Composites Critical Design Review

1/3/26

Agenda

System Overview

- Team/System Goals
- Main Feedback Items
- Purchased Items

System Design

- High Level Parameters

Subsystem Designs

- Part Level Design Breakdown

Research Projects

Slide Owner:

System Overview

Slide Owner:

Team/System Goals

The Composites system

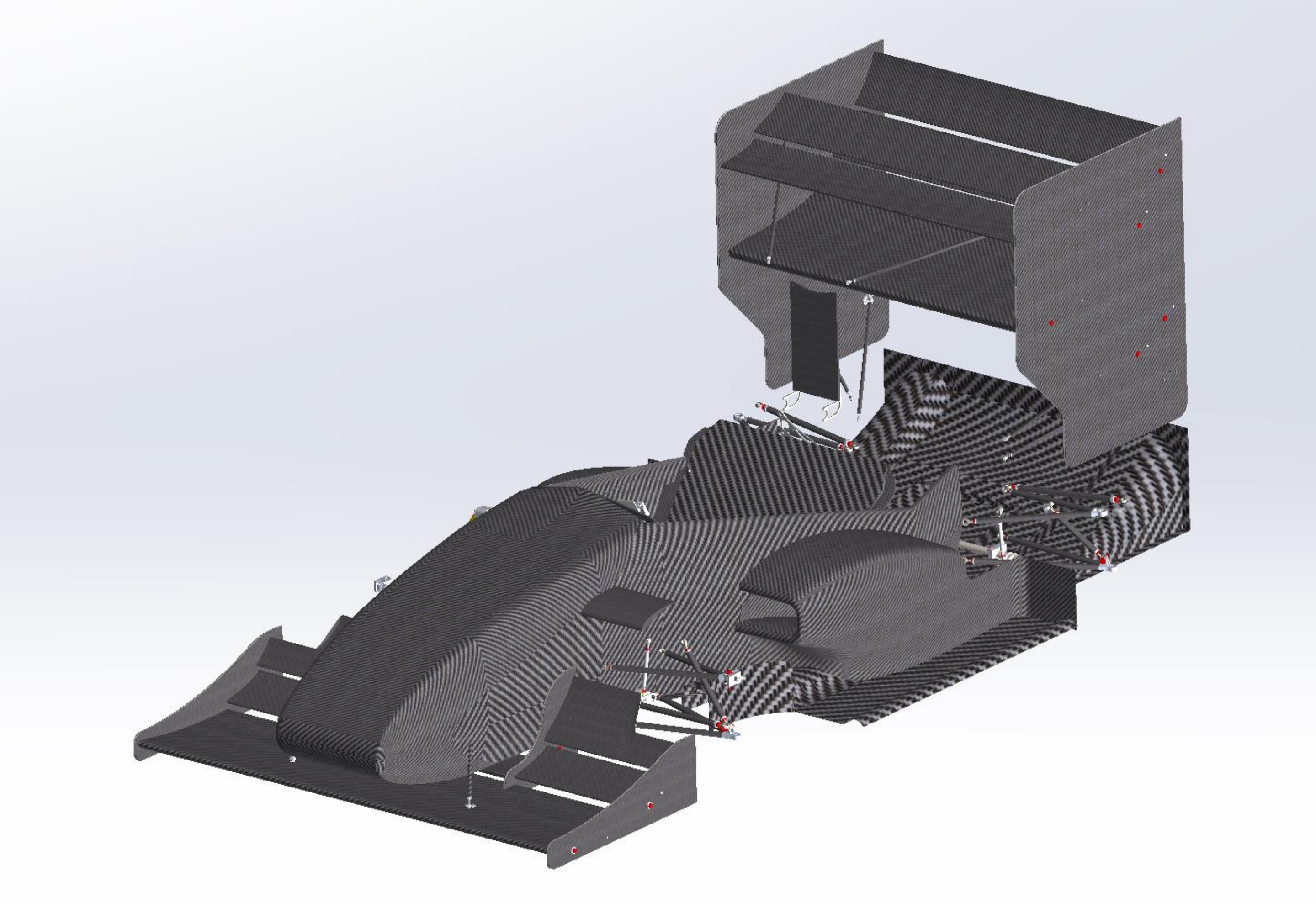
Designing the structures for many aerodynamic and composite components for the race car.

Goals

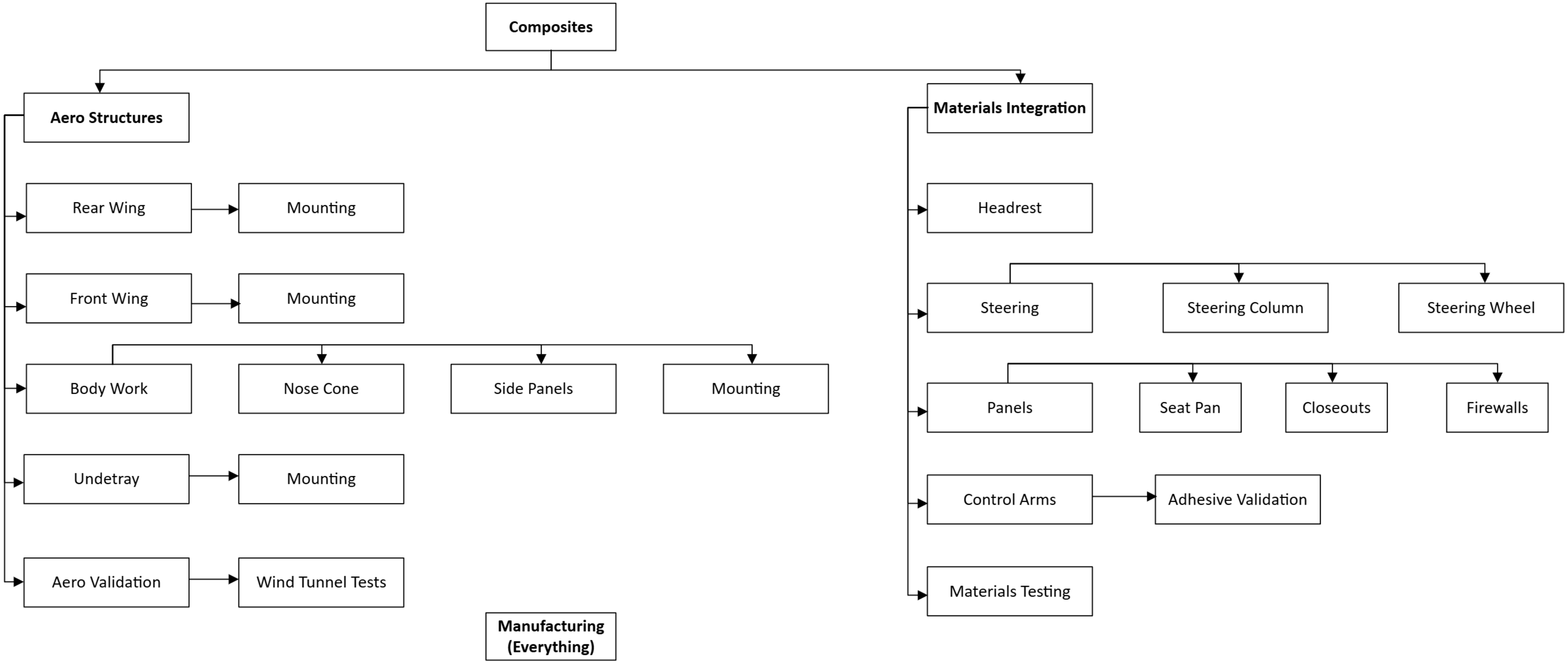
- **Achieve weight savings** through optimized composite layups and material selection,
- **Ensure structural integrity and reliability** by designing composites to meet all expected load cases with appropriate safety factors.
- **Validate composite structures** using analysis, testing, and correlation
- **Improve consistency and repeatability** in composite design and manufacturing processes for current and future vehicles.

System Level Assembly

Pic of system assembly along with carbon components from other systems' assemblies.



System Items Overview [visio]



Slide Owner: Dhruv

Main Feedback Items

Specific quantifiable feedback items (try and be specific)

Mounting structures, anything wrong with them, what will/won't work?

Structural validation; sims, testing. What more should we simulate and validate?

Manufacturing processes. With our changes, is anything a worry?

What would a judge think?

- How would they judge us?
- How would we best prove a better design score?
- How to best cater to judges?
- Are there any major issues that would cause a hit to design score?

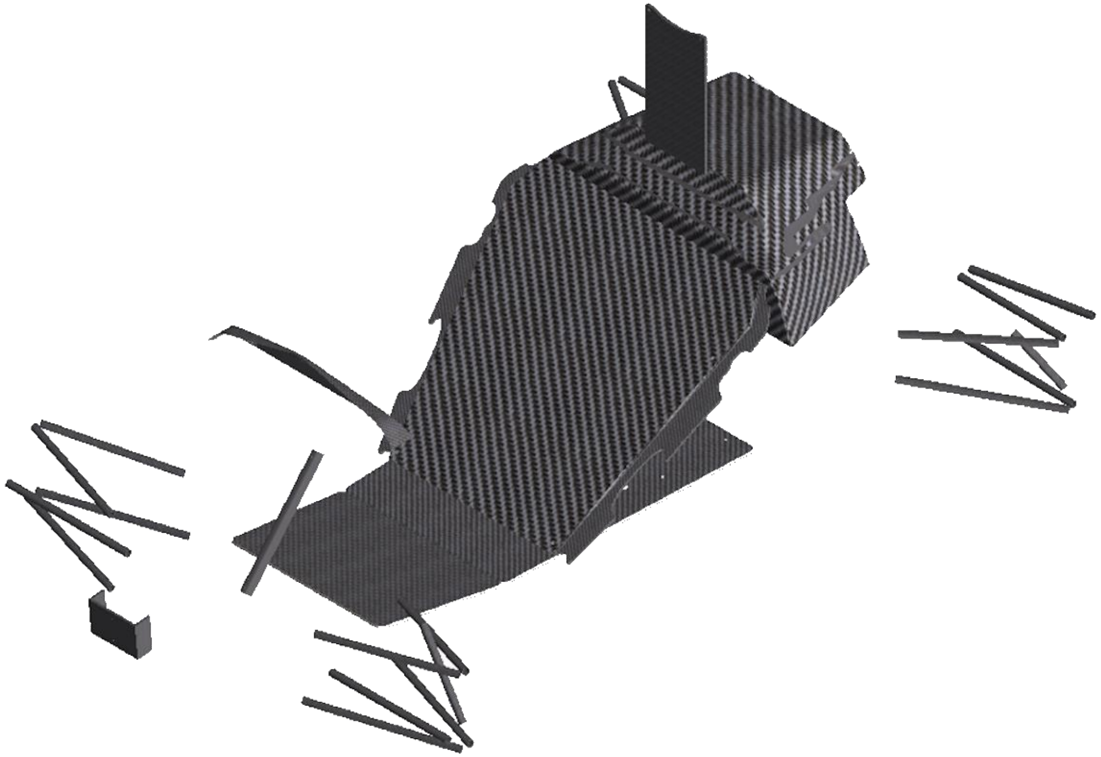
Slide Owner:

LHR

Materials Integration

Materials Integration Subassembly

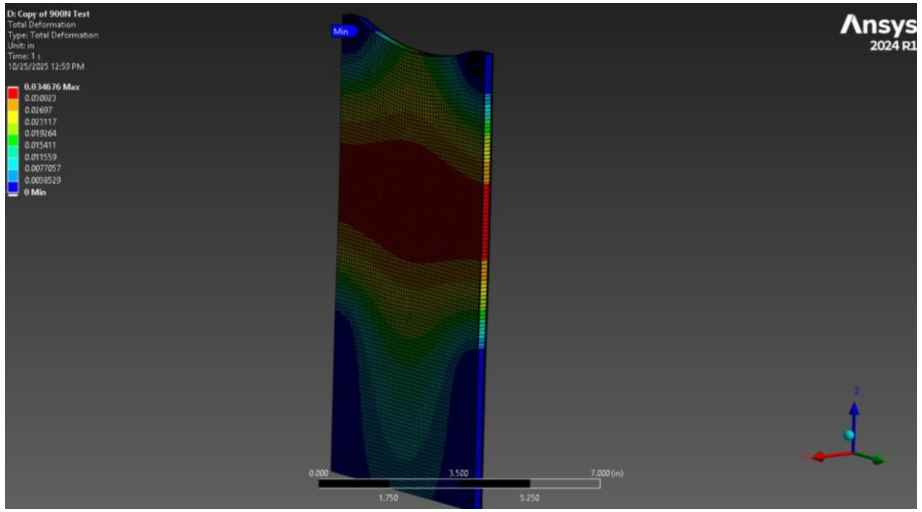
- Topics
  - Headrest back plate
  - Steering Wheel
  - Seatpans
  - Firewalls
  - Heel Pan and Pedal Face
  - Dash
  - Steering Column Tube
  - Control Arms



Slide Owner: Ocean

Headrest - Design

- 900N Load
- Solid plate more stable than cut extrude
- 2 Prong Attachment, 2 Bolts w/ tabs on top

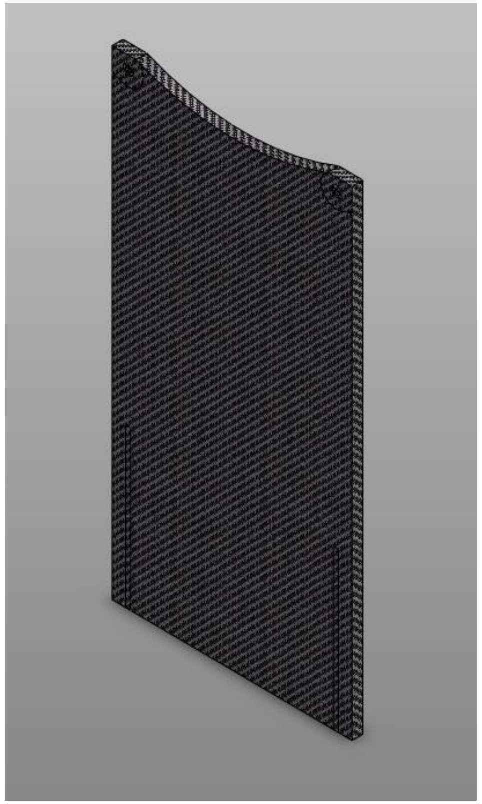


Laminate	Thickness (in)	Max. Deformation (in)	Min. FOS	Weight (lbm)
0/0/0/C/0/0/0	0.266	0.0436	1.356	0.234
0/0/0/0/C/0/0/0/0	0.288	0.0347	1.7255	0.304
0/0/0/0/0/C/0/0/0/0/0	0.310	0.0282	2.094	0.374

Slide Owner: Ocean

Headrest - Manufacturing

- Method: Waterjet Plate
- Manufacture Time in Workdays: 1

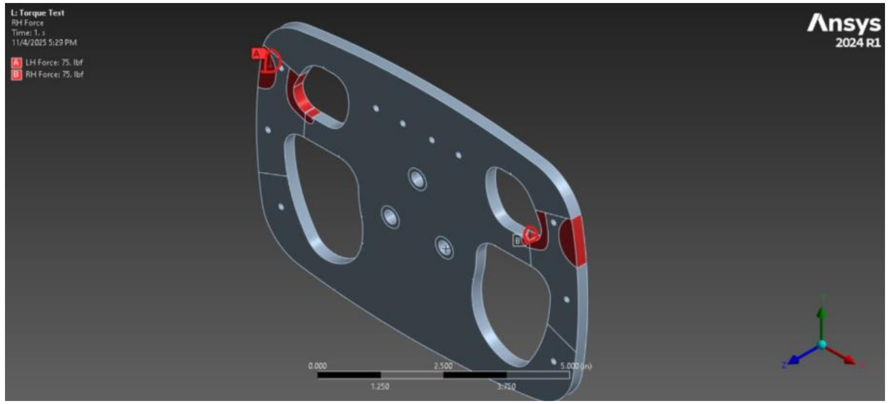


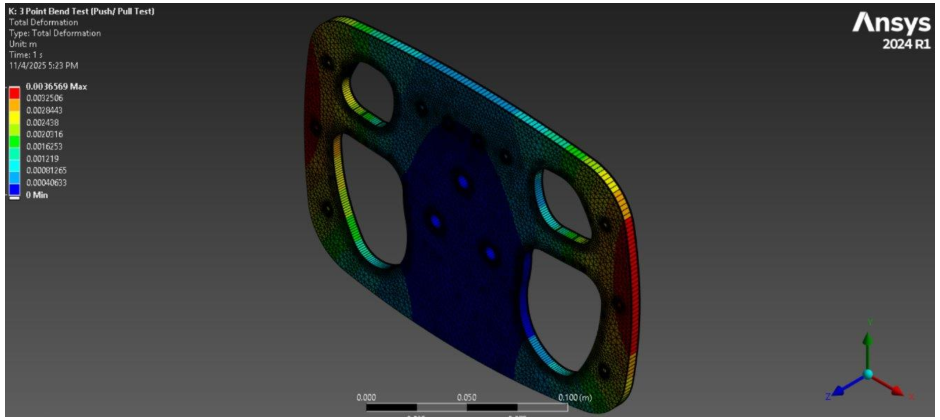
Laminate	24-25 (lbm)	25-26 (lbm)	YoY Delta (lbm)	Part Cost: USD	True Cost: USD
0/0/0/C/0/0/0	0.2393	0.234	0.005	$ 19.34	$ 24.18

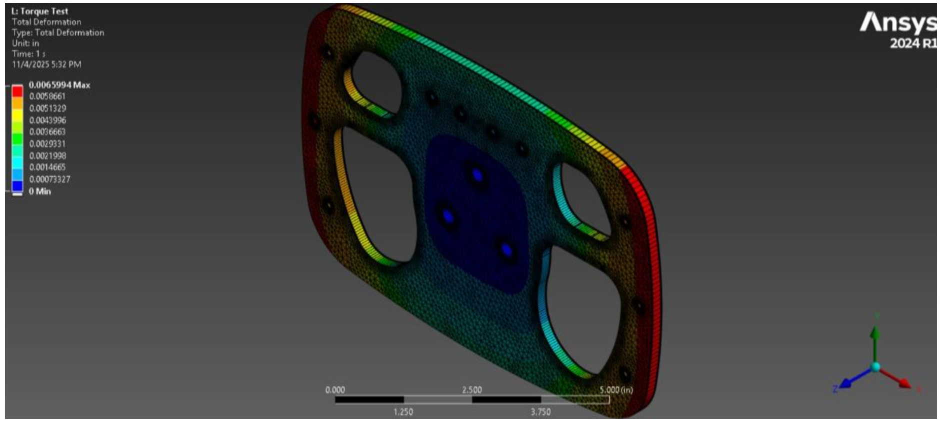
Slide Owner: Ocean

Steering - Design

- 150 lbf Push/Pull Test (3PBT)
- 150 ft-lbf Torque Test (TT)
- <300 lbf Drop Test





