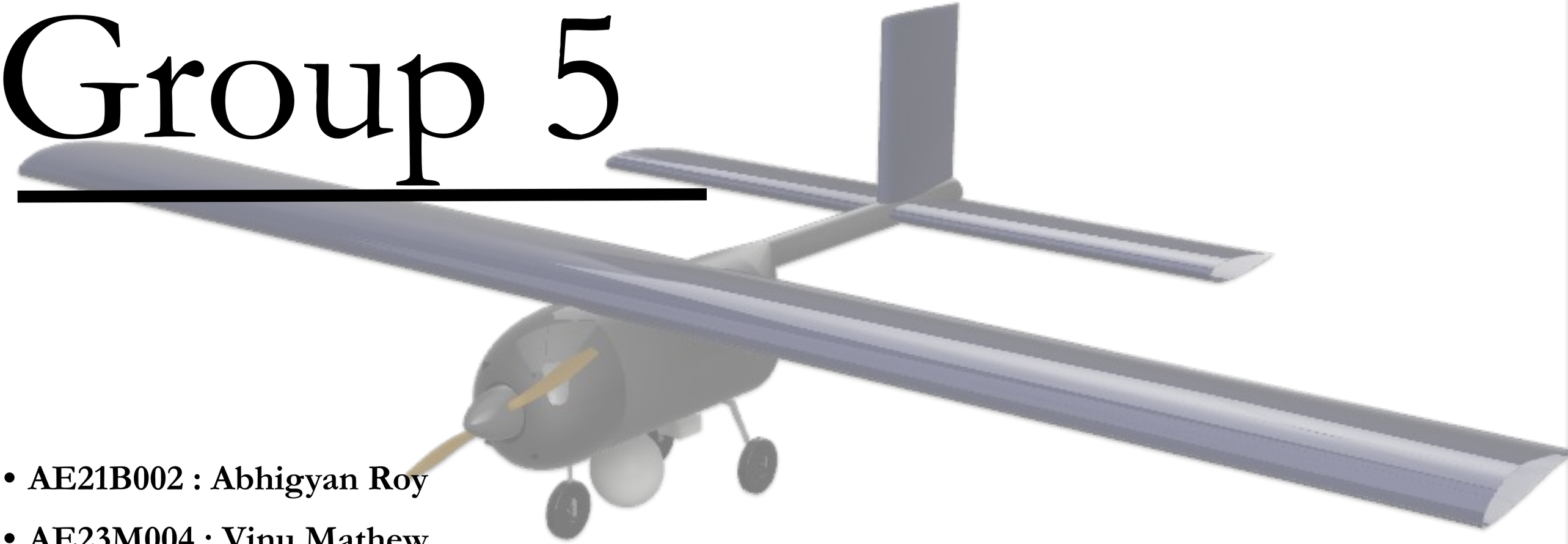
DESIGN OF UAV

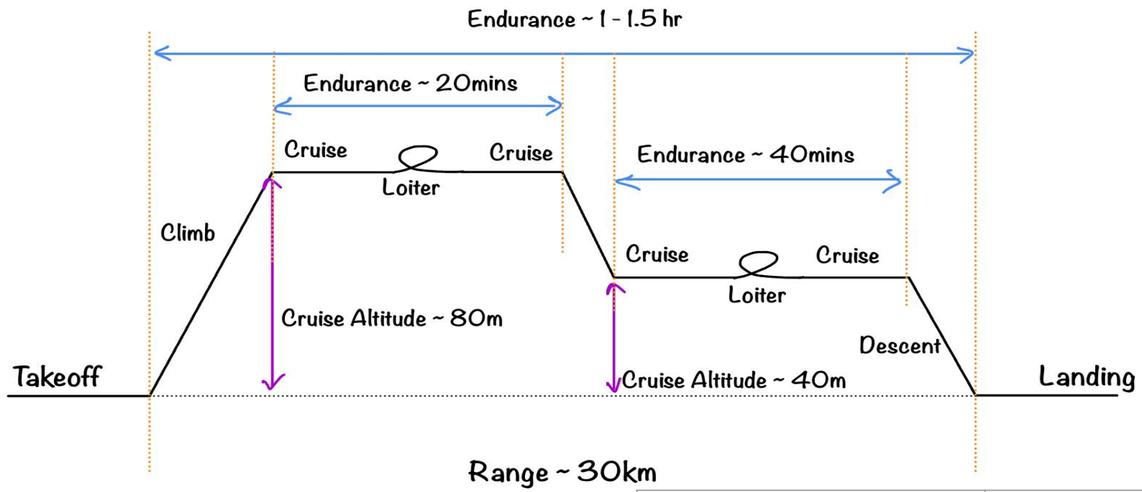
Group 5

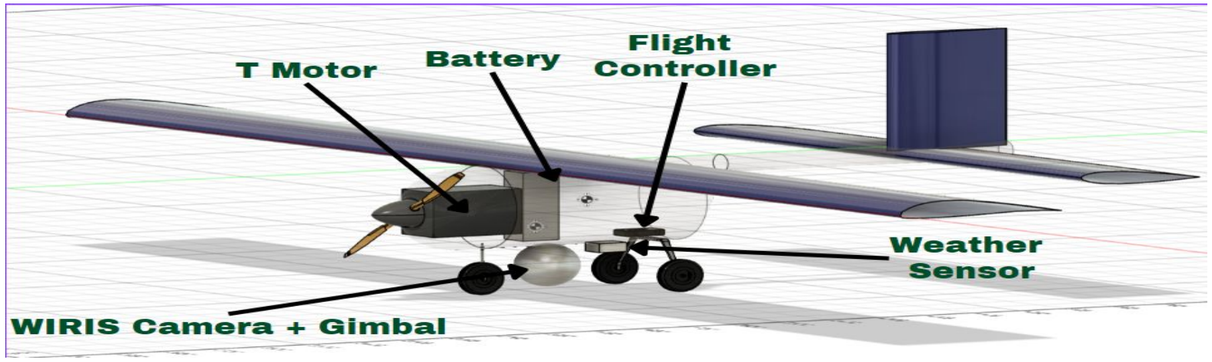


- **AE21B002 : Abhigyan Roy**
- **AE23M004 : Vinu Mathew**
- **AE23M008 : Anish Konar**
- **AE23M014 : Gautham Anil**
- **AE23M006 : Aditya Sai Deepak Rachagiri**

Mission Statement

Monitoring of Flora and Fauna and the environment of forests in the Chennai AOR and Mapping of Forest Cover, including security-based Surveillance of the forest within the said Area of Responsibility.



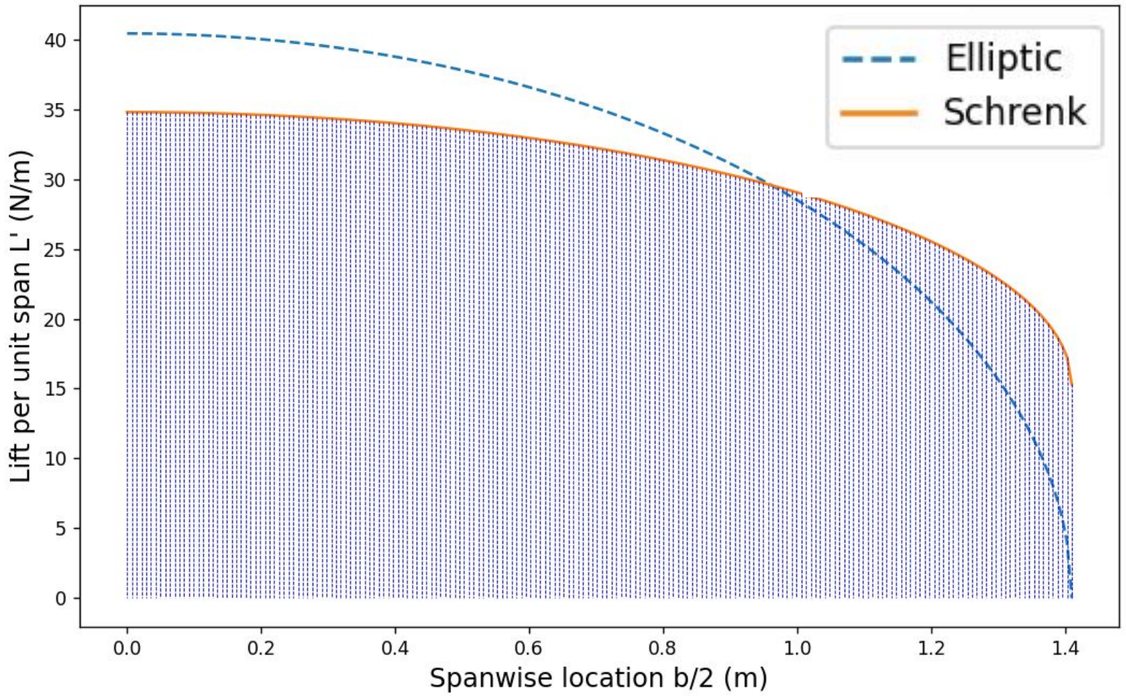


MTOW	8.80 Kg
Wing Area	0.96 m^2
Wing Span	2.80 m
Wing Chord	0.34 m
Wing Aerofoil	GOE 553

