gauge (AWG) / Strand Count	28 / 20