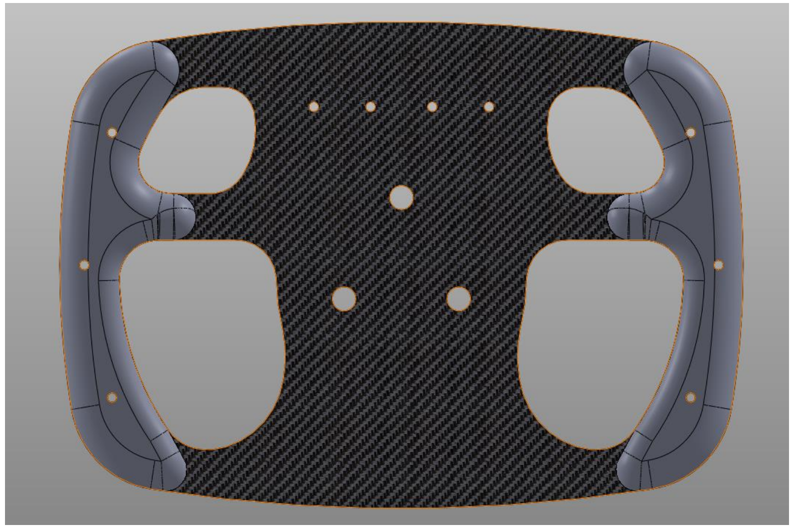


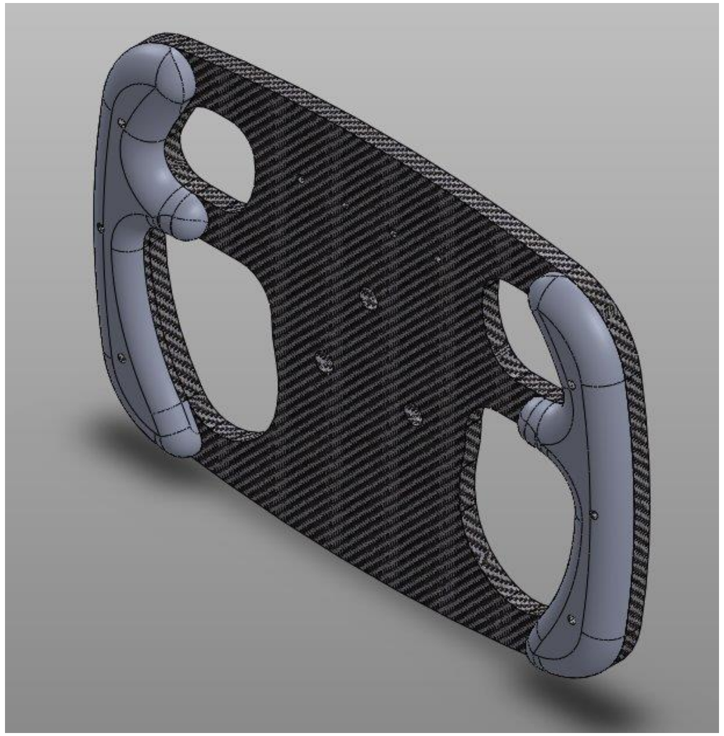
Laminate	Thickness (in)	3PBT Max Deformation (in)	TT Max Deformation (in)	3PBT Min FOS	TT Min FOS
0/0/0/C/0/0/0	0.266	0.144	6.60E-3	1.982	2.688
0/45/0/C/0/45/0	0.266	0.222	4.66E-3	0.421	2.109

Slide Owner: Ocean

Steering - Manufacturing

- Method: Waterjet Plate
  - Handles: 3DP Silicon or Wood
- Manufacture Time in Workdays: 1





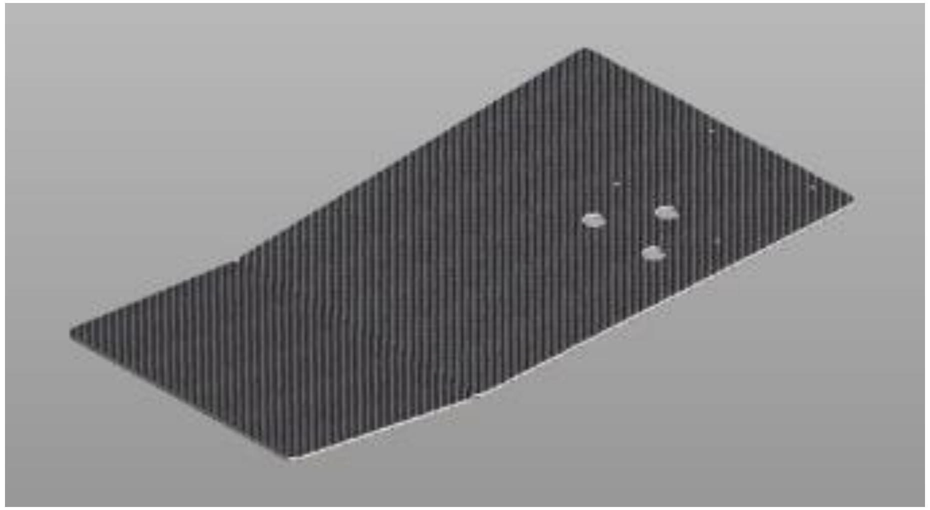
Laminate	24-25 (lbm)	25-26 (lbm)	YoY Delta (lbm)	Part Cost: USD	True Cost: USD
0/0/0/C/0/0/0	0.2662	0.1357	0.1305	$ 11.21	$ 14.02

Slide Owner: Ocean

Seat Pan- Design & Manufacturing

Design

- Parametric CAD
- Upper SP (Smaller)
  - Ply count same, 6
- Lower SP (Bigger w/ holes)
  - Ply count increase, 6 to 8



Manufacturing

- Method: Waterjet Plates
- Manufacture Time in Workdays: 1

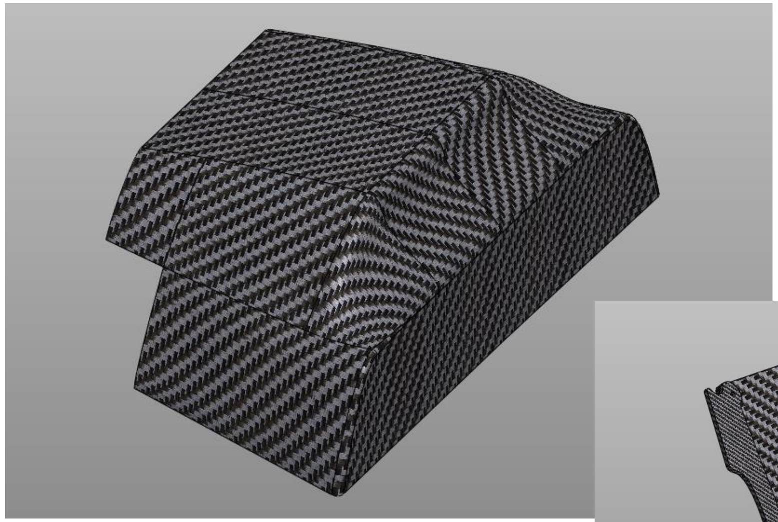
Component	Laminate	24-25 (lbm)	25-26 (lbm)	YoY Delta (lbm)	Part Cost: USD	True Cost: USD
Seatpan - All		2.390	2.494	-0.104	$ 202.07	$ 252.58
Upper	3/C/3		0.643		$ 53.17	$ 66.46
Lower	4/C/4		1.850		$ 148.90	$ 186.13

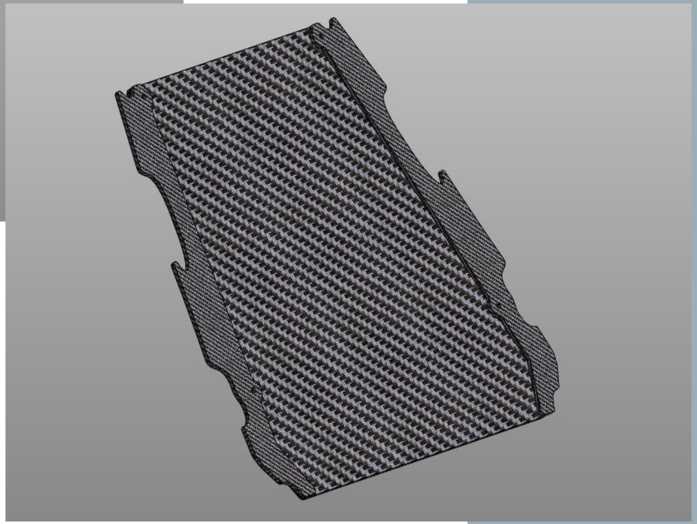
Slide Owner: Ocean

Firewalls - Design

Design
- Upper FW - Aero
  - Ply count same, 3
- Lower FW – Body
  - Ply counts, Sides = 8, Middle = 6

Manufacturing
- Method:
  - Upper: 3DP Mold
  - Lower: Waterjet Plates
- Manufacture Time in Workdays:
  - Upper: Mold ~ 2-3, Layup 1
  - Lower: 1





Component	Laminate	24-25 (lbm)	25-26 (lbm)	YoY Delta (lbm)	Part Cost: USD	True Cost: USD
Upper	0/0/0	1.066	0.804	0.262	$ 55.70	$ 69.62
Lower - All		1.585	2.145	-0.560	$ 176.30	$ 220.37
Lower Middle	3/C/3		1.701		$140.55	$ 175.69
Lower Sides	4/C/4		0.444		$ 35.75	$ 44.69

Slide Owner: Ocean

LHR

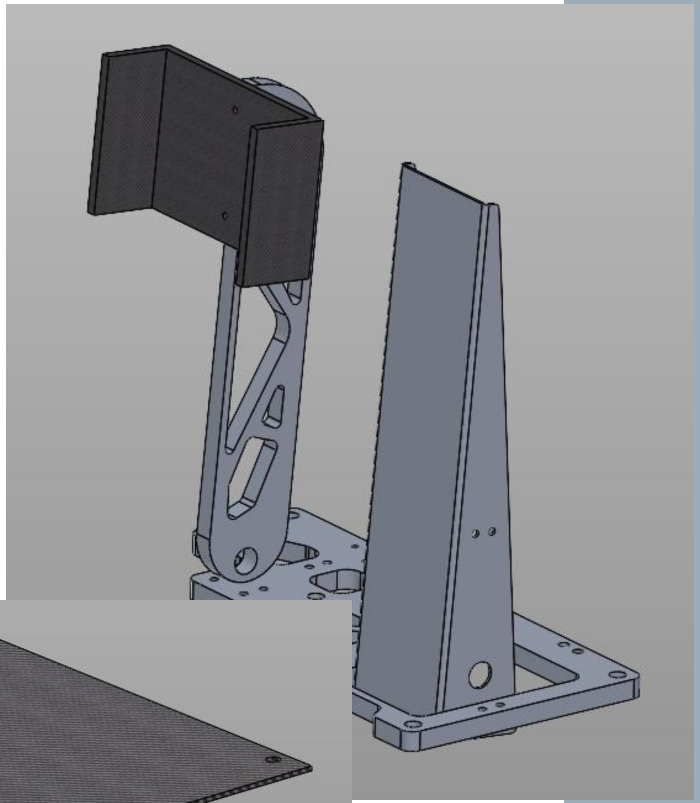
Heel Plate & Pedal Face D&M

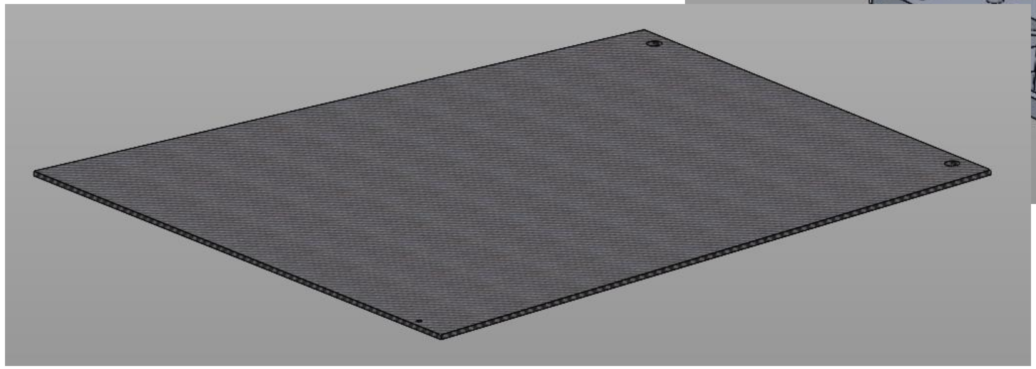
Design

- Heel Plate
  - Ply count, 2
- Brake Pedal Face
  - Ply count, 3

Manufacturing

- Method: Bent Sheet Metal Plate
- Manufacture Time in Workdays:
  - (Very Short) <1
- Cost: USD $
  - Heel Plate: $51.68
  - Pedal Face: $2.36
- Weight: lbm
  - Heel Plate: 0.625
  - Pedal Face: 0.040



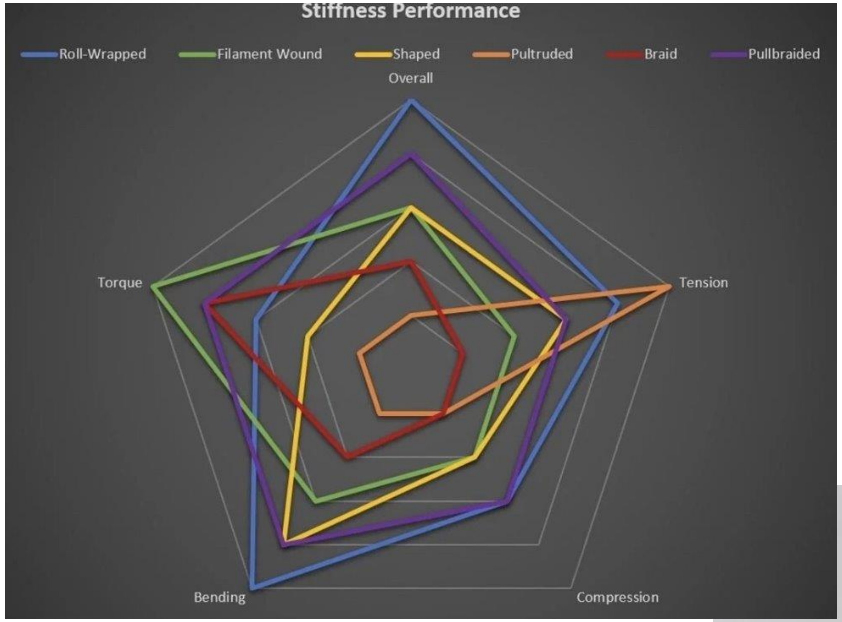


Slide Owner: Ocean

Steering Column

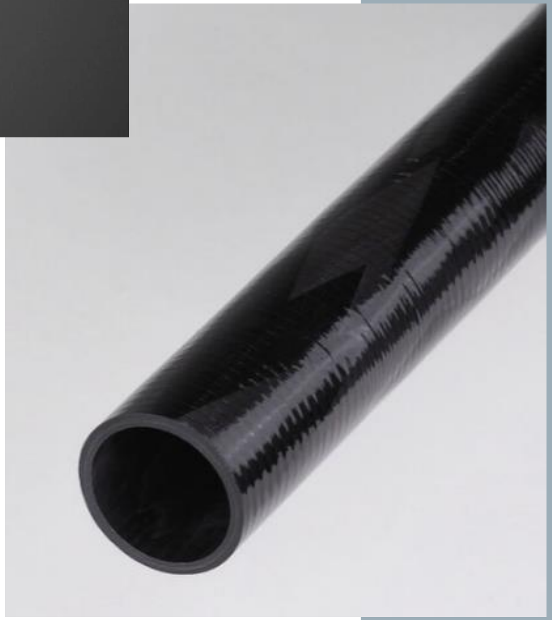
Design
- Filament Wound – Pure Torsion
- 0.1" Wall Thickness

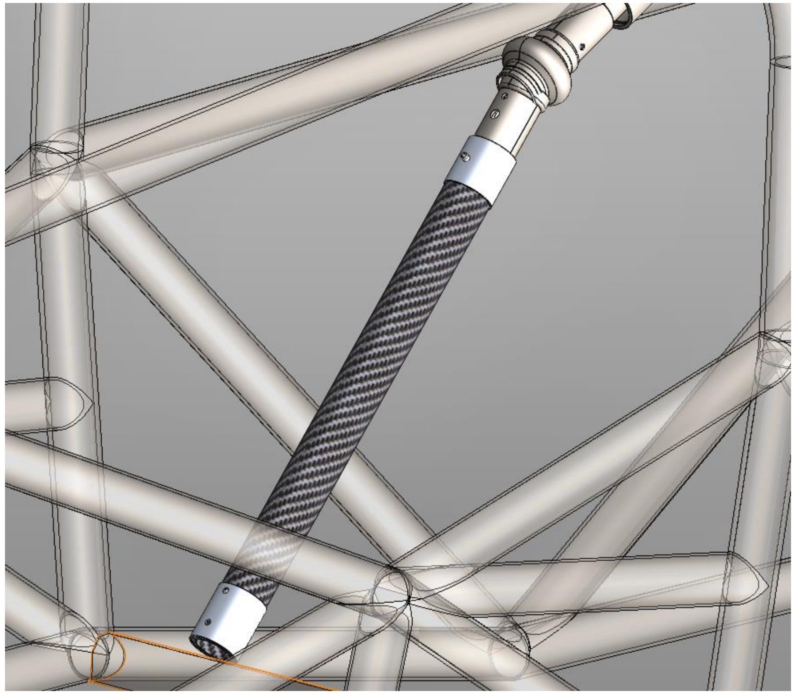
Manufacturing
- Method: Machining then Bonding Exerts/ Drilling for Pins
- Manufacture Time in Workdays:
  - Ctting Tube and Bonding Process, 1
- Cost: USD $
  - 35024 Filament Wound Tube: $91
  - 6061 T6 Aluminum Exerts: ~$100
- Weight: lbm
  - 35024 Filament Wound Tube: 1.461
  - 6061 T6 Aluminum Exerts: 0.02



35024-HM-U Rev B

Ply #	Orientation (degrees)	Location
1	±45	Inside
2	±45	↓
3	±45	
4	±45	
5	±45	Outside