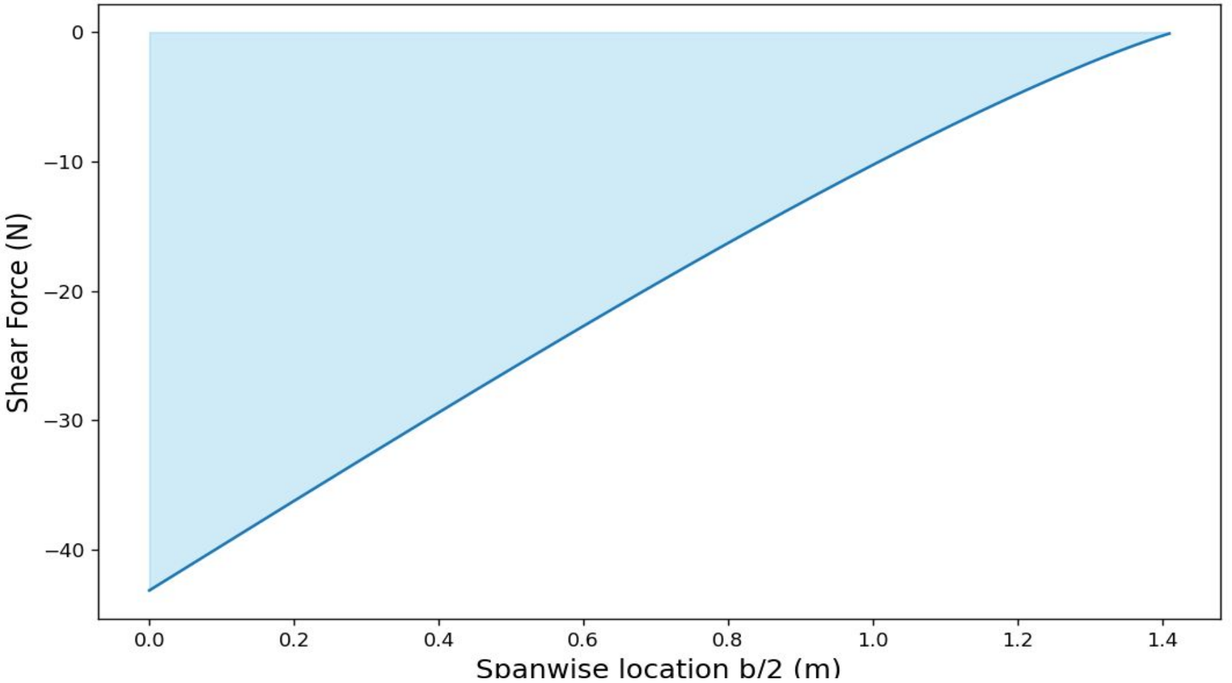
Horizontal Tail Area	0.42 m^2
Horizontal Tail Span	1.5 m
Horizontal Tail Aerofoil	NACA 0014
Vertical Tail Area	0.14 m^2
Vertical Tail Span	0.4 m
Vertical Tail Aerofoil	NACA 0014

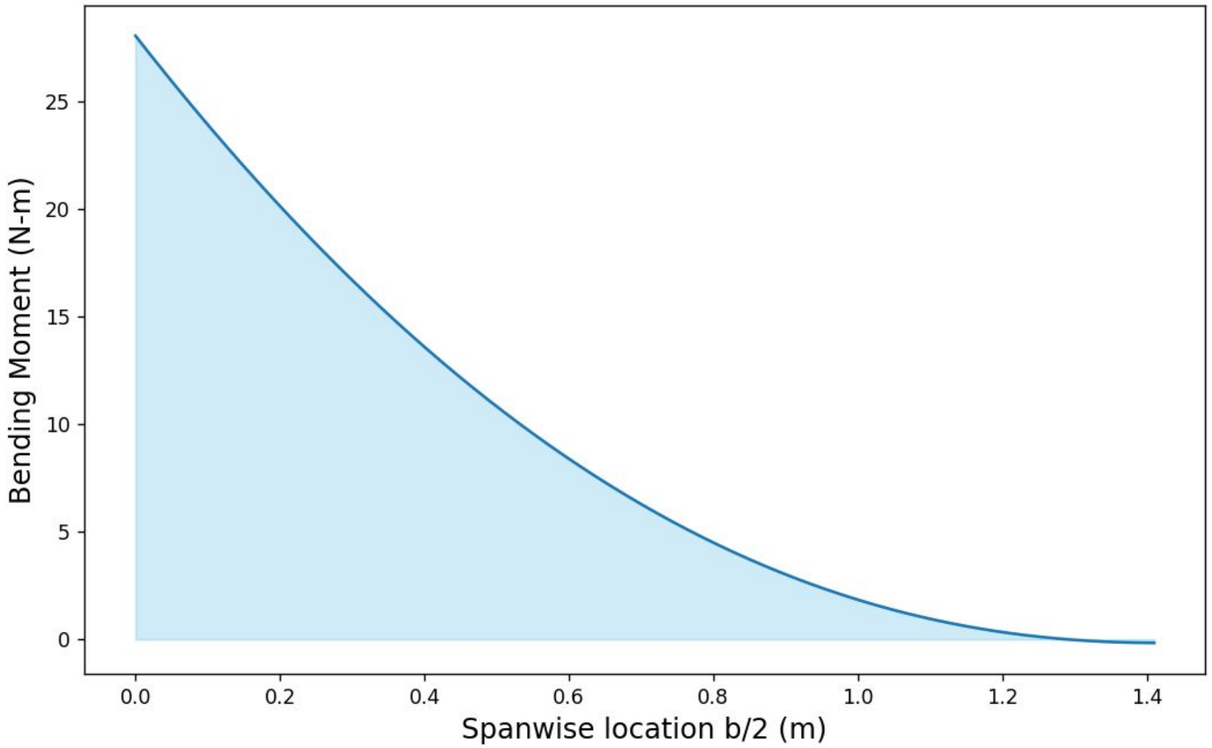
Component	Weight (N)	Position from Nose (mm)
Motor	8.98	53
Propellor	5.46	53
Battery	22.27	186
Wiris Camera	4.21	276
Gimbal	4.56	276
Environmental Sensor	2.23	476
Avionics	1.96	481
Empty Weight	29.43	326
Nose Landing Gear	0.77	150
Main Landing Gear	1.55	350

Wing Lift and SFBM Calculations



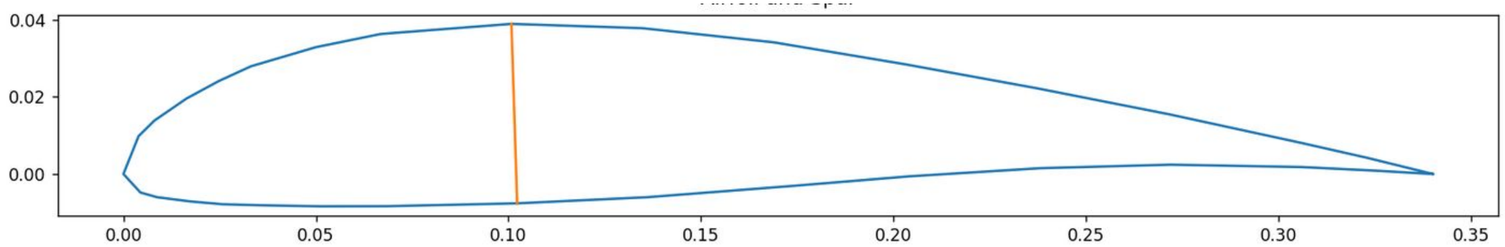
[Schrenk's Method]



