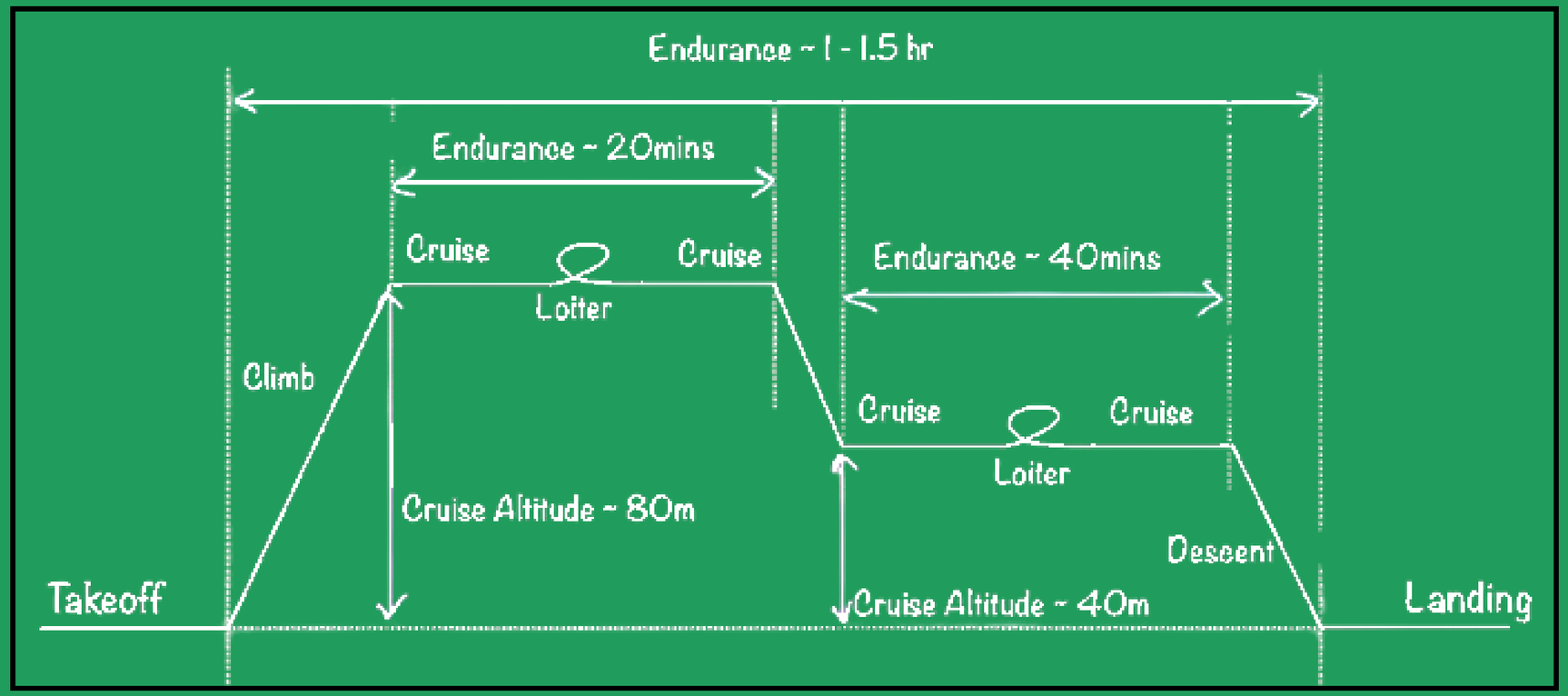
DESIGN OF UAV

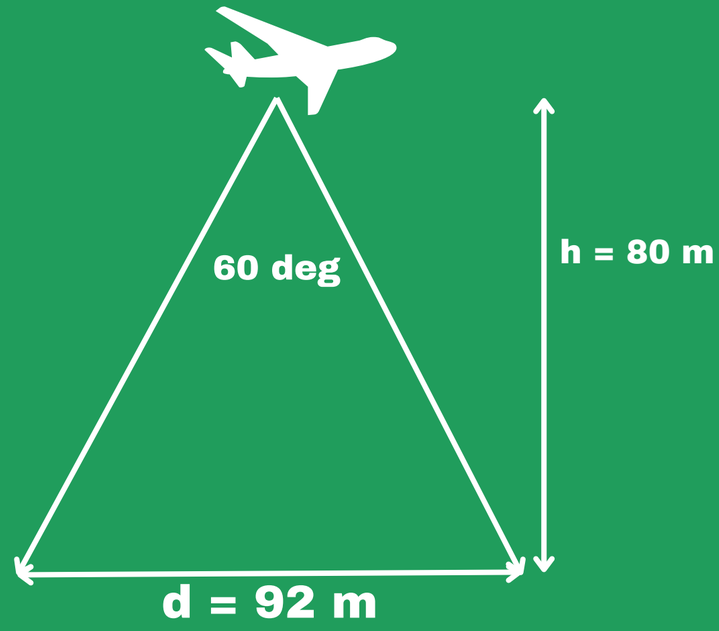
Group 5

- AE21B002 : Abhigyan Roy
- AE23M004 : Vinu Mathew
- AE23M008 : Anish Konar
- AE23M014 : Gautham Anil
- AE23M006 : Aditya Sai Deepak Rachagiri
- AE23M033 : Satyam Chandra

Mission Profile

Environmental Monitoring and Mapping of Forest Cover including Security based Surveillance.