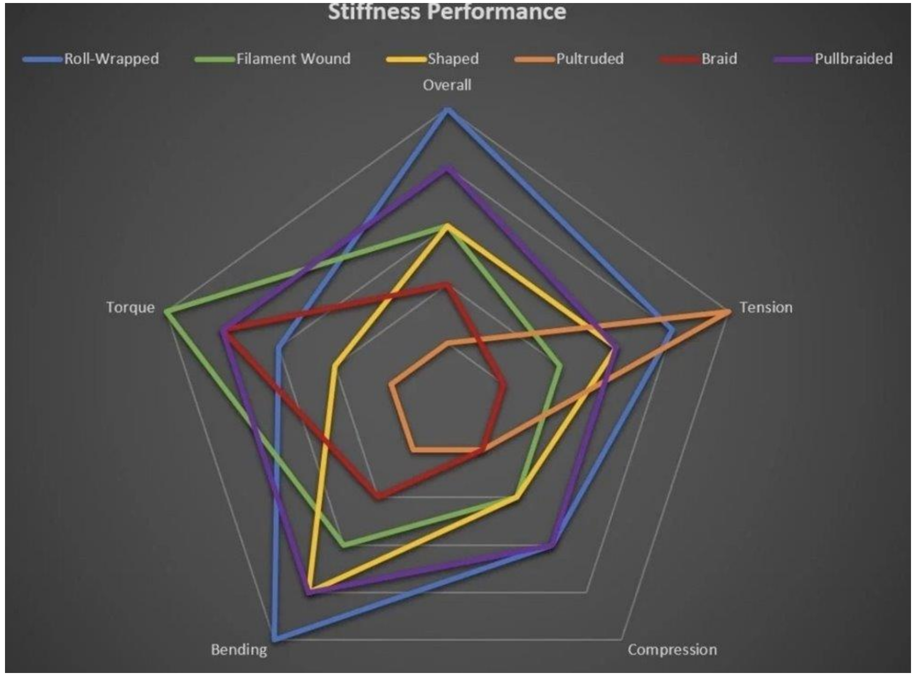
Slide Owner: Ocean

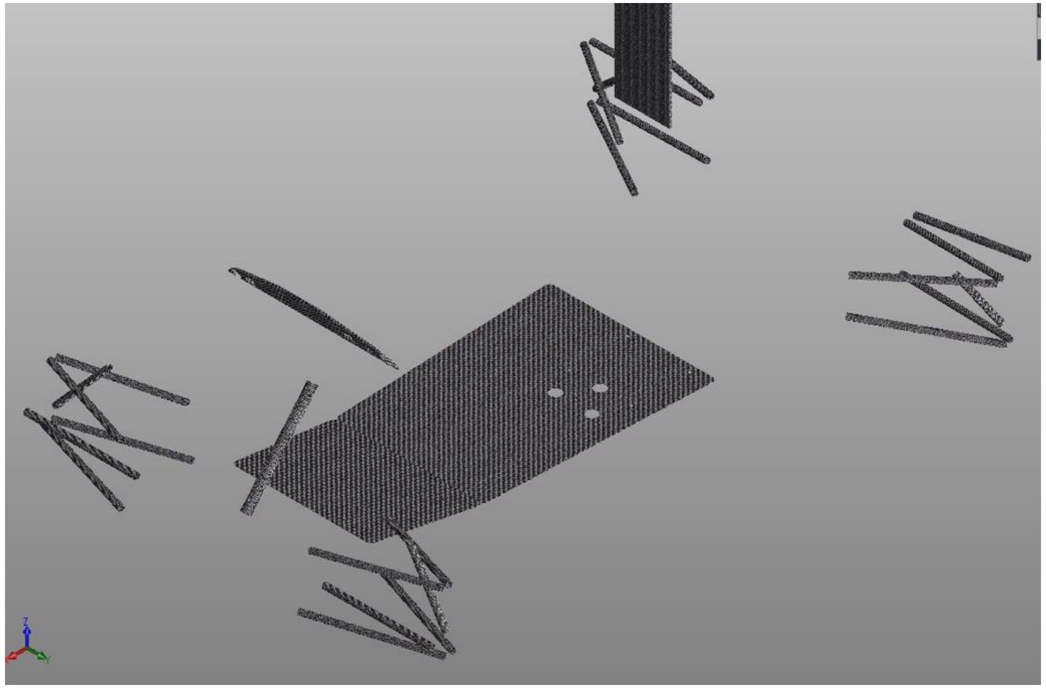
Control Arms - Design

Design
- 45553 Roll Wrapped Tube
- 7075 T6 Aluminum inserts
- Changing 6065 to 7075 for weight weight savings with a slight decrease in strength

45553 Rev B

Ply #	Orientation (degrees)	Location
1	0	Inside
2	0	↓
3	0	
4	90	
5	90	
6	90	
7	0	
8	0	
9	0	
10	0/90	Outside





Slide Owner: Ocean

Control Arms - Manufacturing

- Method: Bonding procedure for CF tubes and Al inserts
- Manufacture Time in Workdays:
  - Cutting Tube and Bonding Process, 1-2
- Cost: USD $
  - 45553 Roll Wrapped Tube: $82 each 4 total $328
  - 7075 T6 Aluminum inserts: ~$100
- Weight: lbm
  - 45553 Roll Wrapped Tube: each 4total 2.25
  - 7075 T6 Aluminum inserts:

Component	**Materials & Process**	**Key Fabrication Details**
Control Arm Tubes	Rock West Composites #45553-IM (10-ply)	OD (Ref. Website); ID (0.5”). 10-ply = 0.064 in.
Control Arm Inserts	7075-T6 Aluminum	OD 0.493 ± 0.001 in; bond length = 1.00 in. Prep = 80 µm Al_2O_3 blast @ 60 psi → Scotch-Brite → acetone → AC-130-2 primer → air dry 1 h.

Slide Owner: Ocean

Overview of Mat. Int. Manufacturing

- 3 Core 3 Plate Layup (0/0/0/C/0/0/0)
  - Headrest back plate
  - Steering Wheel plate
  - Upper Seatpan
  - Lower Firewall Middle
  - Heel Pan
- 4 Core 4 Plate Layups
  - Lower Seatpan
  - Lower Firewall Sides
- Bent Sheet Metal Plate Layups
  - Pedal Face
- 3DP PLA Male Mold to Fiber Glass Female Mold
  - Upper Firewall (3 Ply)
  - Dash (3 Ply)
- Bonding of outsourced tubes and machined inserts
  - Steering Column Tube
  - Control Arms

Slide Owner: Ocean

Aerostructures

Aerostructures Subassembly

Rear Wing

Front Wing

Side Panels

Nose Cone

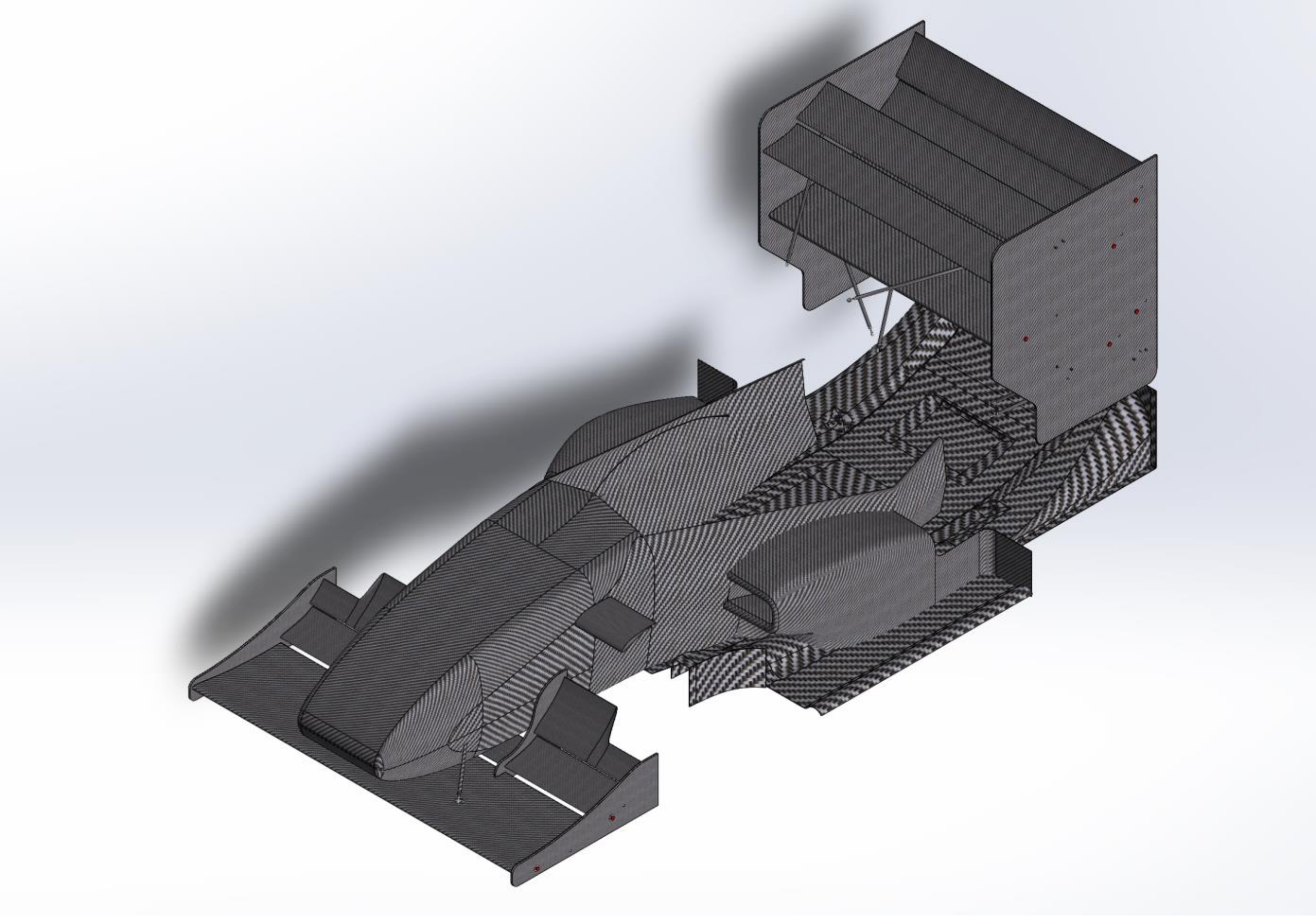
Undertray

Side Pods

Inverted Wings

Air Dams

Mounting Structures



Front Wing Assembly - Design

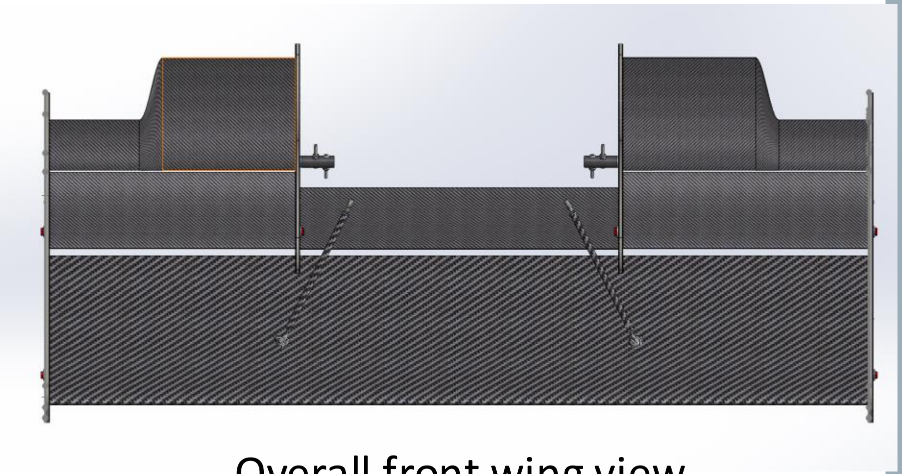
Weight with Tie Rod Mounting

~10.27lbs

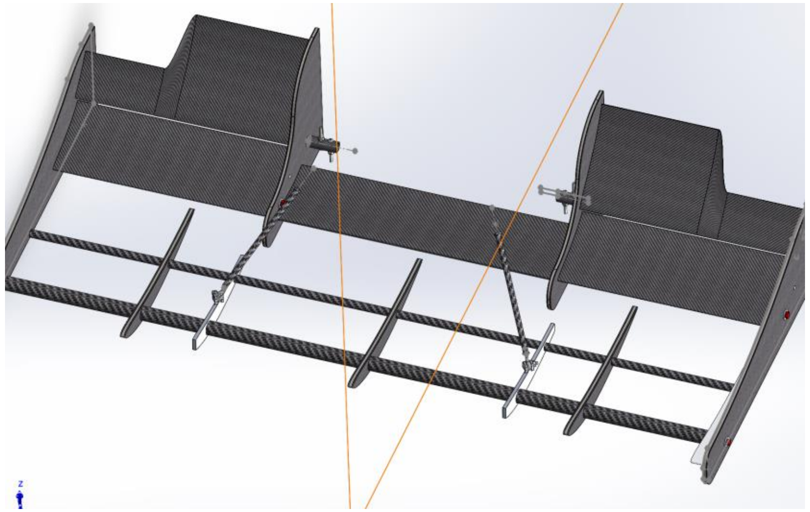
Important Design Considerations and Results

- Went down from 6 plies from last year to 4 plies this year, with added internal structure
  - 3 carbon foam fiber ribs and two spars across the span for added stiffness
  - Decreases need to add more plies as overall stiffness stiffness relatively constant after each additional ply starting at 3 plies (-0.01in deformation at the endplates)

System Name	2024-2025 (lbm)	2025-2026 (lbm)	YoY Delta (lbm)
FWING	9.375	10.27	0.895



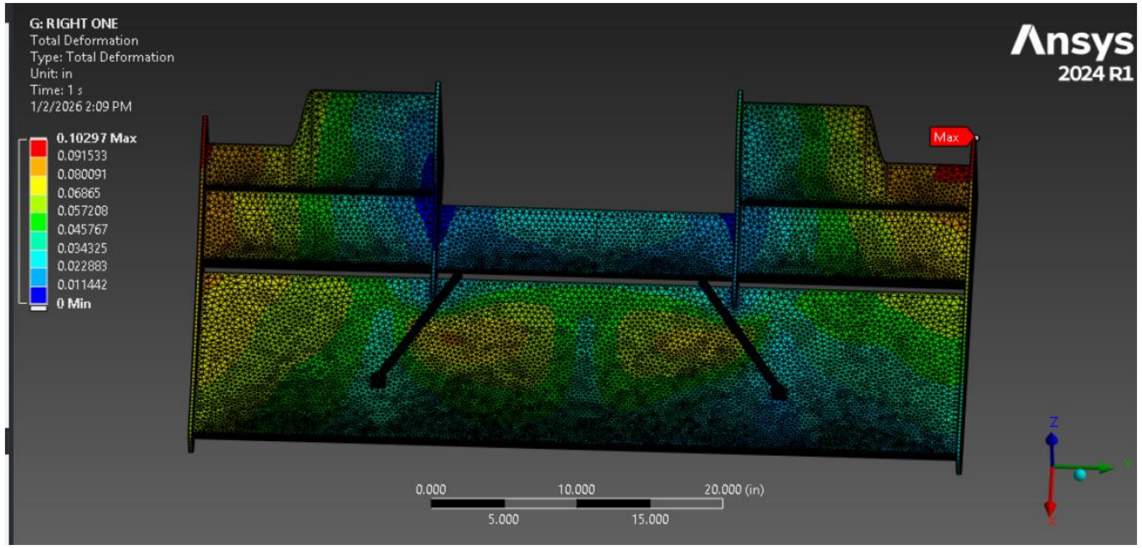
Overall front wing view

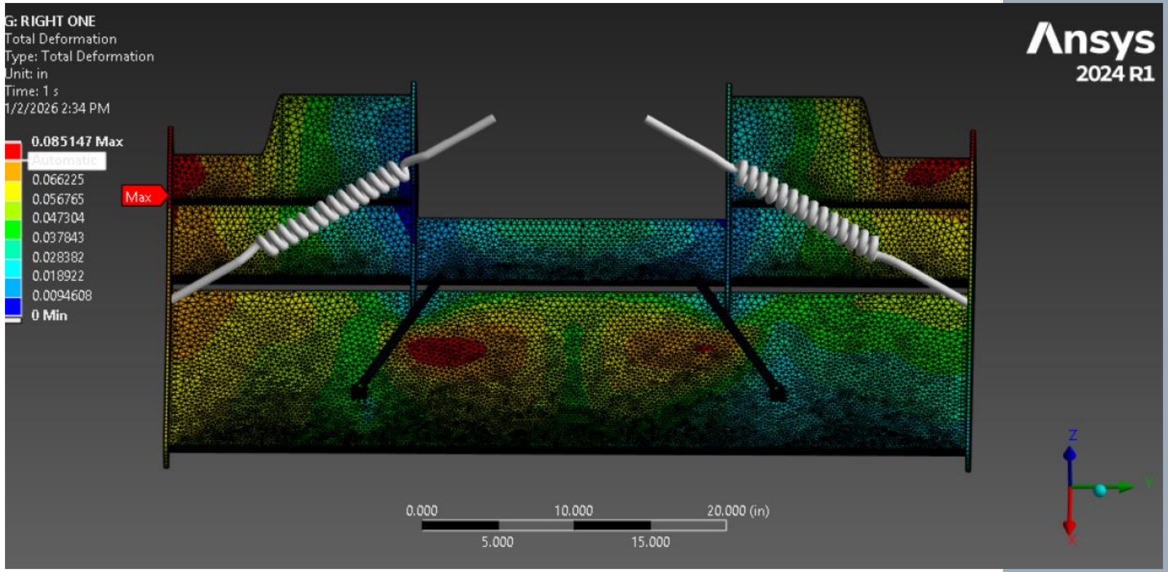


Front wing internal structure plans

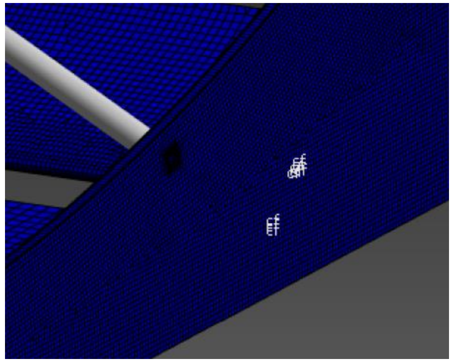
Front Wing Subassembly - Design

Simulation





FWING w/ (left) and w/ out cable (right) : Max Speed Pressure Contour 65mph, 200N of side loading, 2g bump load, and weight



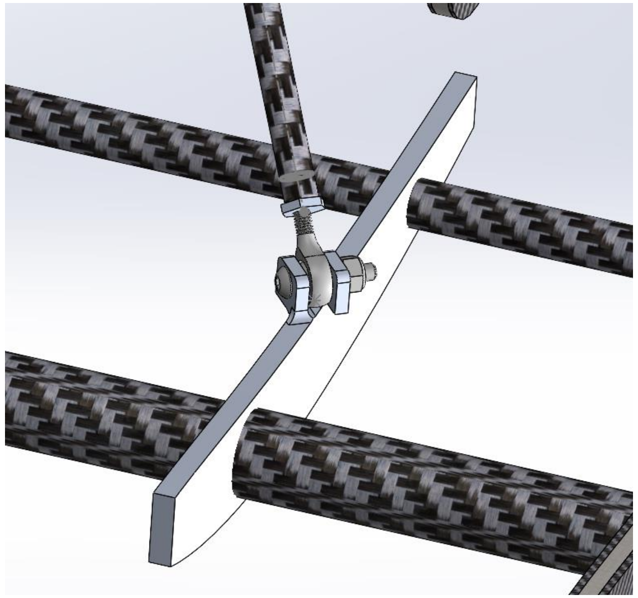
Predicted core failure FOS of 2 on outer endplates w/ and w/ out tension cables

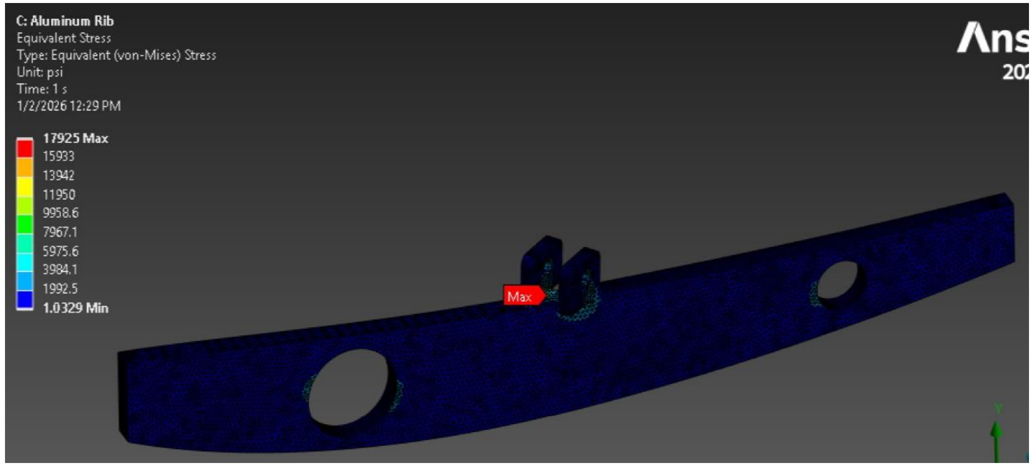
Laminate for Main Element	TT Max Deformation (in)	FOS
0/45	0.15	~1.8 (CF)
0/45/0	0.11	~2 (CF)
0/45/45/0	0.1 03	~2 (CF)
0/45/45/0/0	0.08	~2 (CF)