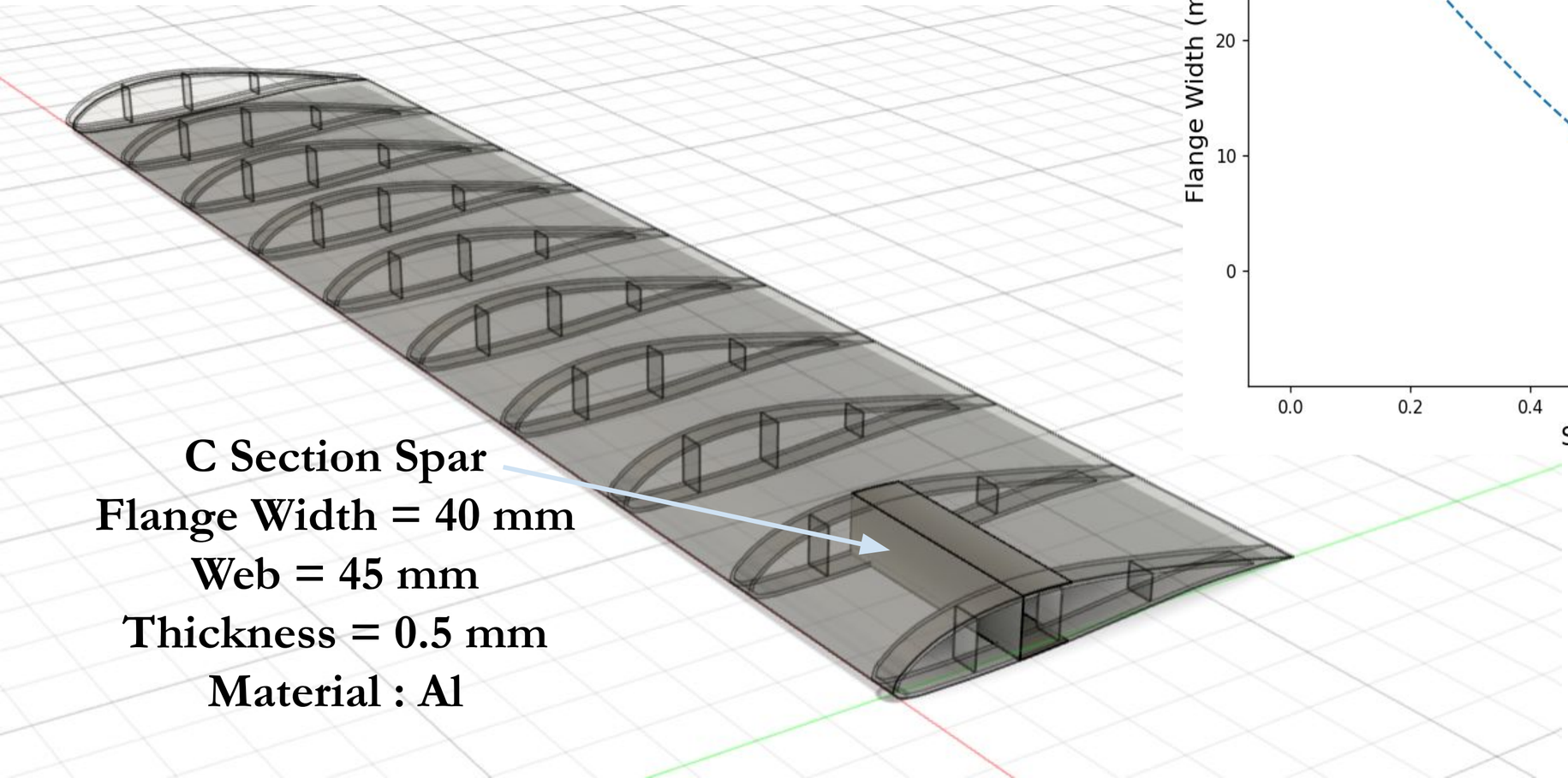


Wing Span (b) = 2.82 m	Half Span (b) = 1.4 m
Chord (c) = 0.34 m	Reaction Force R = - 43 N
Area (S) = 0.90 m^2	Reaction Moment M = - 28 Nm

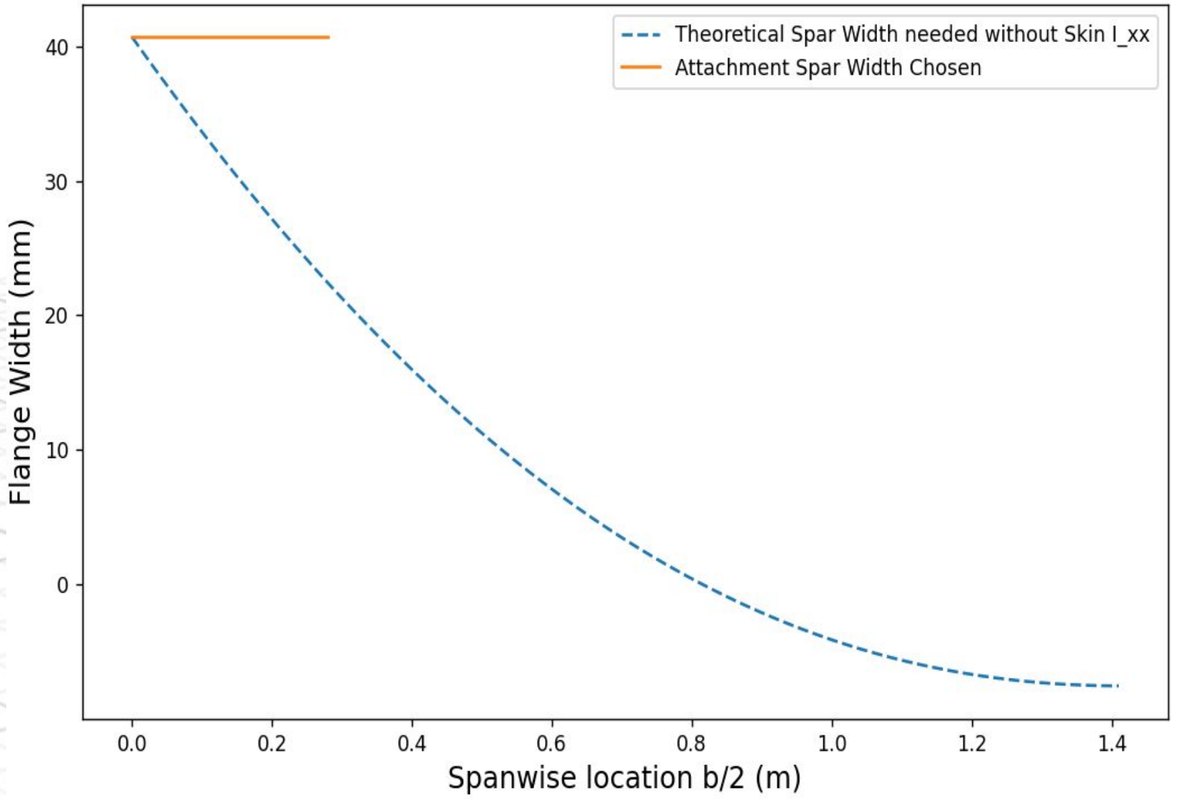
Spar Calculations



Spar (Orange)
Wing Cross Section (Blue)

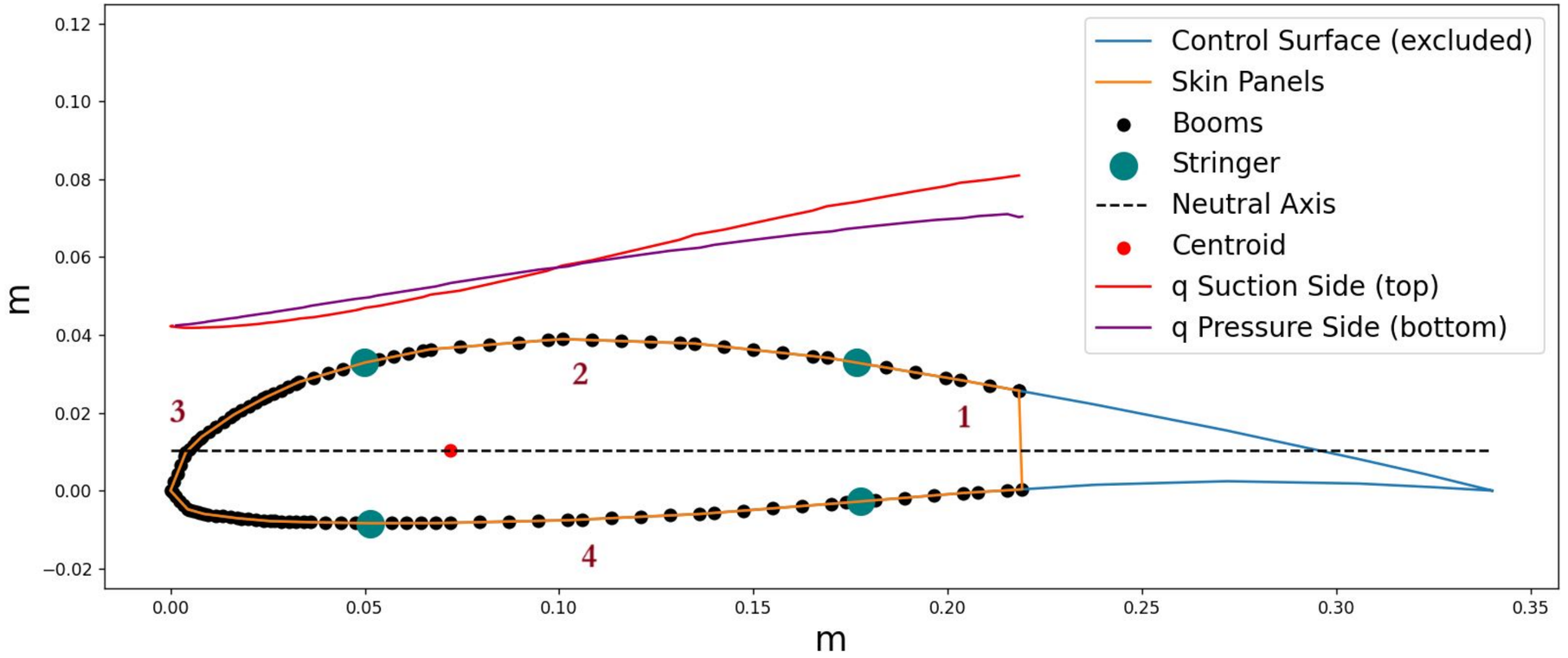


C Section Spar
Flange Width = 40 mm
Web = 45 mm
Thickness = 0.5 mm
Material : Al



Spar Designed keeping contribution of Skin I_{xx} at 0

Wing Shear Flow



$F_{cr,\ initial} = 1836$

Panel No.	F_{cr} (N/m)
1	7760
2	4332
3	4853
4	4332

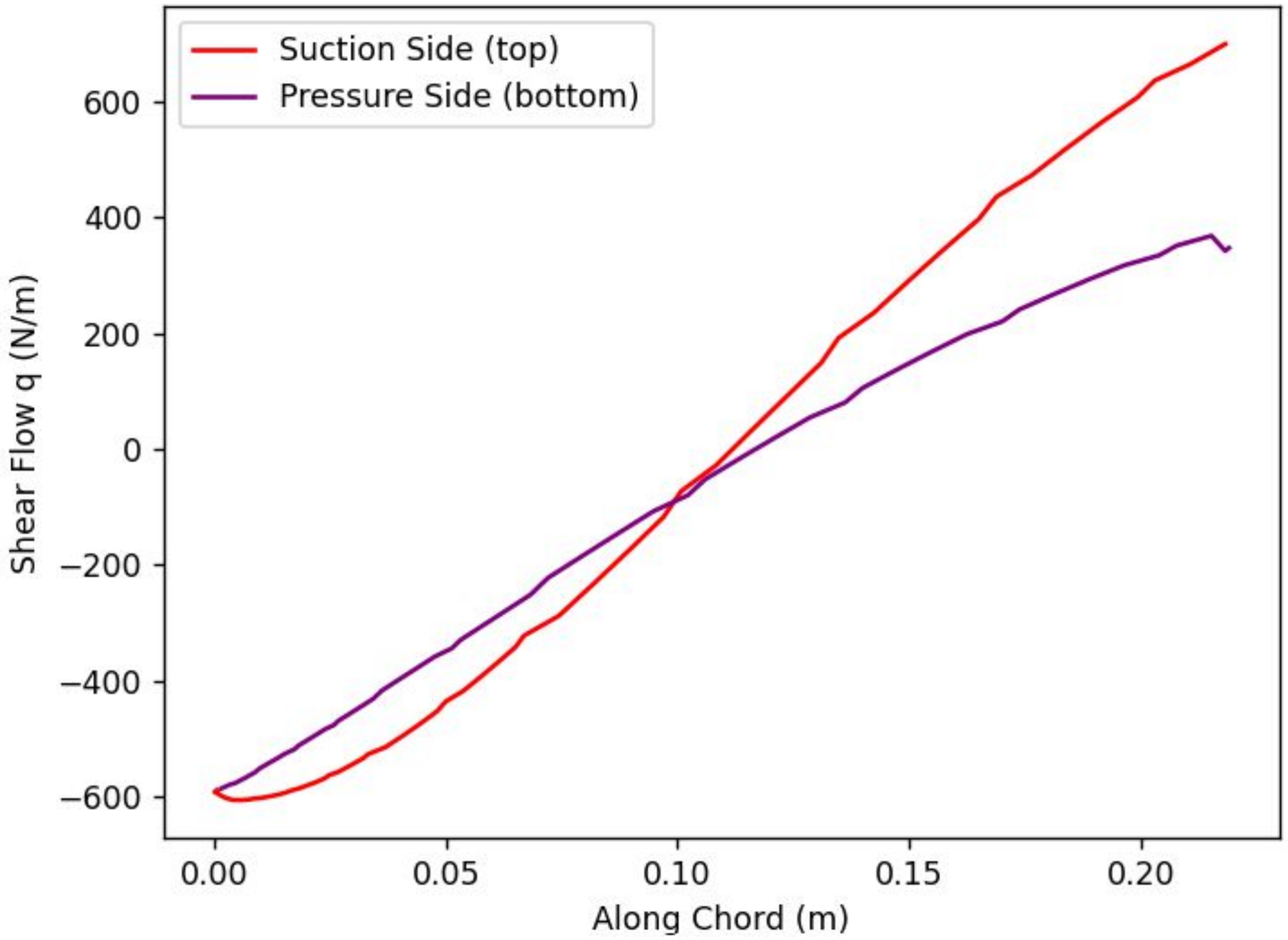
$$q_{total} = \frac{-S_y}{I_{xx}} \sum_{r=1}^{n} B_r y_r + q_{s,0}$$