Front Wing Subassembly - Design

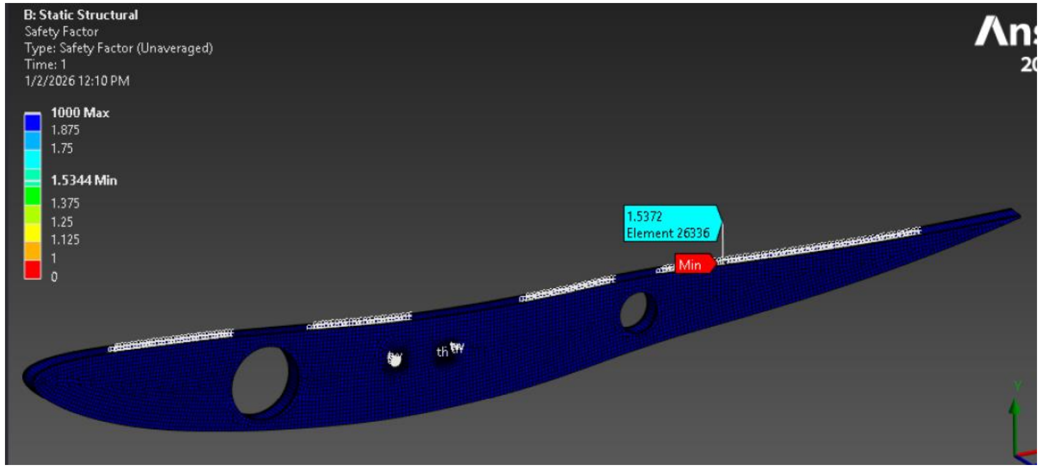
Specific Design Considerations

- Welded on tabs would mitigate usage of bolts and nuts and cut down manufacturing for the angled clevis
- Welded on tabs are 0.13lbs heavier
- Consider honeycomb core as it provides more bonding area and lighter





Max speed, side loading, bump loading, and weight (FOS = 1.5 and 0.25lbs)



Max speed, side loading, bump loading, and weight (FOS = 1.534 and 0.12lbs with clevis)

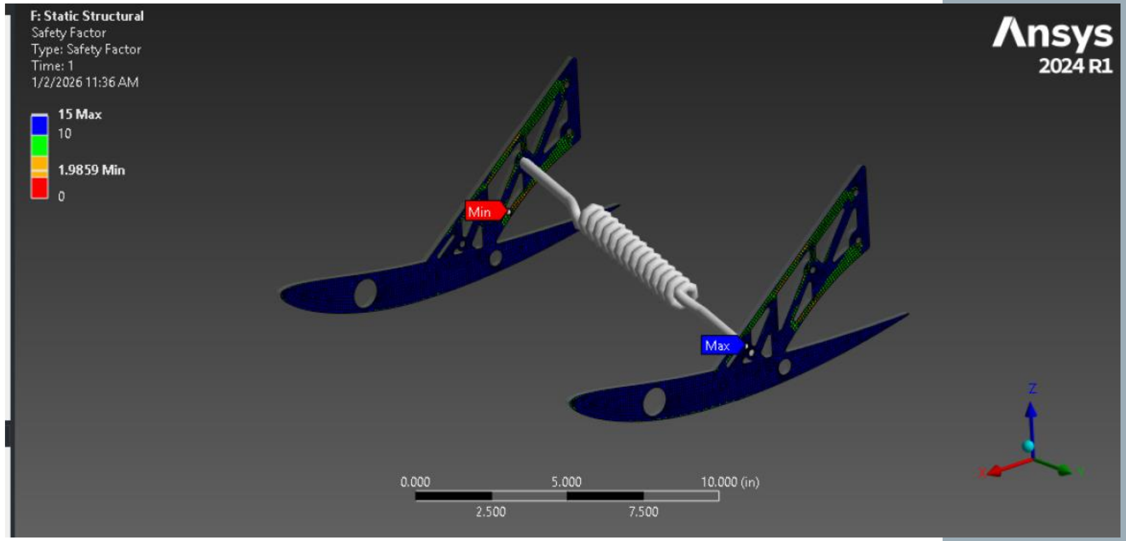
Swan Neck Iteration

Assembly Weight

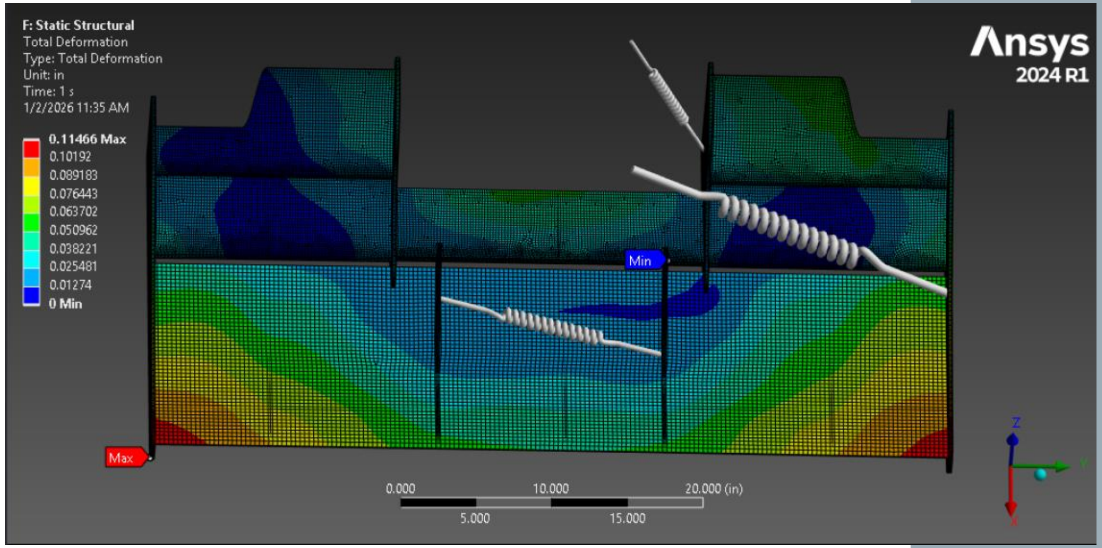
- 10.71lbs (without removal of internal material in the swan neck)

Stiffness Comparison between Swan Neck and Tie Rod

- Overall, the tie rod provides greater uniform stiffness the main profile, while the swan neck provides its maximum stiffness in the center
- With all mounting, the swan neck is about 0.44lbs heavier and requires cables to provides outboard stiffness.
- However, it is overall easier to mesh the swan neck with the rest of the internal structure since it partly consists of an aluminum rib.



Swan neck stress profile: Max speed, side loading, and bump loads

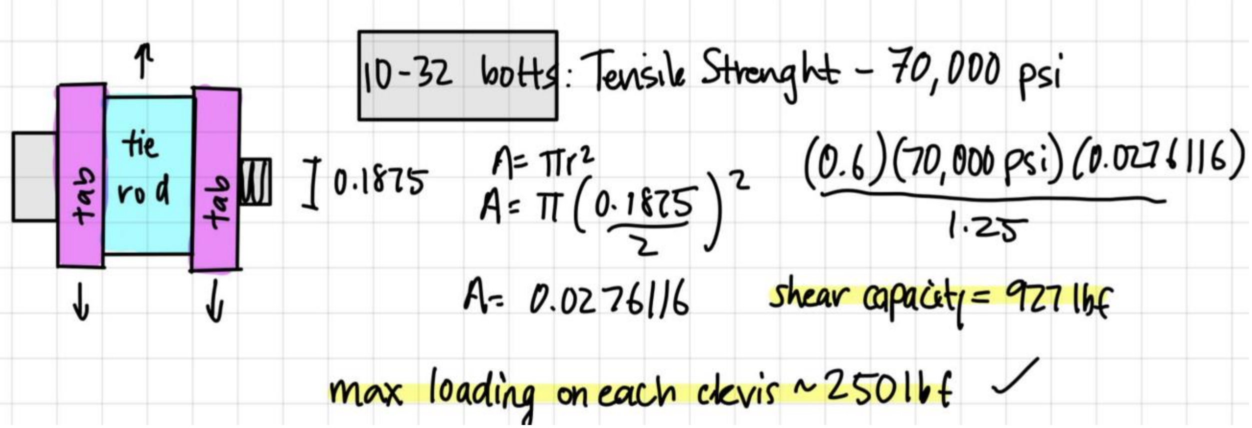


Overall assembly deformation: Max speed, side loading, and bump loads

Additional Design Considerations

Switching from ¼-28 to 10-32 Screws

- Weight of ¼ 28 ~ 0.012lbs
- Weight of 10-32 bolt ~ 0.004lbs (3x as lighter)
- For 15 bolts, that is 0.12lbs lighter



Rockwest 45546 (0.25OD x 0.375ID) Stiffness Corroboration

Inputs

Notes:
- A green highlight indicates a valid input.
- A red box indicates an invalid input.

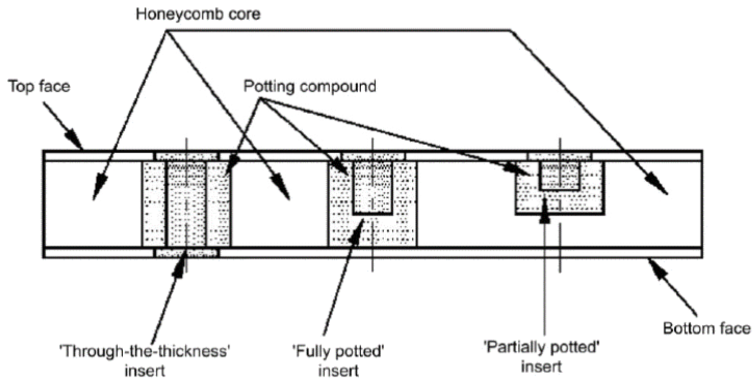
Label	Value	Units
Load	250.000 Positive value indicates tension. Negative value indicates compression.	lb
Outer Diameter	0.375	in.
Inner Diameter	0.250	in.
Length	20.000 Value up to **60.000**	in.
End Conditions	Pinned-Pinned	N/A

Outputs

Notes:
- A green highlight indicates that a sample is unlikely to fail **in this manner**.
- A red highlight indicates that a sample is likely to fail **in this manner**.

Label	Result	Units
Max Axial Stress	4.07e+3	psi
1st Order Buckling Critical Load	SAMPLE IS IN TENSION	lb
Change in Length	0.00800	in. (linear elastic only)
Part Weight	0.0670	lb

Potted Inserts - allows for better load distribution from bolts into the carbon skin



Front Wing - Manufacturing

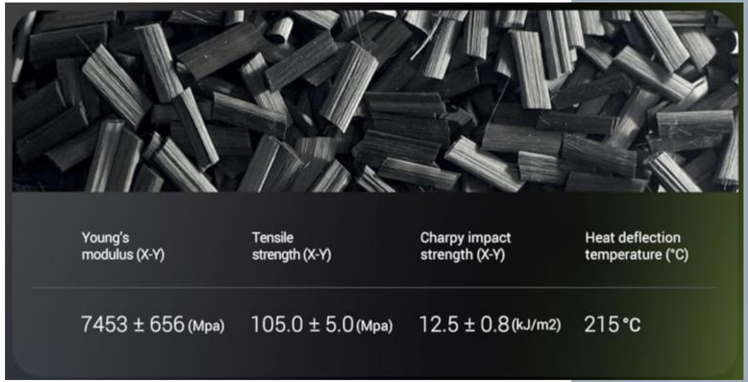
Front Wing Main – 3D printed split mold with Pa6CF- Nylon with prepreg

0-45-45-0

Curved Secondary - 3D printed split mold with Pa6CF- Nylon with prepreg

0-0

3D printed Mold --> Epoxy Coat/ Gelcoat --> Fibrelease--> Layup



Straight Secondaries/Middle Element– previous years aluminum molds with prepreg

0-0

Endplates

0-45-45-0-Core-0-45-45-0

CF Ribs

0-90-90-0-Core-0-90-90-0

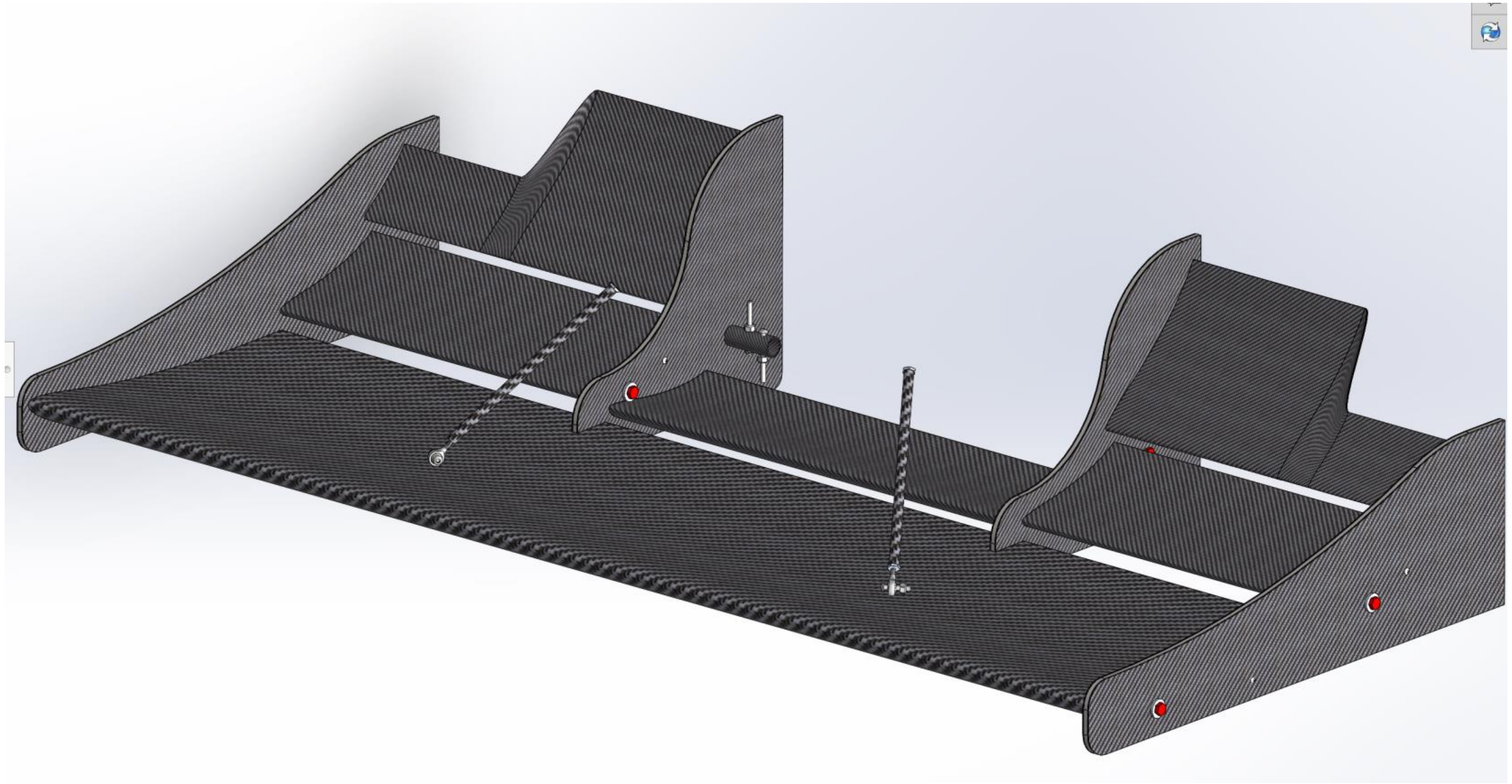
Aluminum Mold --> Fibrelease/Frekote --> Layup

Pa6CF – High Temp Filament Curved Secondary Molds

Front Wing – Future Work

What needs to be done more?

Need to buy more pa6 filament.
Post process and test different techniques of curing on the molds.

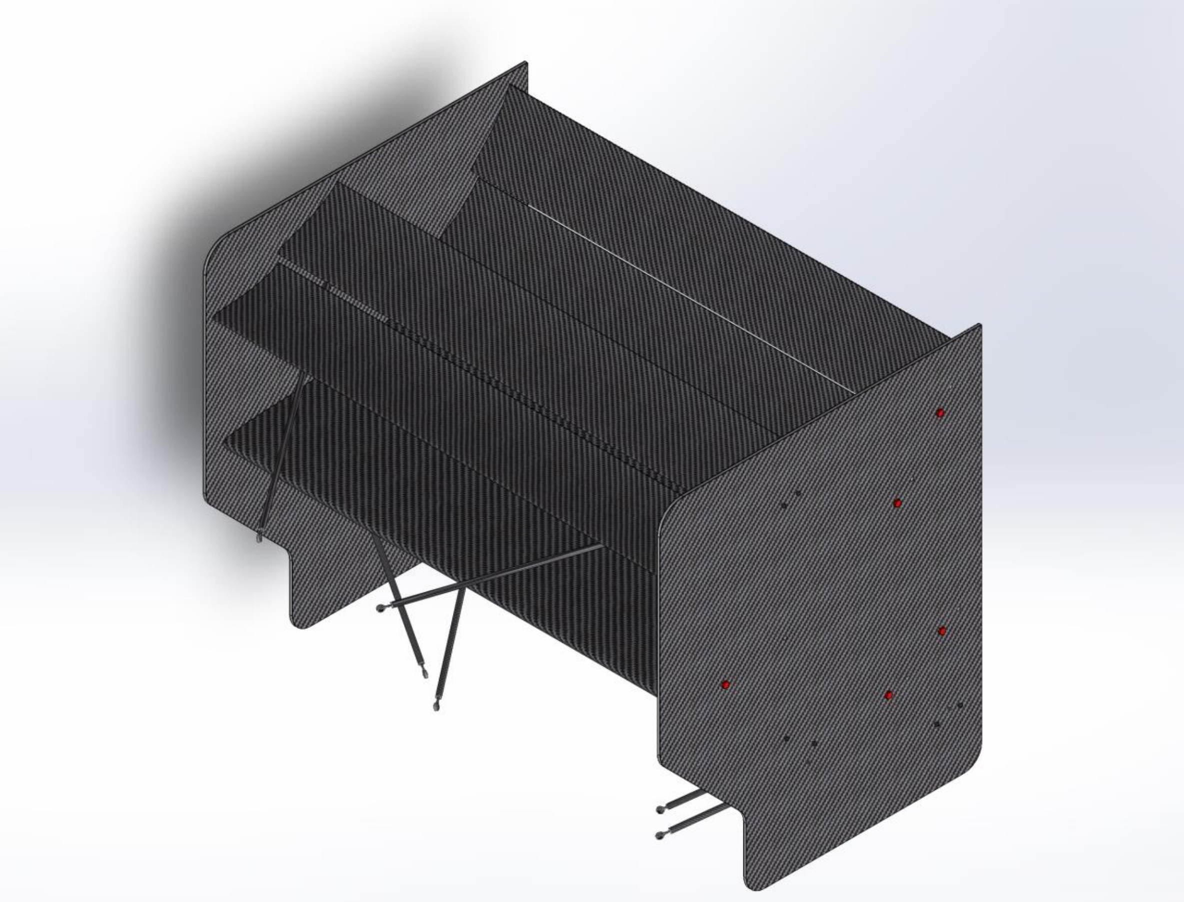


Rear Wing Subassembly

Weight: 16.12lb

Main item to focus on

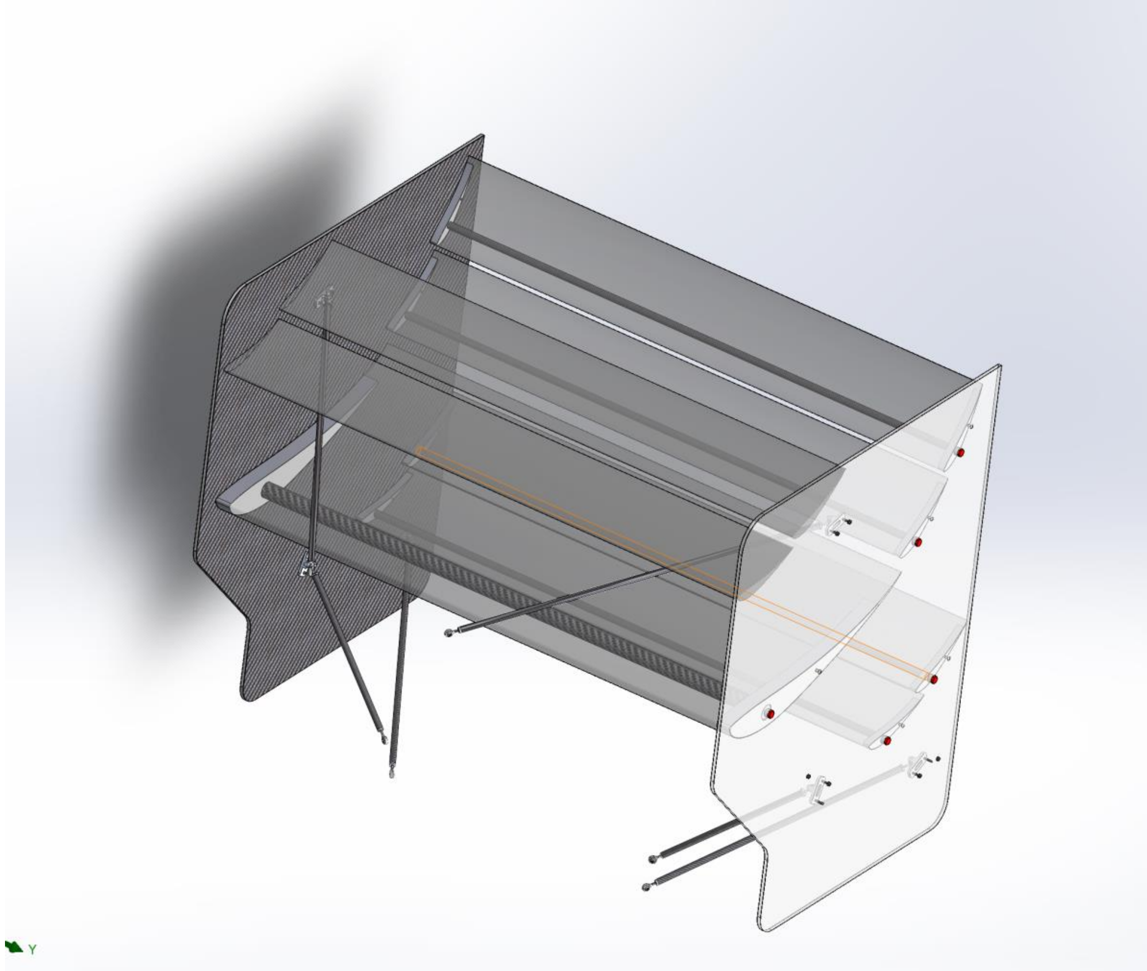
- **Aero Load FEA**
- **Mounting Structure Analysis**



Ply Layout, Internals

- End Plate- 4 core 4, 0, 45, 45, 0, core, 0, 45, 45, 0
- Main- 4 Ply, 0, 45, 45, 0
- Secondaries- 2 Ply, 0, 90

- Changes from previous years
  - Cornering -> Shear



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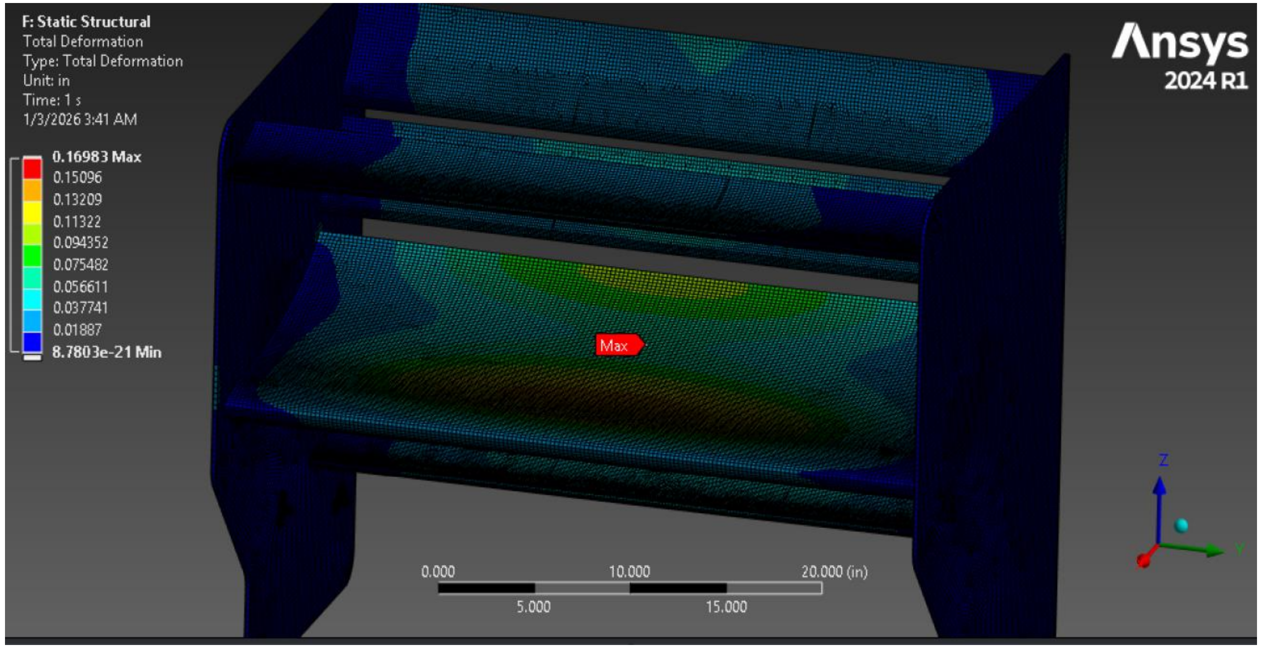
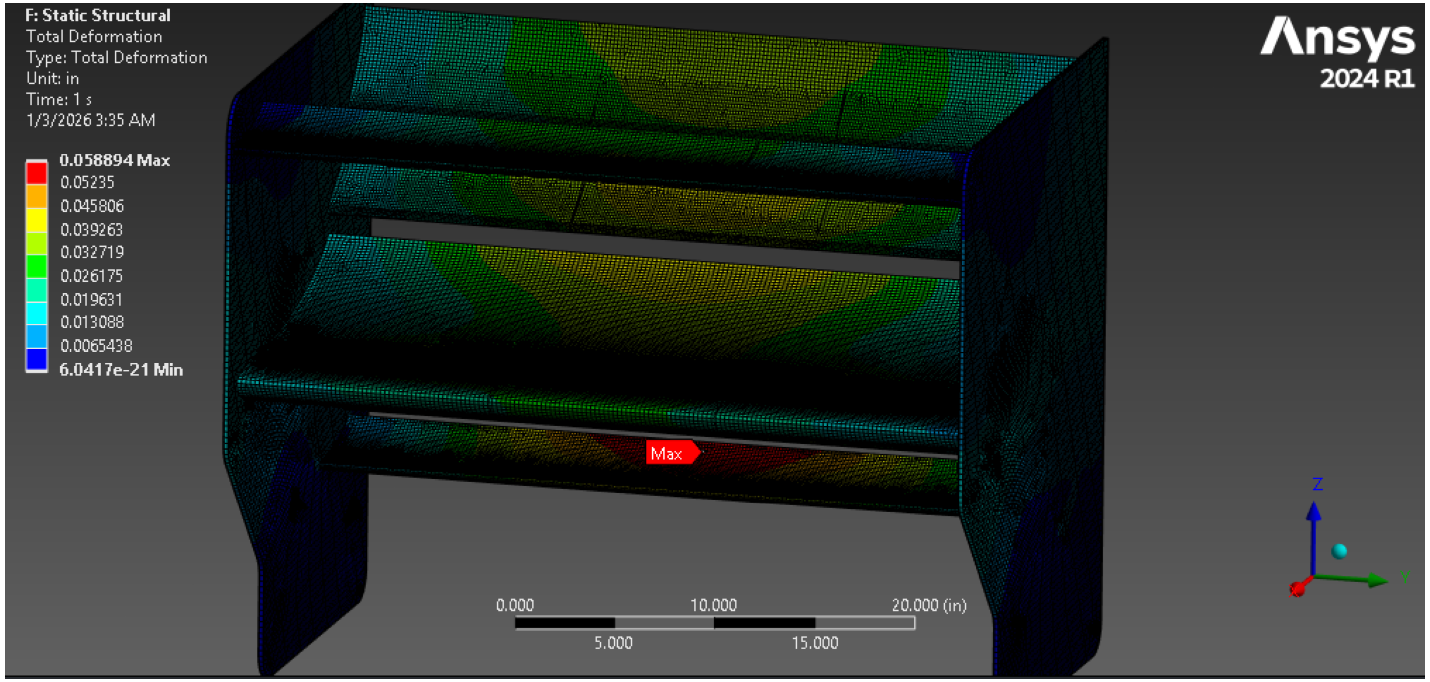


Max speed, side gusts, bump load, and weight; Without Internal Structures
0.17 in max def

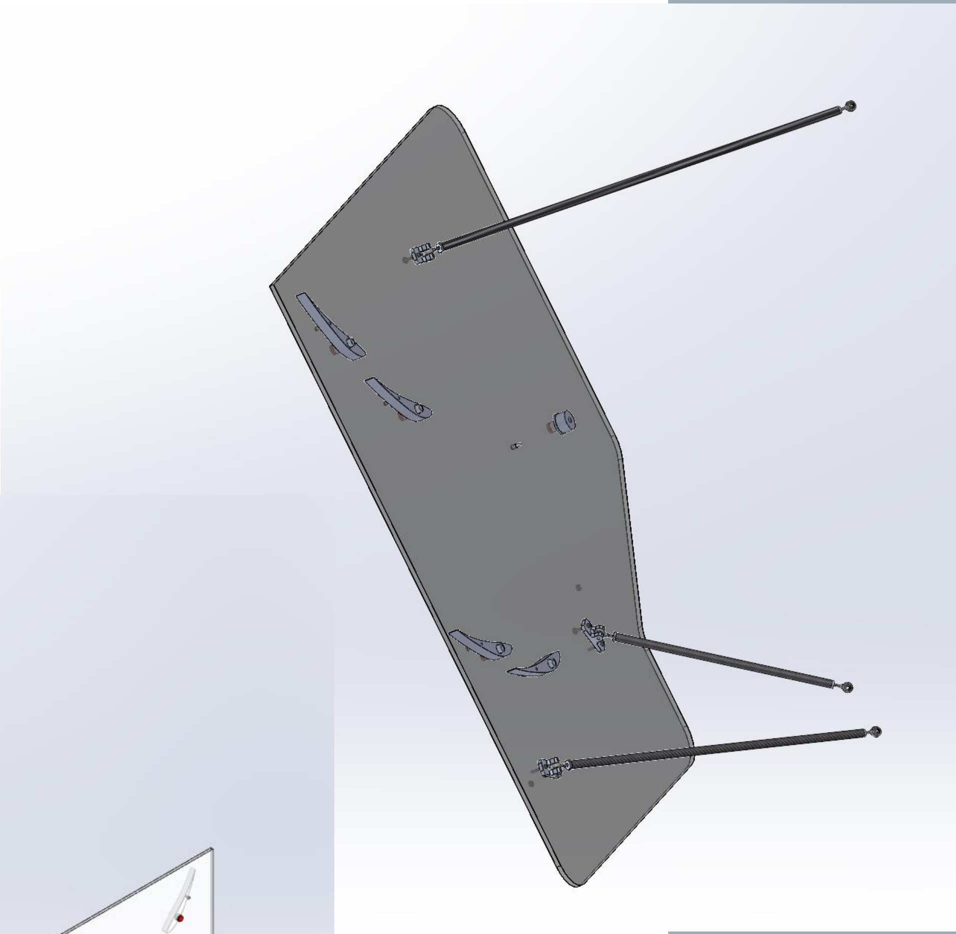
Weight different between with internal structure (2 ribs and one spar) and without is only 0.42lbs

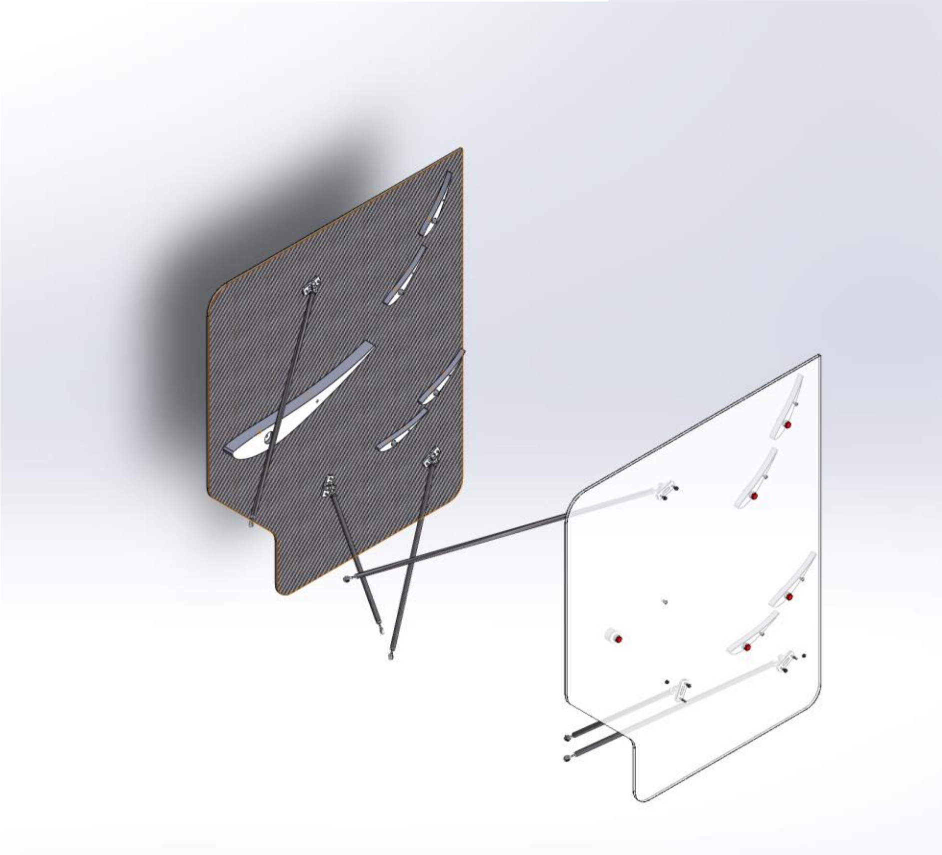
Max speed, side gusts, bump load, and weight; With Internal Structures
0.06 in max def



6 Bar Mounting Structure

- **Prev Concerns:**
  - Cross Wind Shake,
- **Solution:**
  - 6 bars
  - Constraining 6 DOF
    - 2 bars - 4 DOF
    - 4 bars – 0 DOF, but braced upon wing
    - 6 bars – 0 DOF, braced on mounting





Slide Owner:

Truss Solver

6 Bar Truss Solver, with Aero Wrench, considerations for

Downforce, Drag, Cp, Cg

Verified with: 2 Excel Calcs, Python Calc, FEA Probing

C: > Users > dhruv > Downloads > 3dtruss3.py > ...

```python
    [-0.75,  0.25, 0.38],   # Link 3
    [-0.75, -0.25, 0.38],   # Link 4
    [-0.75,  0.24, 0.32],   # Link 5
    [-0.75, -0.24, 0.32],   # Link 6
], dtype=float)

# Wing connection points (wing-side) per link: (x,y,z) [m]
r_wing = np.array([
    [-0.79,  0.46, 1.06],   # Link 1
    [-0.79, -0.46, 1.06],   # Link 2
    [-0.83,  0.46, 0.57],   # Link 3
    [-0.83, -0.46, 0.57],   # Link 4
    [-1.05,  0.46, 0.47],   # Link 5
    [-1.05, -0.46, 0.47],   # Link 6
], dtype=float)

# Aerodynamic wrench about AERO origin
F_aero = np.array([-266.0, 0.0, -957.0])      # [N]  (Fx,Fy,Fz)
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

```
=== Axial Link Forces (+ tension, - compression) ===
Link 1: N = -301.308832  (Compression)
Link 2: N = -301.308832  (Compression)
Link 3: N =  927.156325  (Tension)
Link 4: N =  927.156325  (Tension)
Link 5: N = -192.117385  (Compression)
Link 6: N = -192.117385  (Compression)
```

Frame Connection Points Positions

Link 1	Link 2	Link 3	Link 4	Link 5	Link 6	
-0.325	-0.325	-0.760	-0.760	-0.775	-0.775	x
0.123	-0.123	0.268	-0.268	0.254	-0.254	y
0.947	0.947	0.389	0.389	0.329	0.329	z

Wing Connection Point Positions

Link 1	Link 2	Link 3	Link 4	Link 5	Link 6	
-0.795	-0.795	-0.839	-0.839	-1.12	-1.12	x
0.462	-0.462	0.462	-0.462	0.462	-0.462	y
1.063	1.063	0.57	0.57	0.499	0.499	z

Aerodynamic Wrench

Fx	Fy	Fz	Mx	My	Mz
-266	0	-957	0	-1860	0

Aerodynamic Wrench Acting Point (O)

X,Y,Z
0.767
0
0

Position of Rear Wing CG and Wing Mass

X,Y,Z	Mass
-0.62	10.2
0	
0.67	

Dimensions of Rear Wing Endplate

Height	Width
0.75	0.68326

Position of Rear Wing Endplate Centroid

X,Y,Z
-0.87
-0.49
0.82

Cross Wind Velocity

Velocity
8.9

Linkage Position Vectors

Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
-0.470	-0.47	-0.079	-0.079	-0.345	-0.345
0.339	-0.339	0.194	-0.194	0.208	-0.208
0.116	0.116	0.181	0.181	0.17	0.17

Link Unit Vectors (u_i)

Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
-0.79526682	-0.79526682	-0.28536783	-0.28536783	-0.78901933	-0.78901933
0.57360735	-0.57360735	0.70077669	-0.70077669	0.47569861	-0.47569861
0.19627862	0.19627862	0.65381743	0.65381743	0.38879213	0.38879213

Position Vector from O to Wing Connection Point (r_i)

Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
-1.562	-1.562	-1.606	-1.606	-1.887	-1.887
0.462	-0.462	0.462	-0.462	0.462	-0.462
1.063	1.063	0.57	0.57	0.499	0.499

Cross Wind Drag Force

F_D
28.0076302

Position Vector from Endplate Centroid to Wing Connection Points

Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
0.075	0.075	0.031	0.031	-0.25	-0.25
0.952	0.028	0.952	0.028	0.952	0.028
0.243	0.243	-0.25	-0.25	-0.321	-0.321

Moment Vectors

-0.51906	0.519064	-0.09738	0.097379	-0.05775	0.057752
-0.53878	-0.53878	0.887371	0.887371	0.33993	0.33993
-0.52856	0.528561	-0.99361	0.993607	-0.53312	0.533116

[A]

-0.79527	-0.79527	-0.28537	-0.28537	-0.78902	-0.78902
0.573607	-0.57361	0.700777	-0.70078	0.475699	-0.4757
0.196279	0.196279	0.653817	0.653817	0.388792	0.388792
-0.51906	0.519064	-0.09738	0.097379	-0.05775	0.057752
-0.53878	-0.53878	0.887371	0.887371	0.33993	0.33993
-0.52856	0.528561	-0.99361	0.993607	-0.53312	0.533116

[b]

266
0
957
0
1860
0

[T]

-299.872
-299.872
945.7958
945.7958
-208.387
-208.387

Linkage Forces From Lift and Drag (N)

Link	Link	Link	Link	Link	Link
-299.87	-299.87	945.80	945.80	-208.39	-208.39

Moment Vectors

0.04747066	0.144882386	0.797628366	-0.15688728	0.522829367	-0.14181307
0.20797073	0.207970734	-0.05107362	-0.05107362	-0.350473239	-0.35047324
0.80011456	-0.02075308	0.29339425	-0.01373378	0.632221751	0.14101719

[A]

-0.79526682	-0.79526682	-0.28536783	-0.28536783	-0.789019332	-0.78901933
0.57360735	-0.57360735	0.700776692	-0.70077669	0.475698612	-0.47569861
0.19627862	0.19627862	0.653817429	0.65381743	0.388792135	0.38879213
0.04747066	0.144882386	0.797628366	-0.15688728	0.522829367	-0.14181307
0.20797073	0.207970734	-0.05107362	-0.05107362	-0.350473239	-0.35047324
0.80011456	-0.02075308	0.29339425	-0.01373378	0.632221751	0.14101719

[b]

0
28.0076302
0
0
0
0

[T]

20.5093502
-20.5093502
45.9744605
-45.9744605
-63.0195851
63.0195851

Link Forces With Cross Wind and Inertial Forces (N)

Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
-279.36	-320.38	991.77	899.82	-271.41	-145.37

about the y

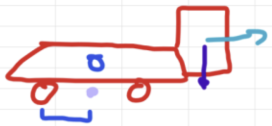
O

7.6x → 13m/s → 35 m/s

Const. Re

Cp ⇒ M = 0

Scale by down Force



Truss Solver Outputs

								N	
ui*	-0.80105	-0.80105	-0.27185	-0.27185	-0.7479	-0.7479	266	F1	-301.309	Compression
	0.576757	-0.57676	0.713609	-0.71361	0.54846	-0.54846	0	F2	-301.309	Compression
	0.16021	0.16021	0.645646	0.645646	0.37395	0.37395	957	F3	927.1563	Tension
ri*ui	-0.53767	0.537666	-0.10976	0.10976	-0.08576	0.085759	0	F4	927.1563	Tension
	-0.59967	-0.59967	0.876142	0.876142	0.327954	0.327954	1860	F5	-192.117	Compression
	-0.52953	0.529527	-1.01458	1.014582	-0.65252	0.652517	0	F6	-192.117	Compression