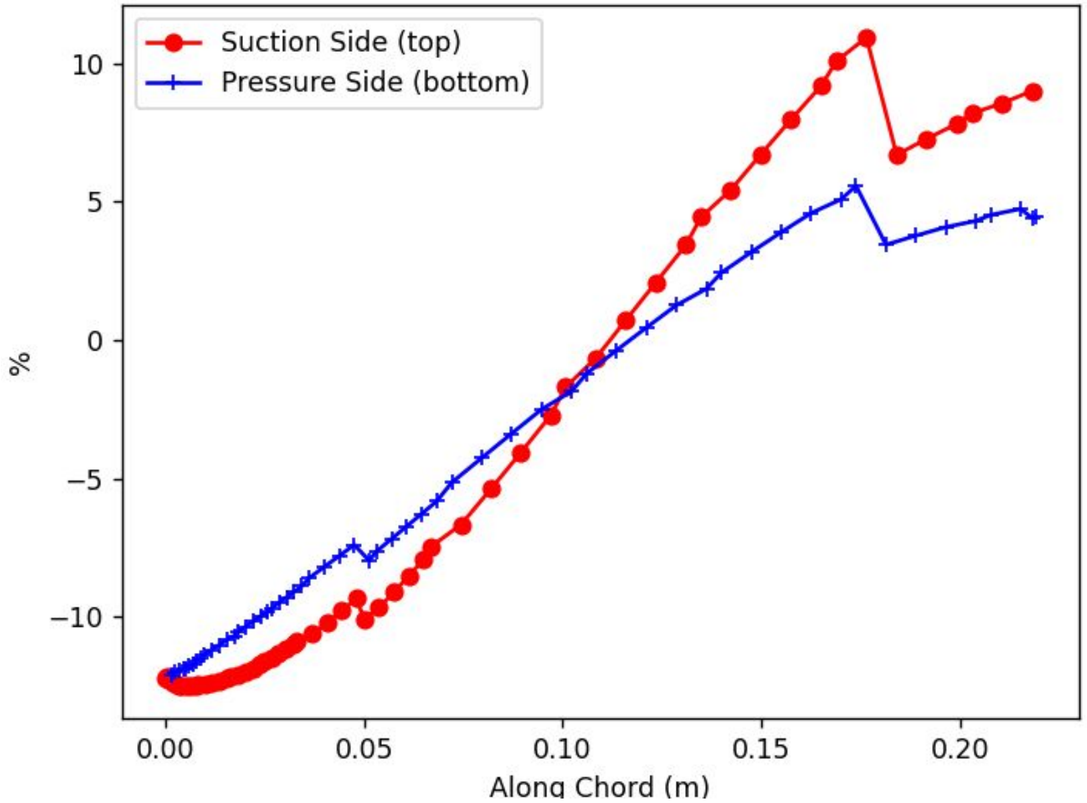
$$F_{cr} = K_{ss} \frac{\pi^2 E}{12(1-\nu^2)} \left(\frac{t}{b}\right)^2 \left[R_a + \left(\frac{R_a - R_b}{2}\right)\left(\frac{b}{a}\right)^3\right]$$

$$\frac{d\theta}{dz} = \frac{1}{2AG} \int \frac{q_s\, ds}{t} = 0$$

$R_a = R_b = 1$ (Simply Supported)
a = Distance between Rib (0.14 m)
b = Distance between Stringer
ν = Poisson's Ratio (0.33 for Al)
E = 70 GPa (Aluminium)

Wing Shear Flow





% of F_{cr} of Shear Flows with Stringers

Total Factor of Safety = 3(n) x 2(FOS) x 1.5(d) = 9

Selected 10 ribs for each half wing

Total : 20 ribs

Wing Fabrication

- Fabrication started with Wing
- Ribs, Ailerons and Flaps were 3D printed
- Wing skin was wrapped in 2 sections
- 0.5 mm Al 6061 thickness skin was used with 4 stringers and 18 ribs