```
=== Axial Link Forces (+ tension, - compression) ===
Link 1: N = -301.308832  (Compression)
Link 2: N = -301.308832  (Compression)
Link 3: N =  927.156325  (Tension)
Link 4: N =  927.156325  (Tension)
Link 5: N = -192.117385  (Compression)
Link 6: N = -192.117385  (Compression)
```

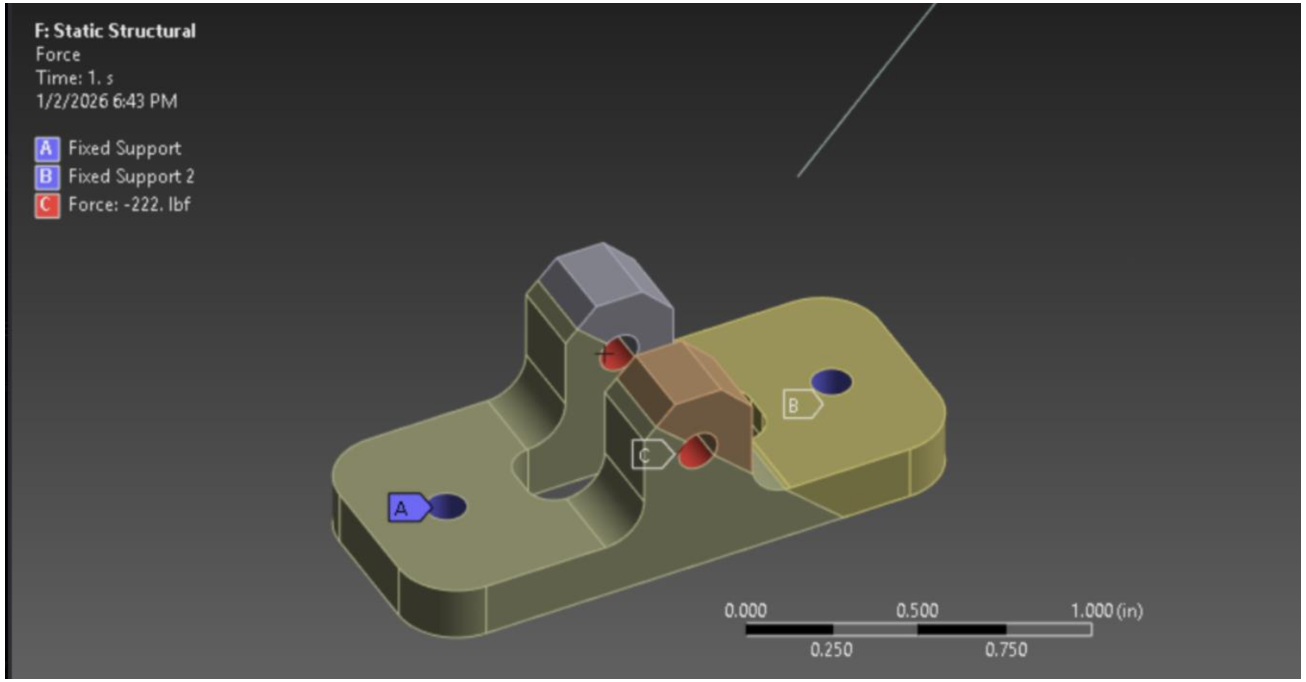
Slide Owner:

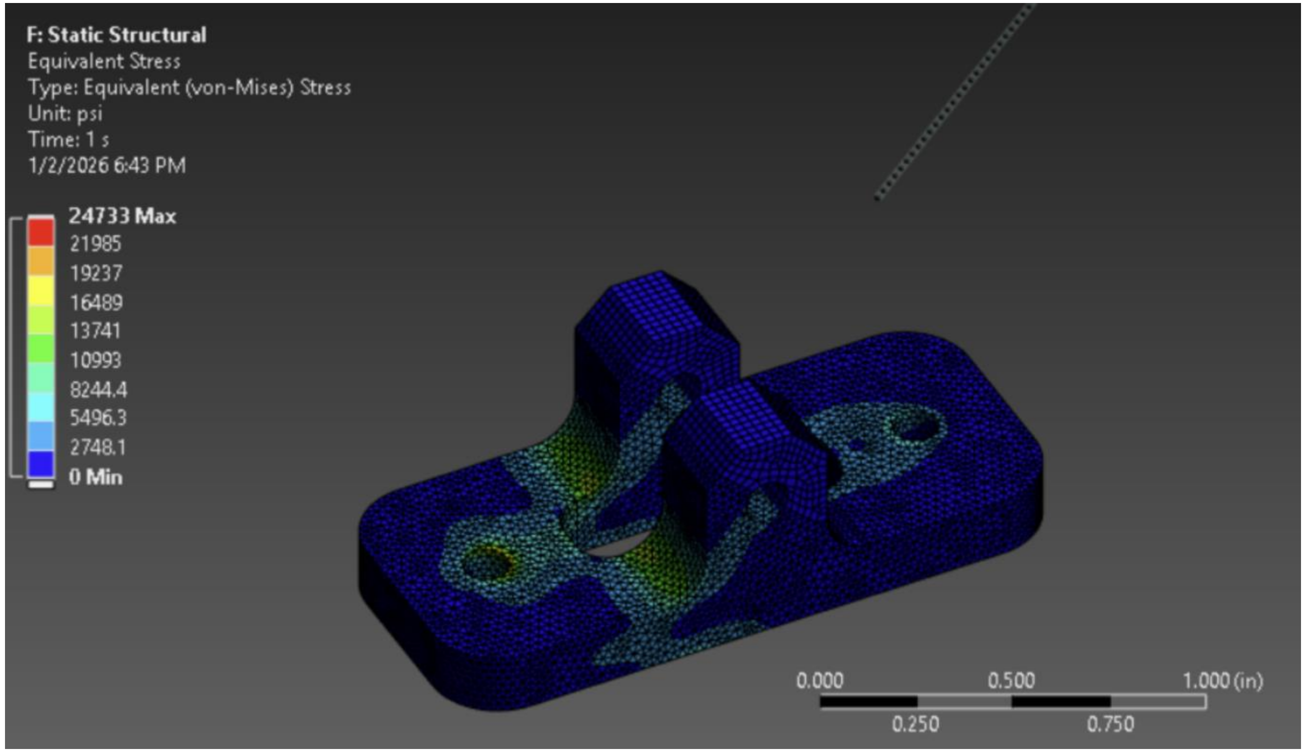
LHRC

Clevis FEA

- Ran on 222lbf, ~982 N, actual 65mph simmed force is 927 N

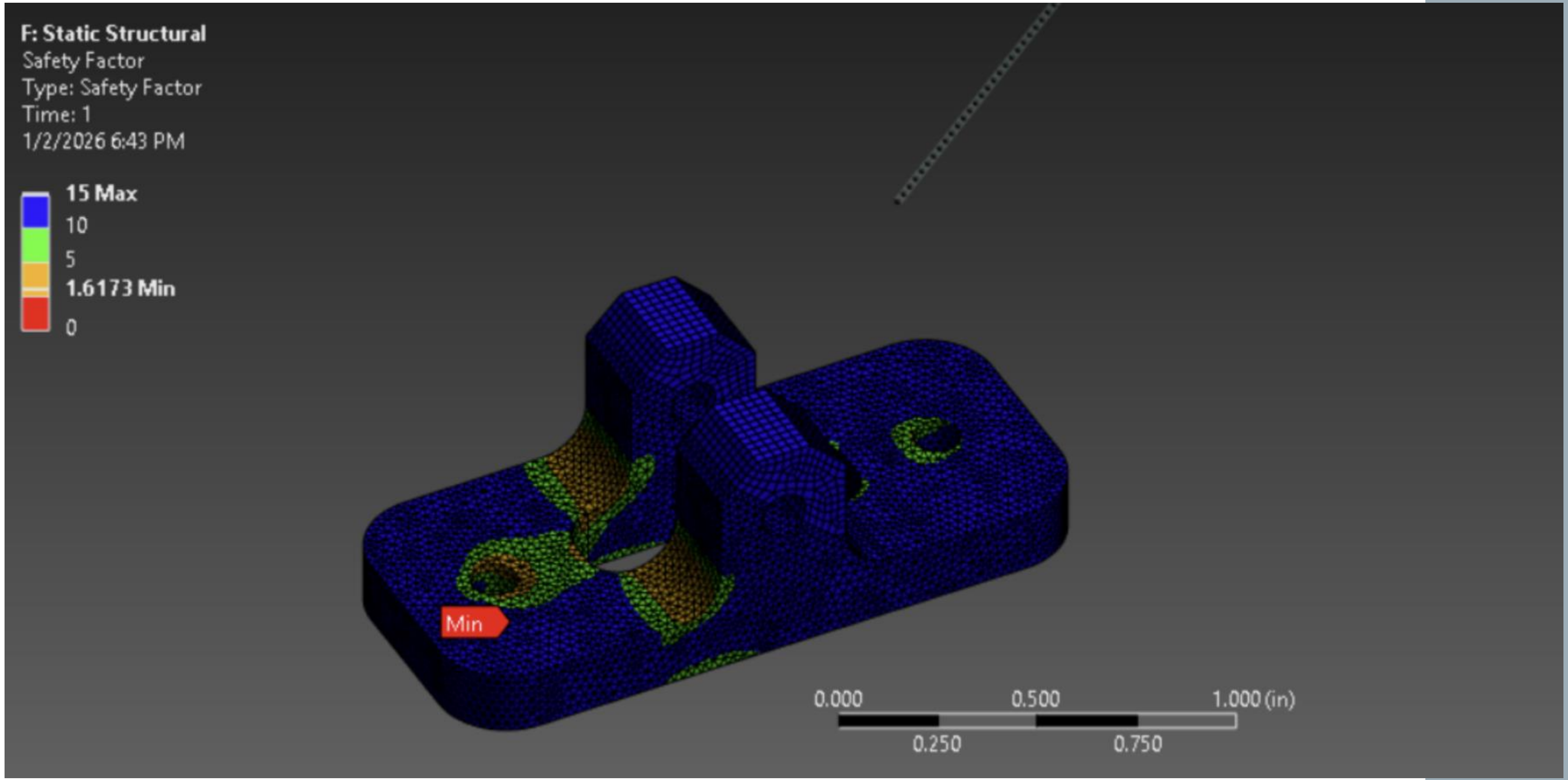
- Bolts are 4-40 (0.125 in dia)





Clevis FOS

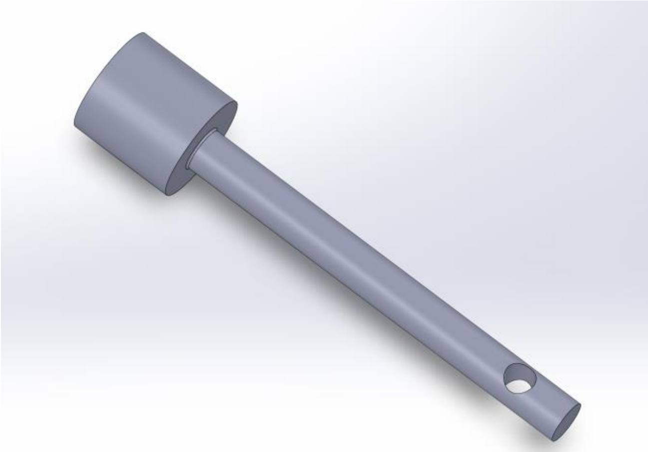
- Resultant FOS at is 1.6

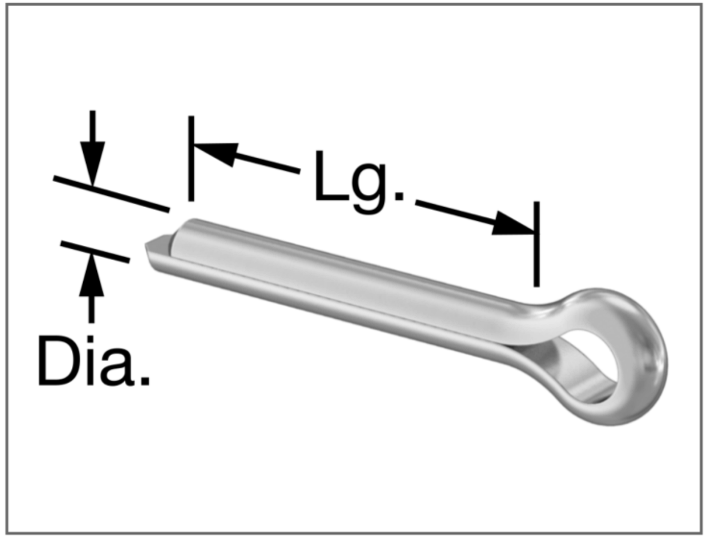


Cotter Pinner

FOS: 2.37

Weight: 88g



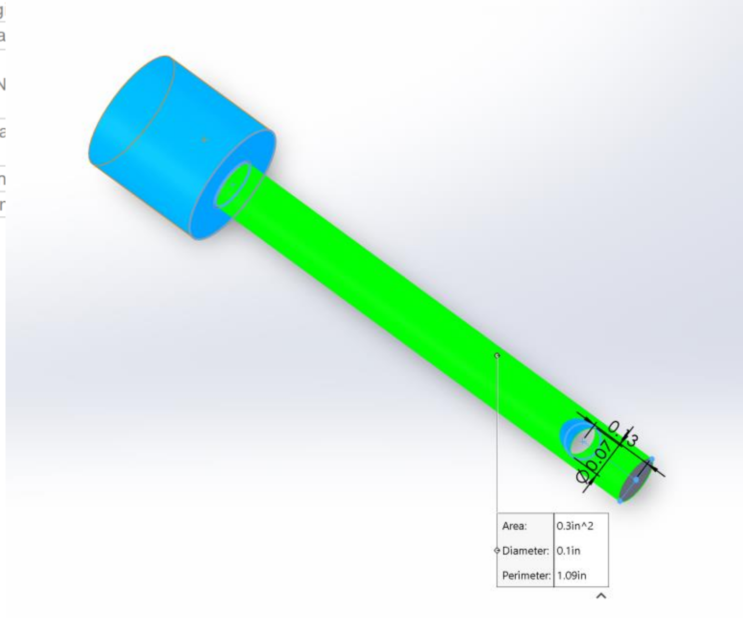


Solidworks Add-In

Download Add-In

Available for Solidworks 2017 or newer.

Cotter Pin Type	Standard
Material	Carbon Steel
Diameter	1/16"
Length	1"
Specifications Met	ASME B18.8.1
Pin Type	Cotter
System of Measurement	Inch
Country of Orig	
DFARS Complia	
Export Control Classification N (ECCN)	
REACH Complia	
RoHS Complian	
Schedule B Nur	