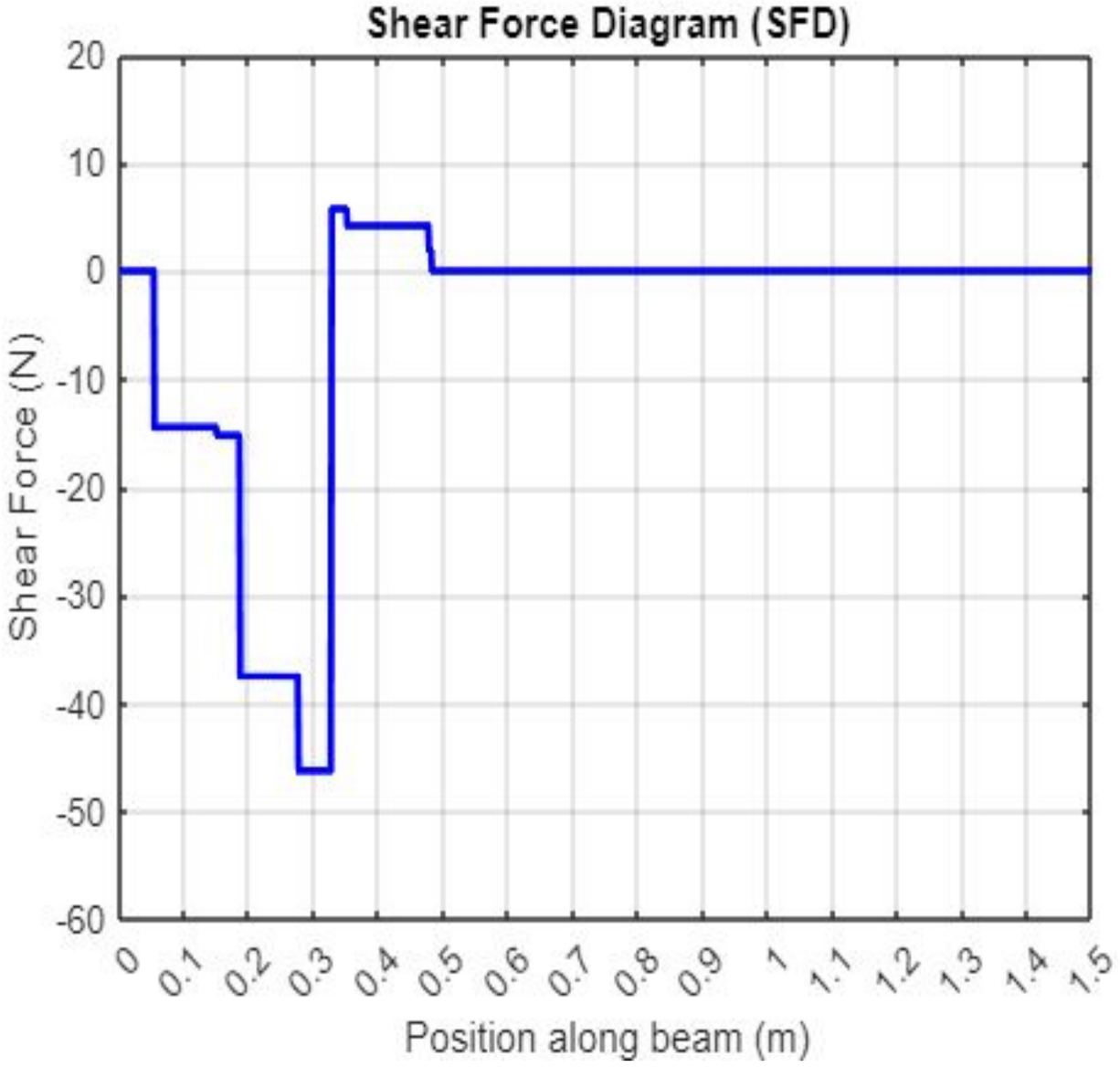
Skin wrapped around Rib

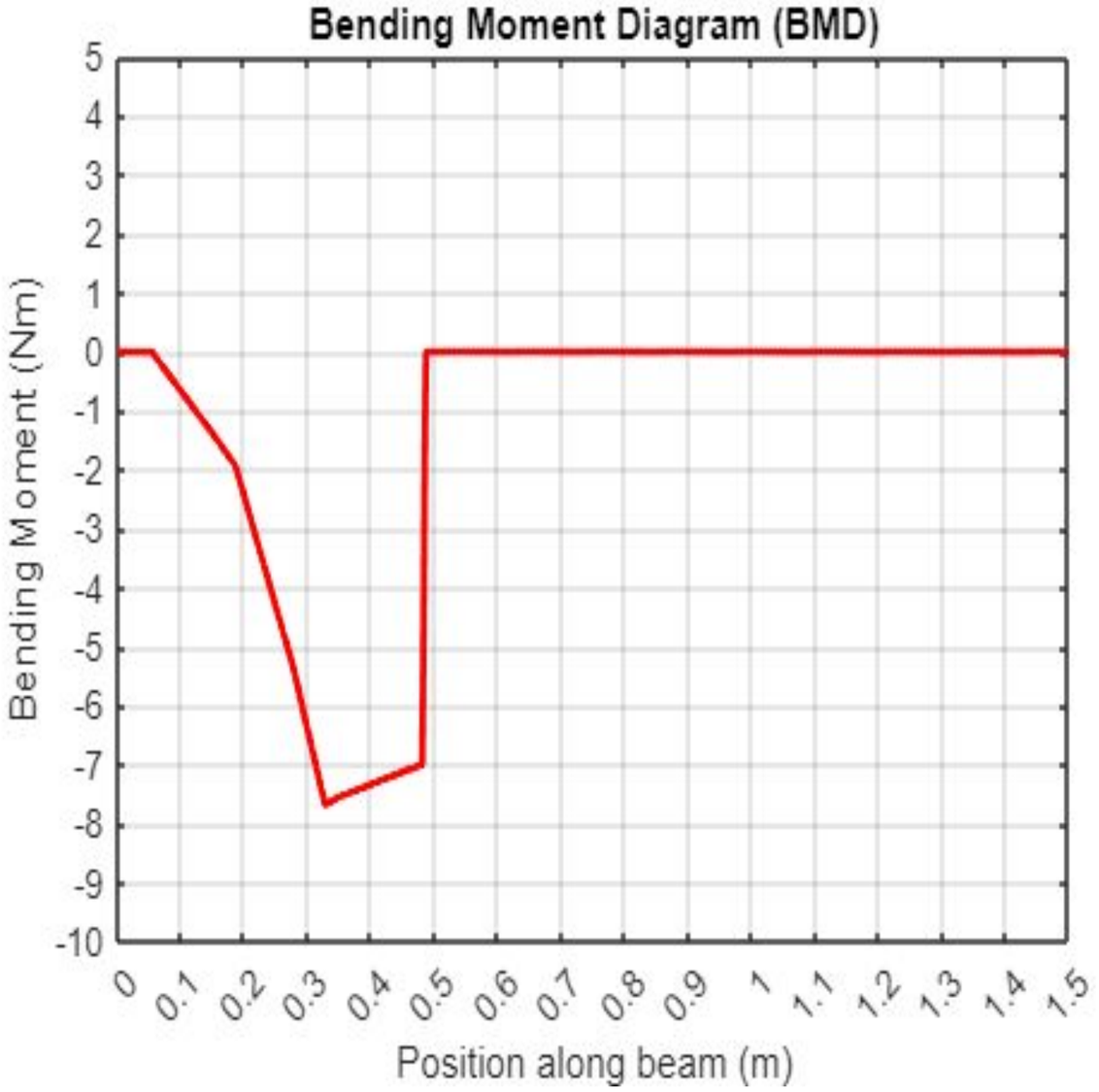
Wing Internal Structure

Wing Section 1 with Aileron

Wing Section 2 with Flap Cutout

Fuselage SFBM Diagram

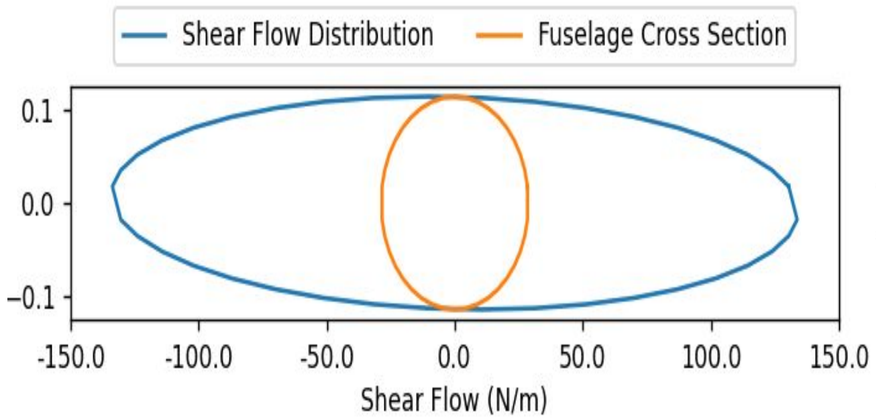




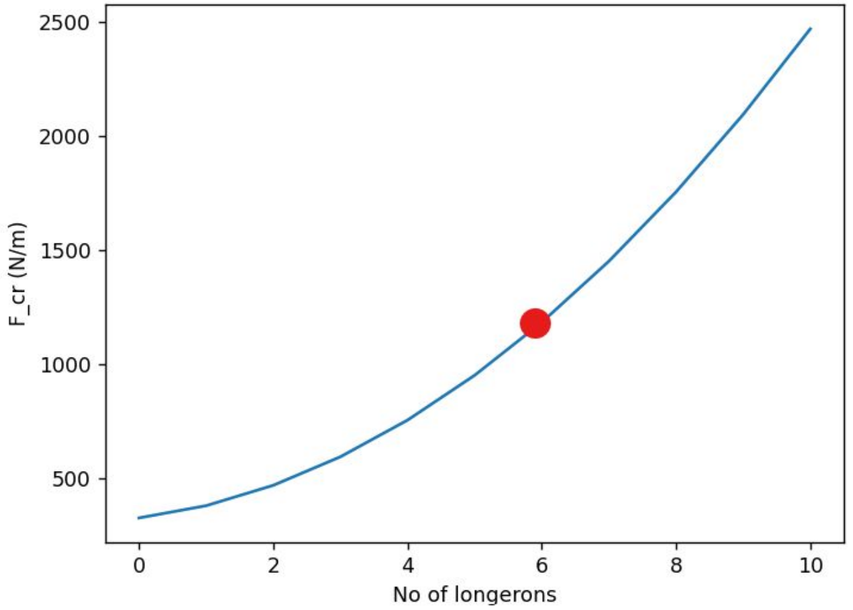
Maximum Shear Force = 46 N

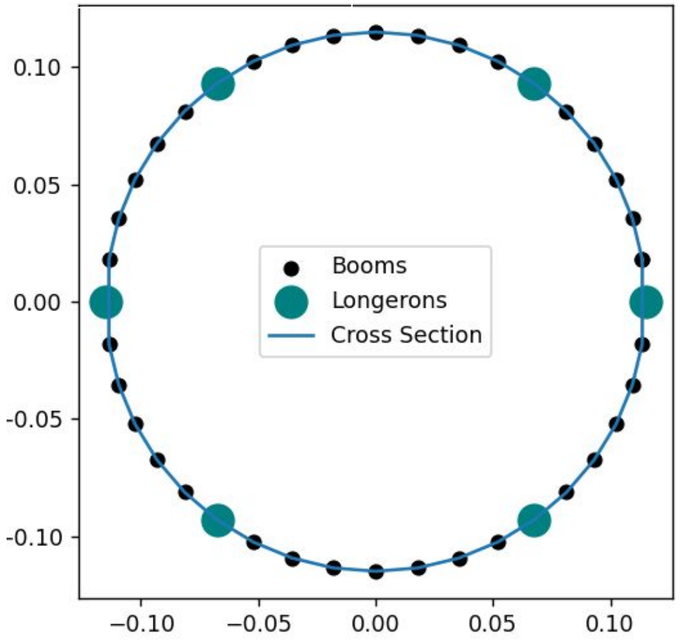
Maximum Bending Moment = 7.7 Nm

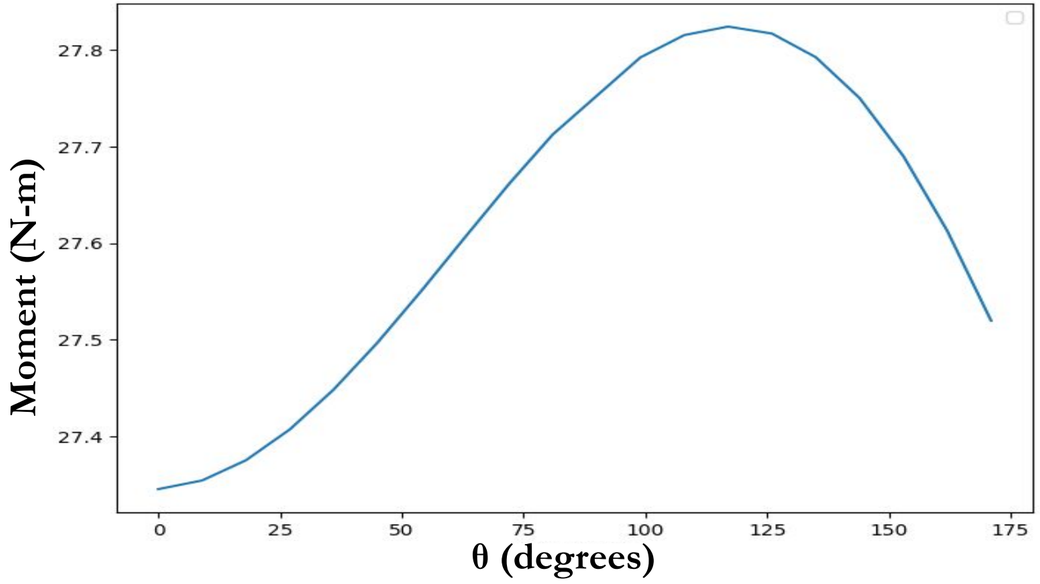
Longeron Selection and Bulkhead Sizing

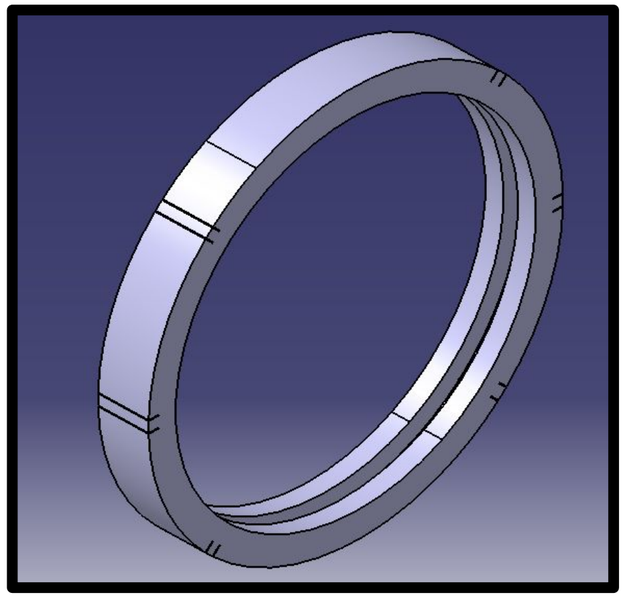


Set Configuration :
4 Frames, 6 Longerons





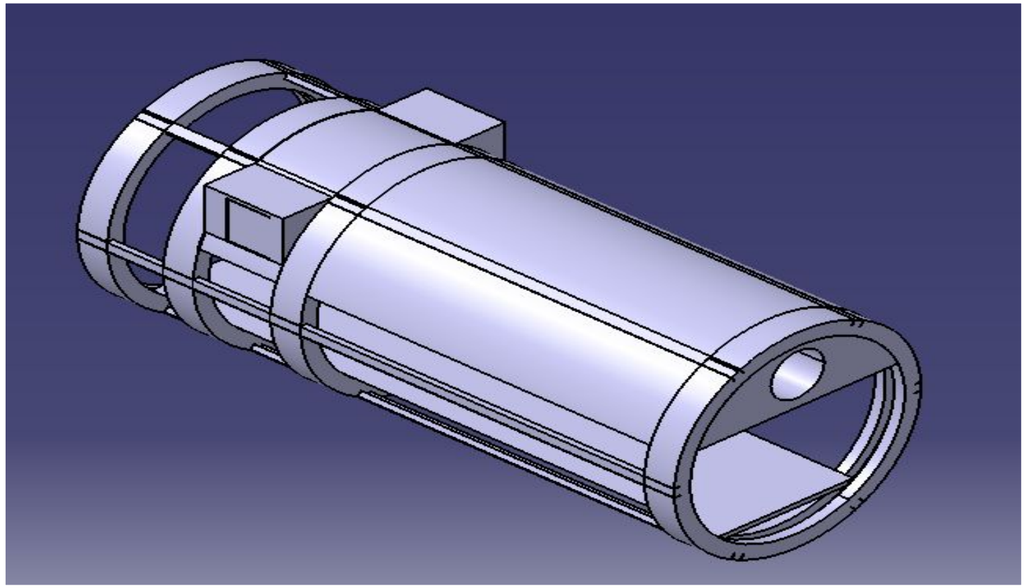




Max BM = 27 N-m