```
=== Axial Link Forces (+ tension, - compression) ===
Link 1: N = -301.308832  (Compression)
Link 2: N = -301.308832  (Compression)
Link 3: N =  927.156325  (Tension)
Link 4: N =  927.156325  (Tension)
Link 5: N = -192.117385  (Compression)
Link 6: N = -192.117385  (Compression)
```

Pin Shear Factor of Safety Calculation (Double Shear)

Given

$$P := \text{applied load}$$
$$d := \text{pin diameter}$$
$$S_y := \text{yield strength of pin material}$$
$$\tau_y := \text{shear yield strength of pin}$$
$$A_s := \text{total shear area}$$
$$\text{FOS} := \text{factor of safety}$$

Load Conversion

$$P = 980\text{ N}\left(\frac{0.224809\text{ lbf}}{1\text{ N}}\right)$$
$$= 220.3\text{ lbf}$$

Material Properties

$$S_y = 40\text{ ksi}$$
$$\tau_y = 0.577\,S_y$$
$$\tau_y = 0.577(40) = 23.1\text{ ksi}$$

Shear Area (Double Shear)

$$d = 0.12\text{ in}$$
$$A_s = 2\left(\frac{\pi d^2}{4}\right)$$
$$A_s = 2\left(\frac{\pi(0.12)^2}{4}\right)$$
$$A_s = 0.02262\text{ in}^2$$

Shear Stress in Pin

$$\tau = \frac{P}{A_s}$$
$$\tau = \frac{220.3}{0.02262}$$
$$\tau = 9.74\text{ ksi}$$

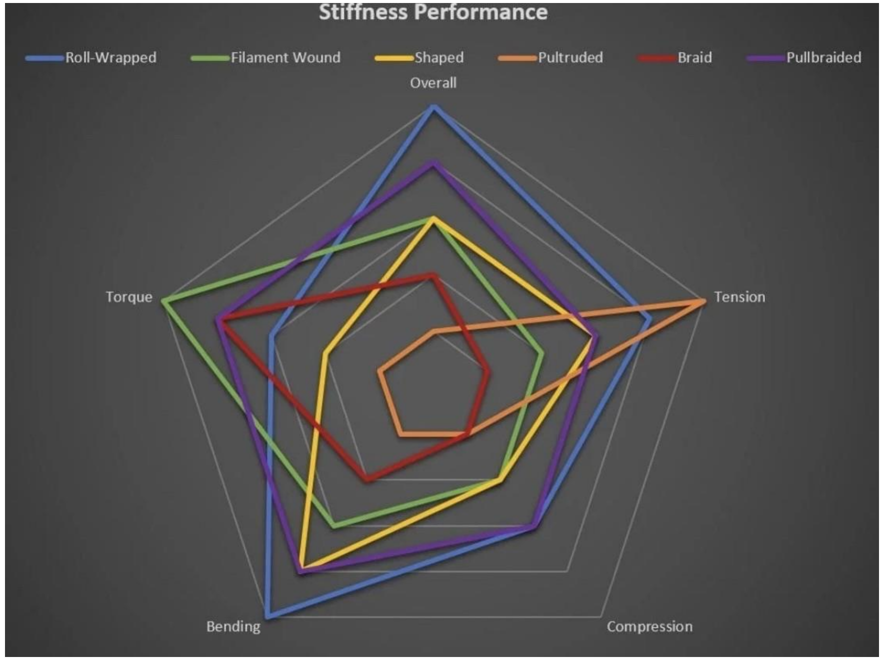
Factor of Safety

$$\text{FOS} = \frac{\tau_y}{\tau}$$
$$\text{FOS} = \frac{23.1}{9.74}$$
$$\boxed{\text{FOS} = 2.37}$$

Slide Owner:

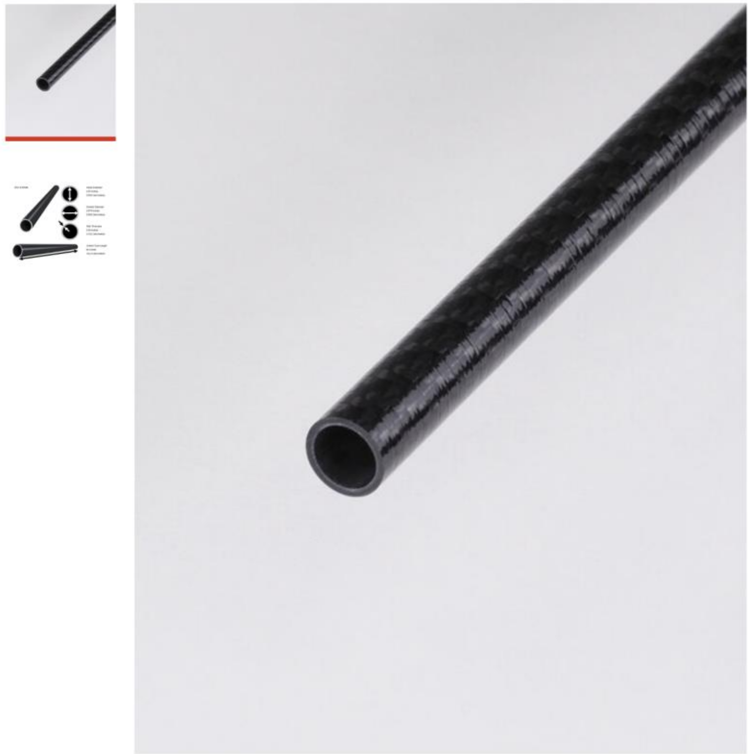
LHRE

Rear Wing Rod Selection



Tube - Fabric - 0.25 x 0.375 x 60 Inch

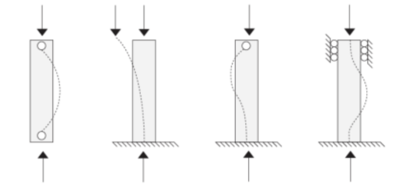
Overview | Features & Benefits | Additional Information | Engineering Properties



Round Tubes and Rods - Axial Tension and Compression

Notes

- Tension uses positive notation and compression uses negative notation.
- End conditions are critical when considering buckling:
  - Fixed = constrained in both translation and rotation.
  - Pinned = constrained only in translation (ie. bolted joints).
  - Free = not constrained (similar to a cantilevered end).
- Long, skinny parts in compression are more susceptible to fail in buckling
- Only parts in compression can fail in buckling



Inputs

Notes:

- A green highlight indicates a valid input.
- A red box indicates an invalid input.

Label	Value	Units
Load	222.000 Positive value indicates tension. Negative value indicates compression.	lb
Outer Diameter	0.375	in.
Inner Diameter	0.250	in.
Length	16.500 Value up to **60.000**	in.
End Conditions	Pinned-Pinned	N/A

Calculate Reset

Outputs

Notes:

- A green highlight indicates that a sample is unlikely to fail **in this manner**.
- A red highlight indicates that a sample is likely to fail **in this manner**.

Label	Result	Units
Max Axial Stress	3.62e+3	psi
1st Order Buckling Critical Load	SAMPLE IS IN TENSION	lb
Change in Length	0.00600	in. (linear elastic only)
Part Weight	0.0560	lb

Rear Wing Subassembly - Manufacturing

- Airfoils: C bagging, donut bagging techniques
- Mold release: Fibrelease from Fibreglast (water based, EHS yay!)
- Rods: cut with diamond blade hacksaw and diamond bit Dremel
- Jigs: certain jigs made of laser cut acrylic

Rear Wing – Future Work

Full Mechanical, Structural, ACP, FEA Sim with most recent aero loads, inclusive of airfoils and structures.

Aero Val- Aero wind tunnel validation of CFD

LHRE

Nosecone/Bodywork - Manufacturing

Main Design Considerations for Nosecone:

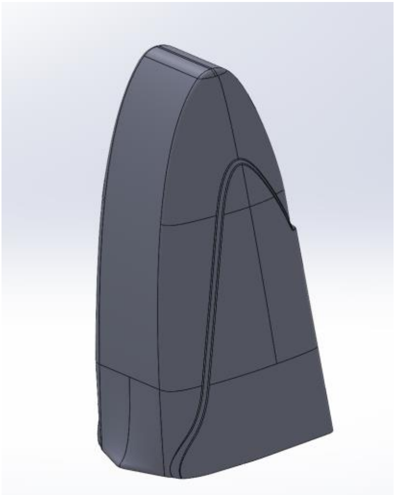
Weight

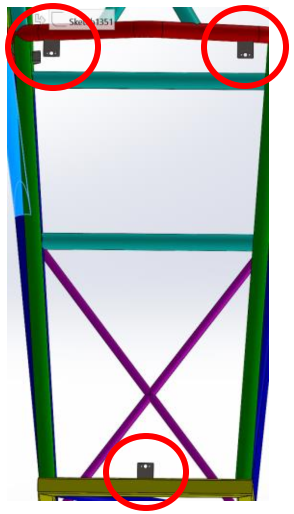
- 3.74lbs

- Dzus Tabs- 2 off of front hoop, and one off of front bulkhead

- Foam mold using pink panther foam- 5 ply layup

Foam Mold --> Surfacing --> Styroshield --> Fibrelease/Wax --> Wet Layup





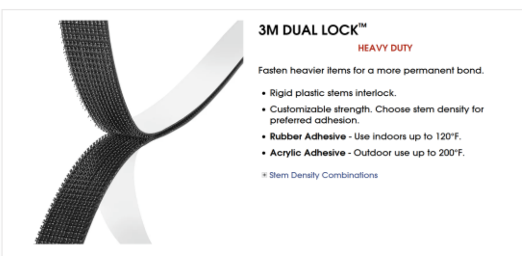
Main Design Considerations for Bodywork:

Weight

- 2.48lbs

- Zip tie patches for bodywork/frame connections (lightweight) and body panels will not need to come off

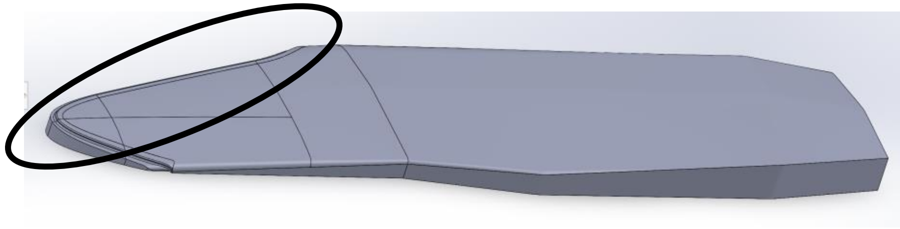
- IF NEED BE, we can clamp/bond a 3D printed lego arm to frame



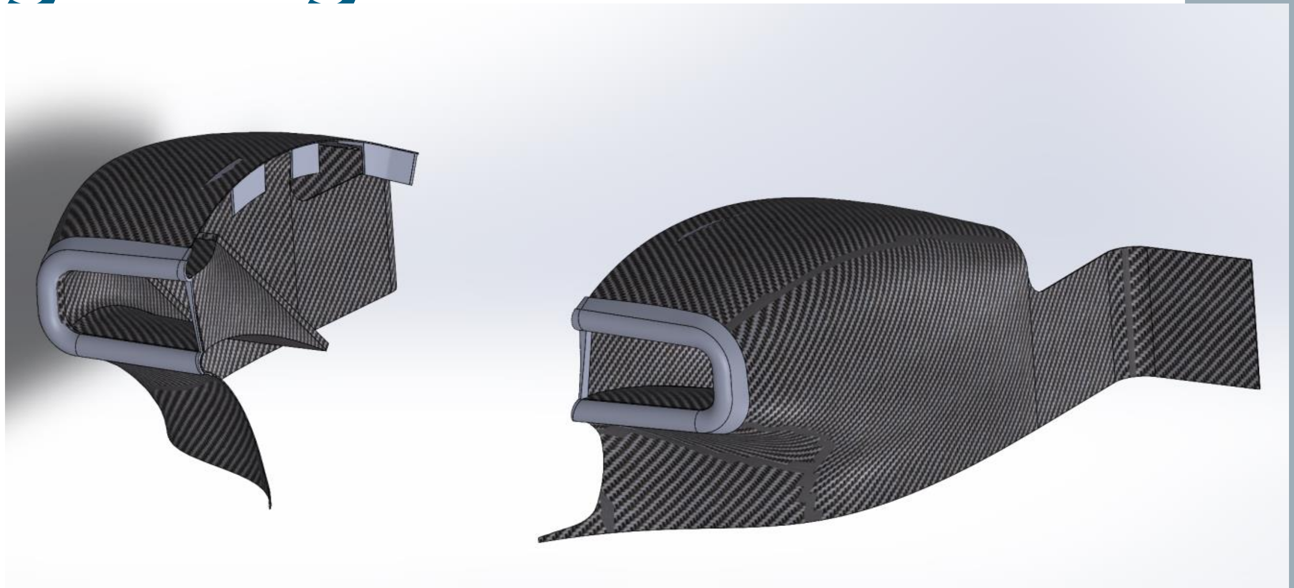
Boundary Between Nosecone and Body panel :

- 3D printed flange piece to incorporate into body panel layup

- Dual lock to seal the bodywork/nosecone interface



Side Pod – Mounting Design



Weight

- 4.72lbs

Design Considerations

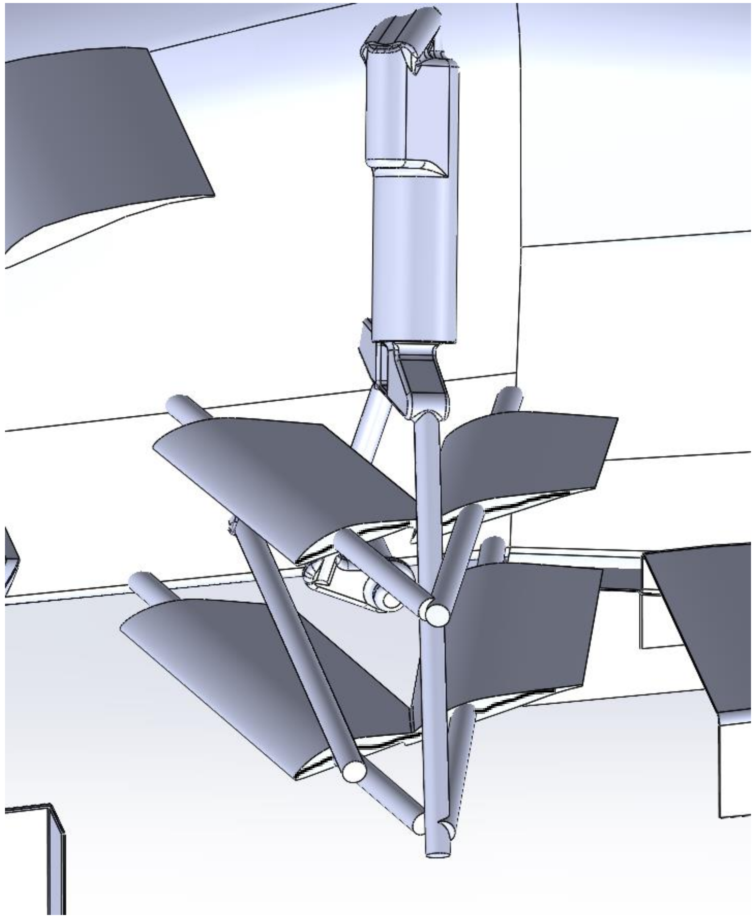
- Carbon Fiber Tabs that follow the curvature of the side pod internally and mesh with body work
- These tabs will be made from laying up on a 3D printed L-bracket
- Side Pod will be mounted through these tabs, and connected to the side pod lip which connect to the radiator duct.

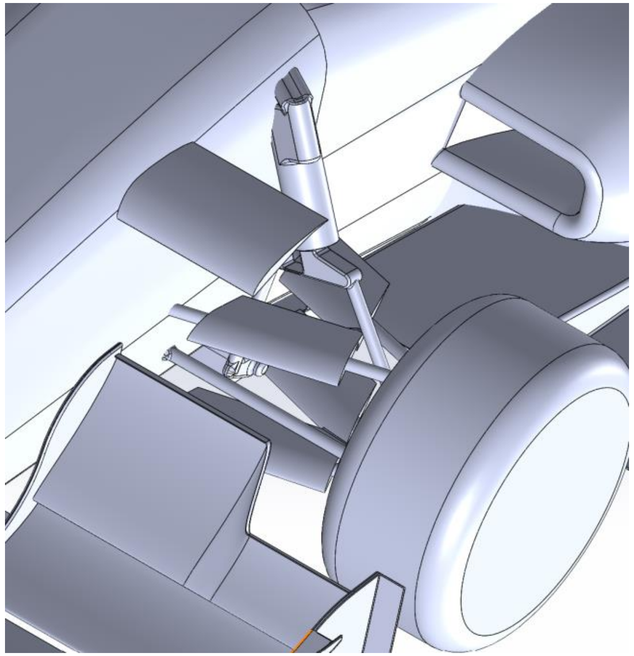
Control Arm Covers

Main Design Considerations for Nosecone:

Weight

- TBD based on the material used to 3D print the covers
- Control arms covers will be split in two halves, and each of the halves will be clamped together with a bolt
- Both airfoils together will be constraining all degrees of the freedom

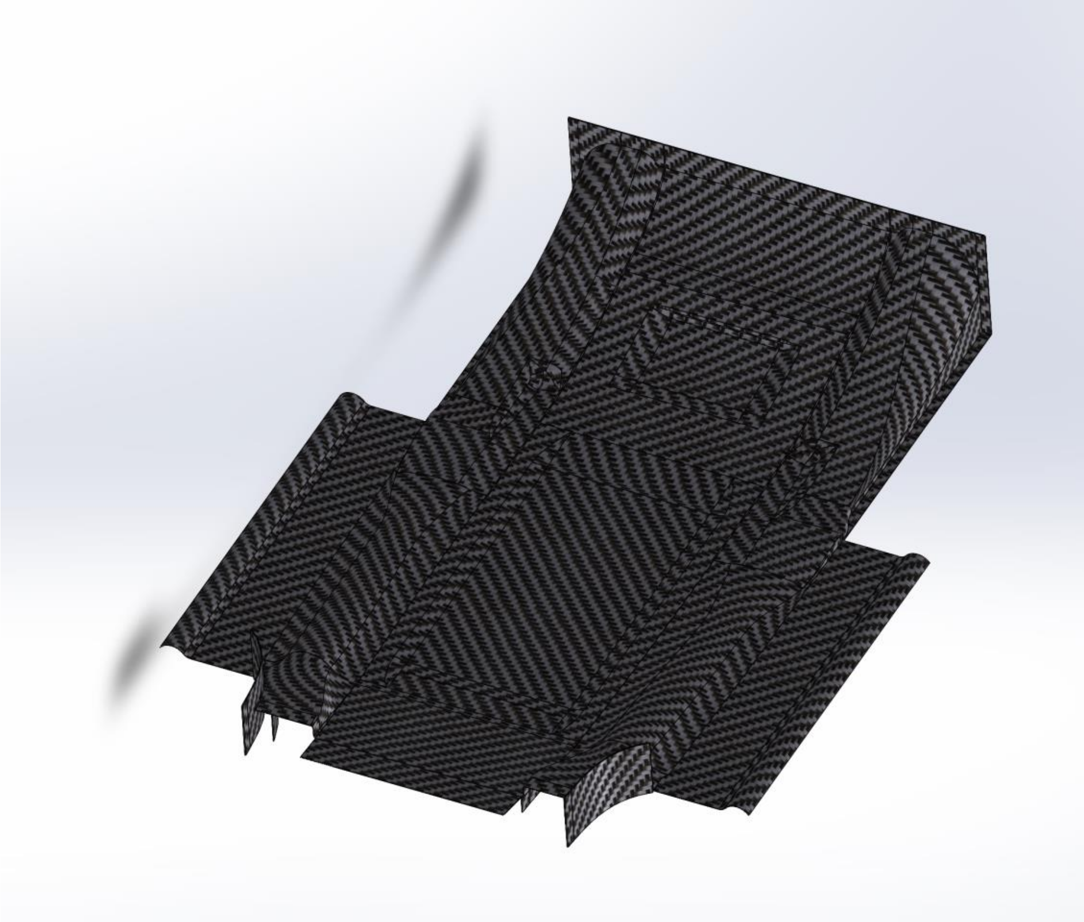




Undertray

- 2 core 2
- 0, 45, core, 45, 0

- Previous Concerns: not sturdy enough in certain regions, flaps, diffuser

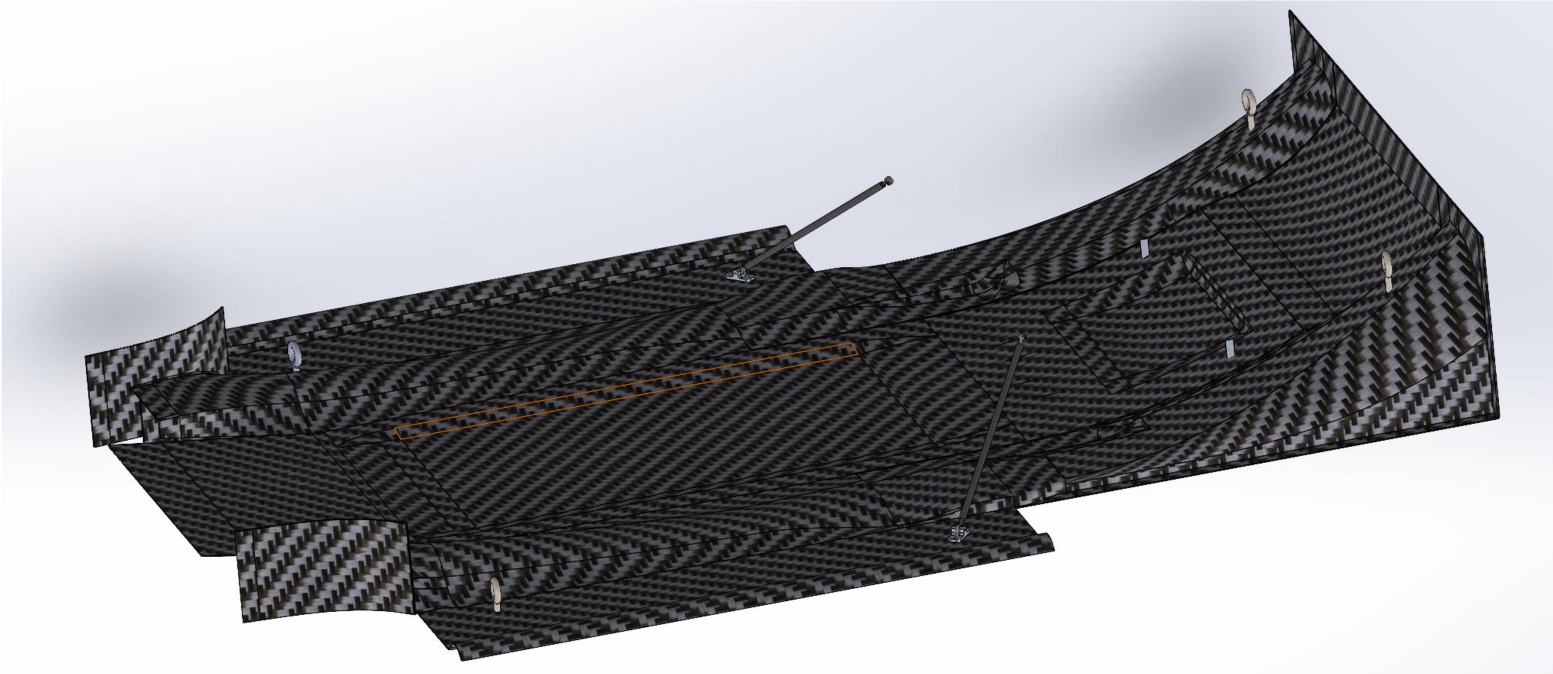


Slide Owner:

Undertray Mounting

- Tab mount: Front Wheel, Aft of Driver
- Cables: Diffuser, Side Pod
- Tie Rod: Aft of Driver

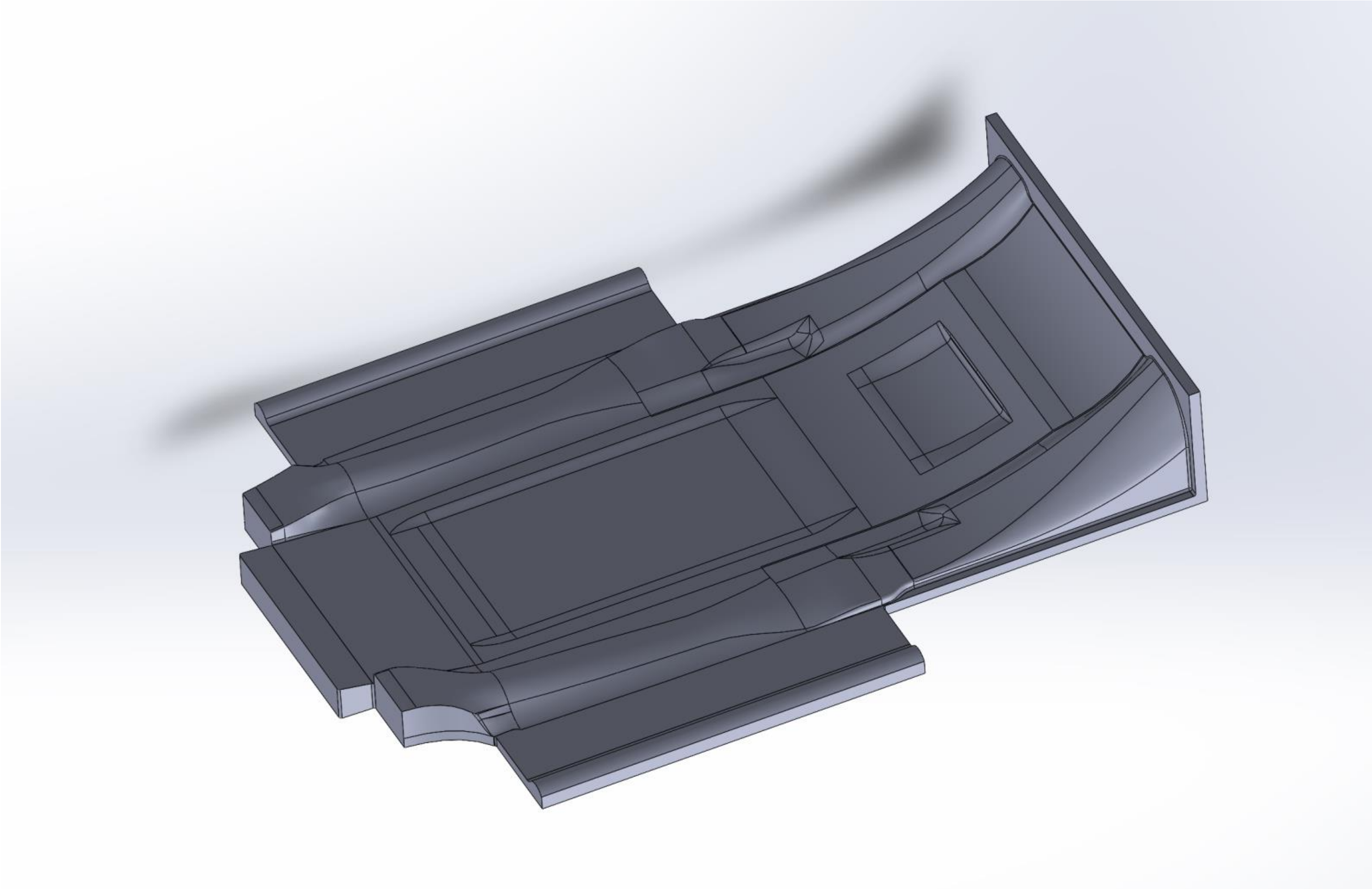
Experiment with embedding plates within our layup to avoid having bolts stick through undertray



Slide Owner:

Undertray Subassembly - Manufacturing

Pink Panther Foam --> StyroShield --> FibRelease --> Layup



Slide Owner:

Undertray Future Work

Minimize tab weights, optimize for structural rigidity
Finalize cables, tab mounts, and tie rods
Run sim on composite components with ACP and aero loads to validate composites
Run full structural, mechanical, and ACP sim with aero loads to validate mounting

Research Projects

Materials Testing (1/3)

- **Project implementation season:**
  - Current Season: Dog bone Coupons 3/Core/3 & 4/Core/4, Steering Wheel Plate, CFCAS
  - Upcoming: Dog bone Coupons 6/Core/6 & 13/Core/13 for monocoque
- **Current progress:**
  - Testing Plan complete and approved by Dr. Davies
  - Ordered materials, received carbon rods
- **What design work has been done so far?**
  - Is this feasible for this current years car? Yes
  - Does it need descoping? If manufacturing and testing time is limited, may need to reduce the amount of coupons we test etc.. 6C6, 13C13.
  - Will this be shelved for future years? Repeatable, easy to follow testing documentation

Slide Owner: Ocean

Materials Testing (2/3)

- **Purpose:** These tests aim to test different material interactions and structures for different projects on the car. Tensile capacity and failure modes of bonded aluminum inserts and flexural stiffness, core shear strength.
- **Approximate Cost:**
    - Carbon & Core Plate Layups (Coupons): 4x4=16 Coupons, 2 Steering Wheel for 2 diff laminates. $50-$150
    - CFCAS: 3-4 Tensile Test, 45553 Tubes, 7075 Al Inserts. $340
- **Specs:**
    - 3PBT Dog Bone Coupon: ASTM D7264 128"x13"x(0.266"-0.332")
    - 3PBT Steering Wheel: 9” x 6” x .266”
- **Link to full testing plan will be sent after CDR**

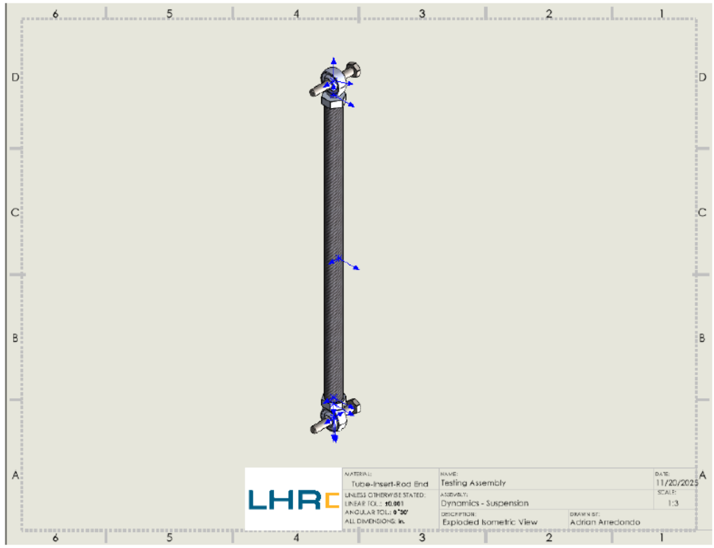


Figure 1: Carbon Fiber Control Arm Assembly Cad Drawing

Slide Owner: Ocean

Materials Testing (3/3)

6 | Relevant Table for Testing Procedure

Sample/ Material	Test Type	Data to be Recorded	Extensometer	Max Load (kN)	Standard	Dimensioned Engineering Drawing
CFCAS assembly: Rock West Composites #45553-IM (10-ply) Carbon Fiber Tube and 7075-T6 Aluminum Insert	Tensile	-Load -Stress -Instron Plots	No	30	N/A	Refer to Appendix Figure 1-3
Standard Coupon for Sandwich Panel Laminates: Carbon-fiber (14033 Rockwest Prepreg T300 Torray 3K Twill) (0.011 in) with Rohacell 51 foam core (0.2 in)	Bending	-Load -Displacement -Stress -Instron Plots	Yes	-3core3 : 1.5 -6core6 : 3 -13core13: 6	ASTM D7264	Refer to Standard (mm): 32:1 128 x 13 x 4
Steering Wheel Sandwhich Panel: Carbon-fiber (14033 Rockwest Prepreg T300 Torray 3K Twill) (0.011 in) with Rohacell 51 foam core (0.2 in)	Bending	-Load -Displacement -Stress -Instron Plots	Yes	1.5	N/A	Refer to Appendix Figure 4 and dimensions (in) below 9 x 6 x .266

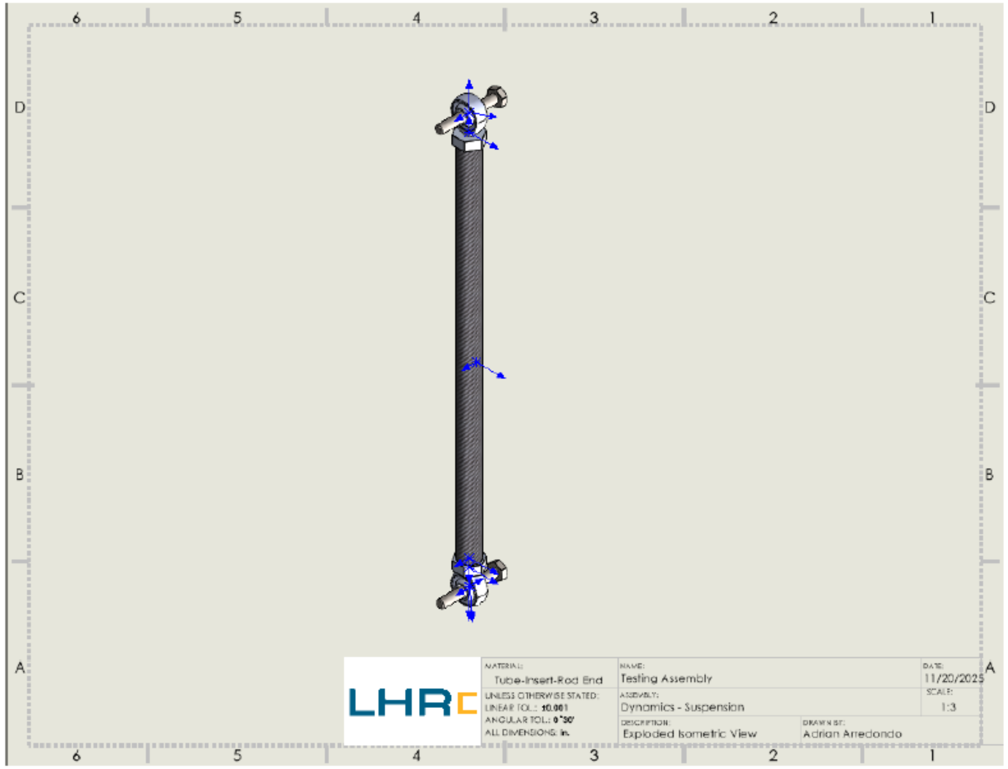


Figure 1: Carbon Fiber Control Arm Assembly Cad Drawing

Slide Owner: Ocean

Aerostructure Validation (CFD Coupling and Wind Tunnel Testing) Next Steps

Wind Tunnel Testing

Project implementation season: Winter and Spring Semesters

Current progress

- Detailed Wind Tunnel Testing have been drafted for repurposing an old airfoil from one of the cars
- Wind Tunnel Testing

What design work has been done so far?

- Mock of CAD models for the endcaps, as well as the airfoil set up are present
    - Is this feasible for this current years car? Does it need descoping? Will this be shelved for future years?
        - It is definitely feasible for this current year. Admittedly, this has been put on the back burner because we were waiting for facilities, but we will make do with what we have, and contact Bogard as soon as we know which airfoil we will use

FEA-CFD Coupling

Project implementation season: Winter and Spring Semesters

- Work with aerodynamics to figure how to take deformed geometry and have it output a CFD, to then get a delta value between deformation and performance dropoff. This couples perfectly with wind tunnel testing, requires no cost, and can be done on the sidelines

Resin Infusion (1/4)

Status Quo

- Wet layup results in highly variable resin content and fiber volume fraction due to manual resin application, leading to inconsistent laminate thickness and mechanical properties.
- Prepreg fabrication shows variability caused by out time sensitivity, storage constraints, and inconsistent consolidation pressure when autoclaves are not available.
- Both methods depend heavily on operator technique and environmental conditions, making repeatability difficult across parts, build cycles, and team turnover.

Slide Owner: Achyut Nair

Resin Infusion (2/4)

Solution

- Vacuum Assisted Resin Infusion, VARI, uses a sealed mold and full vacuum to drive resin through dry fiber preforms, providing controlled and uniform resin distribution that is not achievable with wet layup.
- VARI decouples fiber placement from resin delivery, allowing precise control of resin content and significantly improving repeatability of fiber volume fraction and laminate thickness.
- The closed mold process minimizes air entrapment and environmental sensitivity, resulting in lower void content, cleaner parts, and consistent quality across operators and build cycles.

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Resin Infusion (3/4)

Implementation

- Implement VARI using a standardized consumable stack and vacuum hardware, including peel ply, flow media, spiral feed lines, sealant tape, vacuum hoses, and a resin catch pot to ensure consistent resin flow and vacuum integrity.
- Establish controlled process parameters such as resin temperature, acceptable vacuum leak rate, infusion timing, gate and vent placement, and cure schedule to reduce variability between parts.
- Validate the process through staged test panels and representative components, using void content, fiber volume fraction, and surface quality as acceptance metrics before scaling to full vehicle parts.

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Resin Infusion (4/4)

Project implementation season

Planned for the current season, starting with test panels and low risk components, with expansion based on validation results.

Current progress

Process research and consumable selection completed, with preliminary documentation and candidate components identified.

What design work has been done so far?

Initial VARI process definition completed, including bagging stack, vacuum layout, cure strategy, and quality acceptance metrics.

Is this feasible for this current years car? Does it need descoping? Will this be shelved for future years?

Feasible for this year on simple geometries, with higher complexity parts deferred if schedule risk arises and carried forward for future seasons.

Approximate cost

Initial setup cost is approximately $300 to $600 for reusable vacuum hardware and initial consumables, with per part consumable costs comparable to current composite fabrication methods.

Research projects may not be funded through our budget and CR funding will be required

If treated as a research effort, CR funding may be required for initial setup, with long term costs absorbed into the composites budget.

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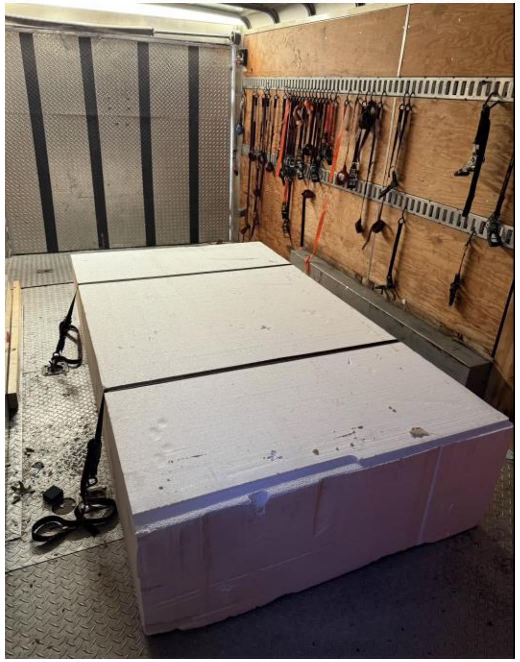
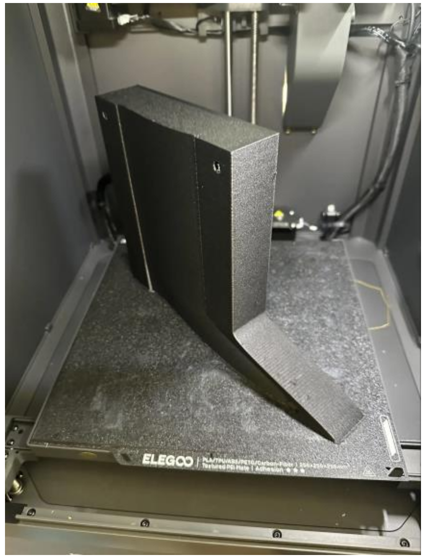
Manufacturing

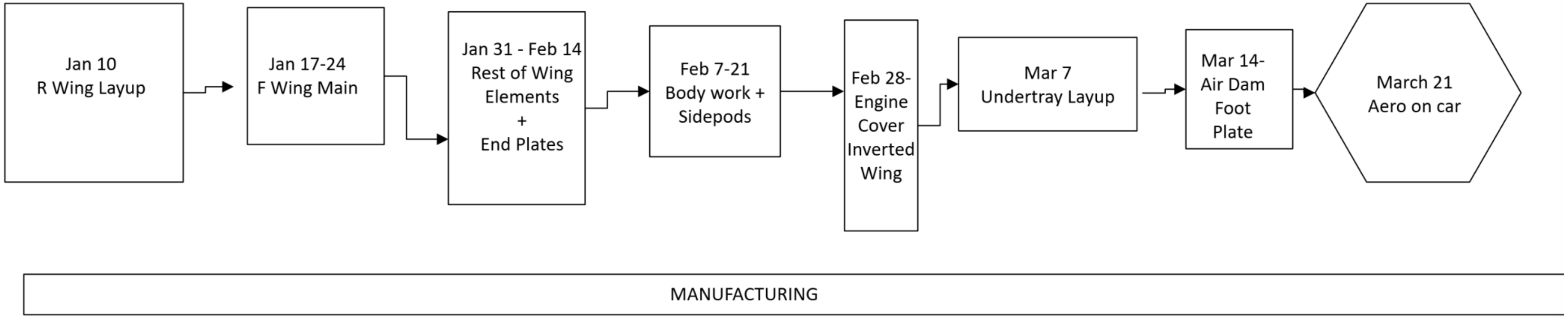
Manufacturing

In depth discussion previously discussed on each sub assembly slides.

Foam Mold Machining: ~ $1200








2025 LEADS:
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TEXAS
The University of Texas at Austin
Chevron
brembo
Hello I-PEX
cadence
Chevron Phillips
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ROHACELL
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Thank You!

Thank You!!!

Thanks to everyone that came this morning, it truly means the world to us.

Looking forward to a great manufacturing and testing season, and a wonderful 2026!