Radius = 0.115 m

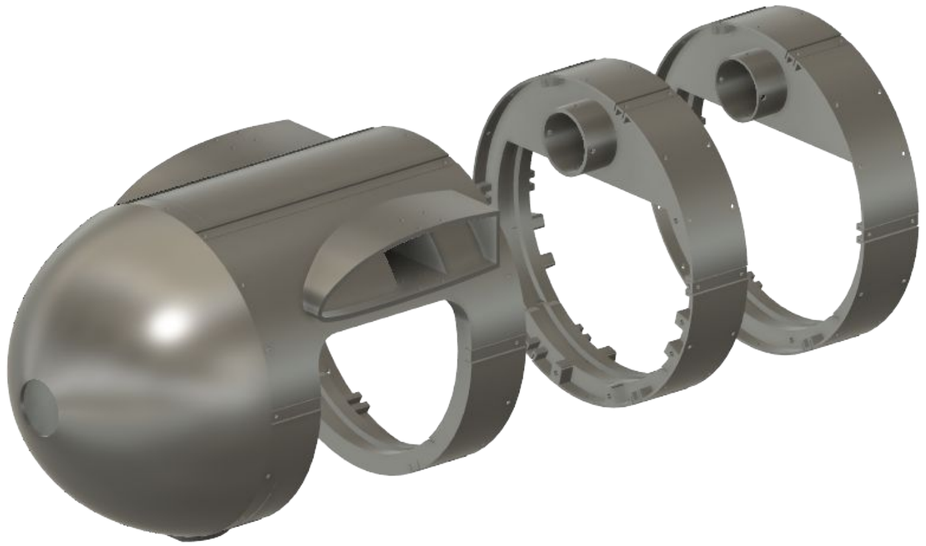
Material: PLA
Cross Section: C Section
Thickness: 10mm
Web: 21 mm
Flange: 15 mm

Fuselage Fabrication



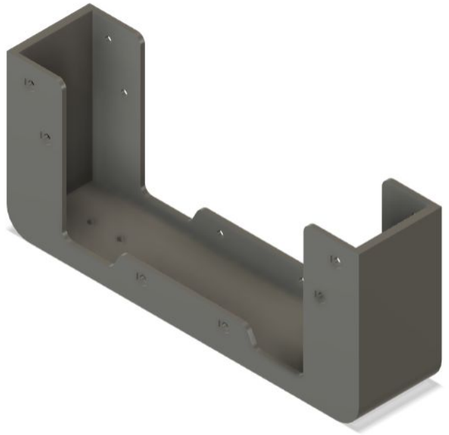
Material Used:

Bulkhead: PLA
Longerons: Al 6061
Platform: PLA



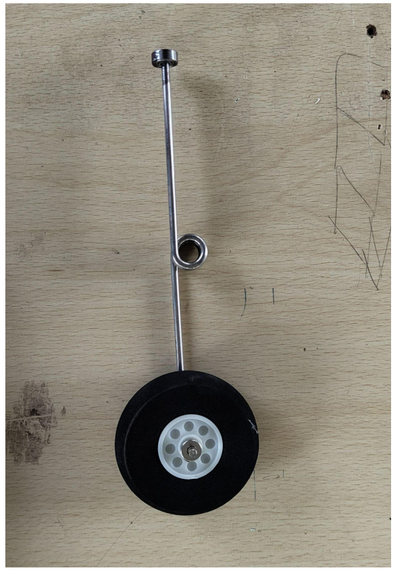
Landing Gear

Configuration	Tricycle LG
Retractability	Fixed
Position of Nose LG (From Nose)	0.15m
Position of main LG (From Nose)	0.35m
Wheel Base	0.2m
Wheel Track	0.75m
Wheel Height	0.29m
Wheel Dia	89 mm
Wheel Thickness	31mm
Wheel Material	PU
LG Strut Cross Section	Rectangular
Struct Web	25 mm
Strut Flange	20 mm

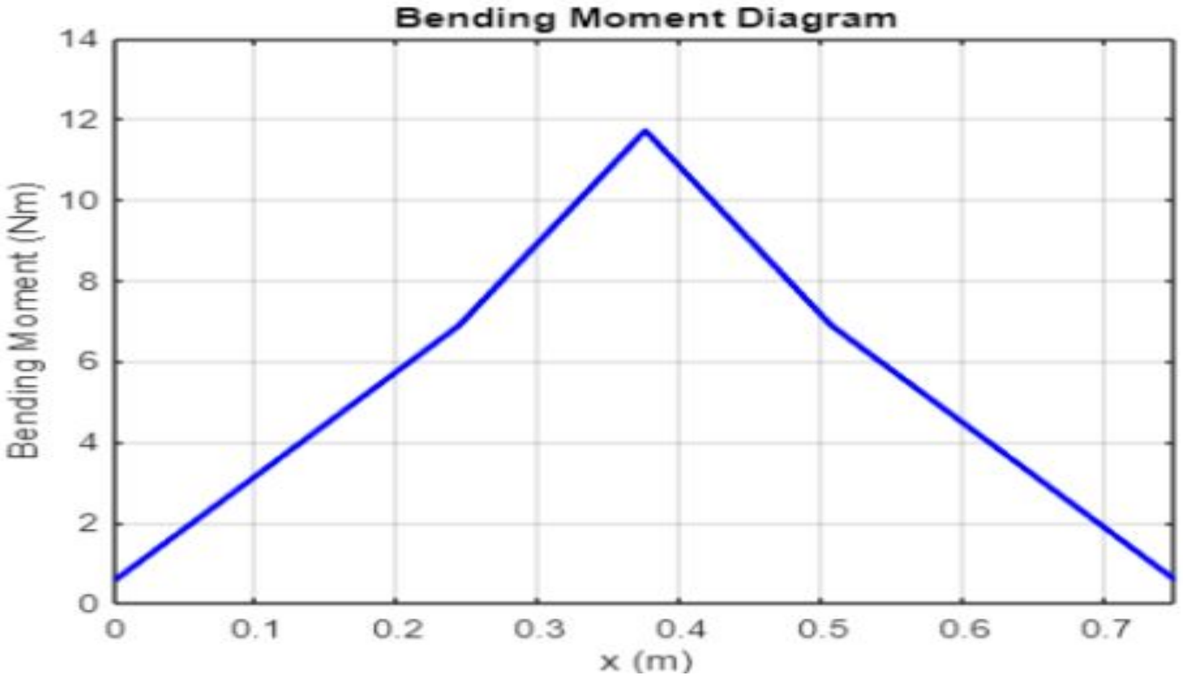


Landing Gear Adapter CAD

Landing Gear Assembly



Front Landing Gear Spring Strut



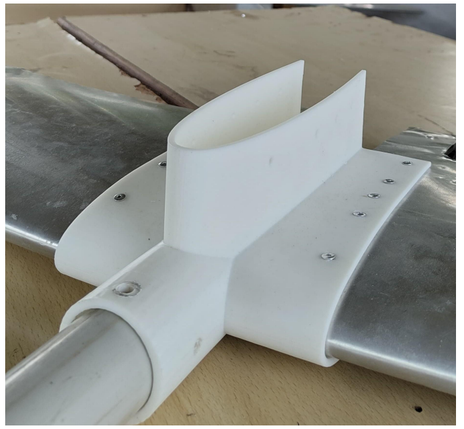
Max Bending Moment: 11.71N
Max Bending Moment at 0.375m

Empennage Fabrication

Tail CAD Model

- 0.3 mm Al 6061 Skin
- Each Horizontal Tail contains 4 NACA 0014 Ribs and 1 Spar of 30 mm web height at max thickness
- Ribs and Tail Mount were 3D printed with PLA
- 2 Tail booms were experimented on :
  5cm diameter with 1 cm thickness
  4cm diameter with 0.5 cm thickness(displayed)
- Vertical Tail couldn't be assembled due to a 3D printer error

Empennage Assembly



Tail Adapter

Skin wrapped around Tail Rib

Final Assembly and Challenges Faced

- **Challenges with Stringer Production**: Shear cutting machine couldn't cut 0.5mm sheets, requiring manual cutting, leading to inaccuracies; bending machine only reached 120°, requiring manual bending with wooden mallets, weakening stringers.
- **Riveting Issues**: Faulty rivets caused rework and increased hole diameter, necessitating larger rivets and occasional metal sheets; one rib was damaged beyond repair, delaying wing assembly.
- **Wing Skin Attachment**: Difficulty in shaping 0.5mm aluminum sheets along the airfoil led to errors, especially at the trailing edge, and misalignment of wing-skin sections.
- **Bulkhead Assembly Challenges**: 3D printer limitations caused delays, and a 0.2mm gap at attachment points proved insufficient, requiring manual adjustments with hacksaw blades to meet tolerances and a subsequent 2nd iteration was modelled and printed.
- **Front Landing Gear Failure**: The PLA-made strut, designed for impact absorption with a spring action, failed under fatigue loading; soldering iron molding for roller bearing attachment was unsuccessful.

Broken Nose Landing Gear

Final Assembly

Fabrication Summary

Part	Qty	Material	Fabrication Process
Fuselage			
Bulkhead	4	PLA	3D Print
Longeron	18	Aluminium	Machining
Wing Attachment	1	PLA	3D Print
Tail Boom Attachment	1	PLA	3D Print
Platform	1	PLA	3D Print
Nose Cone	1	PLA	3D Print
Skin	NA	Aluminium	Machining
Wings			
Ribs	18 (9+9)	PLA	3D Print
Spar	01	Aluminium	Machining
Stringers	8 (4+4)	Aluminium	Machining
Flaps	2 (1+1)	PLA	3D Print
Ailerons	2 (1+1)	PLA	3D Print
Skin	1	Aluminium	Machining

Fabrication Summary

Part	Qty	Material	Fabrication Process
Empennage			
Tail Boom	1	Aluminium	Machining
Tail Boom Adapter	1	PLA	3D Print
Horizontal Tail	2	PLA	3D Print
Elevator	2	PLA	3D Print
Vertical Tail	1	PLA	3D Print
Rudder	1	PLA	3D Print
Landing Gear			
Struts	1	Aluminium	Machining
Wheels	1	PU	NA

Contributions

ANISH : Report : Lift Distribution, Wing SFBM, Spar Design, Wing Idealization and Shear Flow Calculation, Shear Flow Calculations with Stringers and Spar, Fuselage Cross Section Shear Flow Calculations, Longeron Selection, Bulkhead Sizing (Validation), Fabrication Chapter
Fabrication : Riveting Rib and Stringer, Attaching Wing Skin, Helped in assembling 1st fuselage, 2nd fuselage iteration CAD Modelling and 3D Printing, manufacturing longerons and spar, assembling 2nd fuselage, brought 2nd tail boom, CAD Modelling Empennage and 3D Printing Tail Ribs and Tail Adapter, Manufacturing Tail Spar, Assembling both Horizontal Tails, CAD Modelling Landing Gear Adapter and 3D Printing, attaching Main LG to Adapter and Bulkhead

Abhigyan: Report: Problem Definition, Wing SFD BMD writing, Spar Design writing, Fuselage design writing, Bulkhead design and calculations; **Fabrication:** Different Wing Ribs and Ailerons CAD Modelling and 3D printing, Helped in Wing and Horizontal Tail assembly and Skin riveting, assembly of Landing Gear adapter with Main LG, involved in most of the 3D printed parts and helped in overall assembly of both iterations

Aditya
Report : Assisted in Bill Of Materials, Assisted in torque estimation of servo selection, Assisted in Fuselage SFD and BMD.
Fabrication : Fabrication of stringers and longerons, wing rib and striger attachment, assembly of fuselage, fabrication of Spar.

Vinu:
Report : Bill Of Materials, Assisted in Spar design, Torque estimation of servo selection, Fuselage SFD, BMD, Bulkhead sizing, Landing Gear Design, Fabrication Chapter
Fabrication : Fabrication of stringers and longerons, assisted in design of wing ribs, wing rib and stringer attachment, Design of 1st iteration of bulkhead and fuselage skeleton, assembly of fuselage, fabrication of Spar, Wing skeleton layout, Aileron and flap attachment to wing, assembly of wing skin, assembly of tail skin, attachment of tail booms to fuselage, fabrication of Landing gear strut. redesign of main landing gear strut, assembly of landing gear to fuselage, design and assembly of nose landing gear, design and assembly of nose cone.

Gautham:
Report : Assisted in Torque estimation of servo selection, Fuselage SFD, BMD, Landing Gear Design.
Fabrication : Fabrication of stringers and longerons, wing rib and striger attachment, assembly of fuselage, fabrication of Spar, Aileron and flap attachment to wing, assembly of wing skin, assembly of tail skin, attachment of tail booms to fuselage.fabrication of Landing gear strut. redesign of main landing gear strut, assembly of landing gear to fuselage, design and assembly of nose landing gear, design and assembly of nose cone.

Thank You