Area of Coverage per frame = 7000 m2

Payload

WIRIS Thermo-optical Sensor

IR Resolution : 640 x 512
Visual Resolution : 1920 x 1080

Environmental Sensor: Prana Air SQUAIR

TVOC: 0-20 PPM
CO: 1-200 PPM

Pixy WP Gimbal

Payload	Weight
Integrated Thermal and Optical Sensor- Workshell WIRIS	450 g
Environmental Sensor- Prana Air SQUAIR	227 g
Gimbal for Optical Stabilization	465 g
Misc	358 g
Total	1500 g

Wing Loading

Mission Segment	Wing Loading (kg/m2)
Takeoff	30.76
Climb	3.43
Cruise	17.56
Absolute Ceiling	11.93
Stall	9.30

Power Calculation

Phase	Power	Time (approx)
Take Off	130 W	10 s
Climb	284 W	5 min
Cruise	129 W	1 hr

L/D max = 19.5

AR = 8.3

Battery & Powerplant

Tattu 18000mAh 15C Lipo Battery

Battery weight = 2270g

Power Requirements	Battery Capacity (mAH)
Powerplant	16996
Sensors	1000
Total	18000

Powerplant weight = 700g

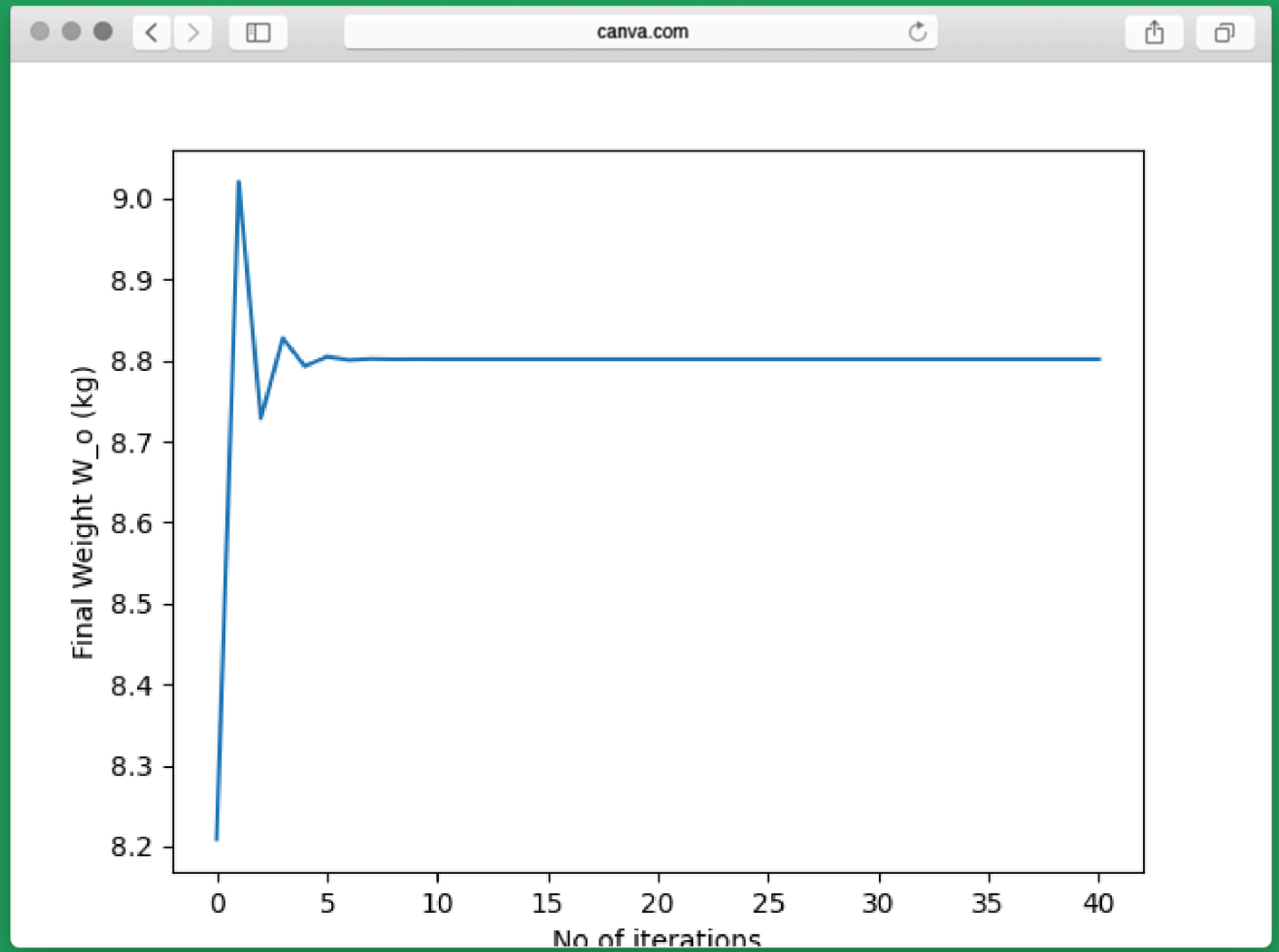
Part	Model	Specifications
Motor	AT 7215	Power @ 55%: 414W Net weight: 550g
Propeller	TF 16 * 8	Weight : 150 g Diameter : 16 Inch

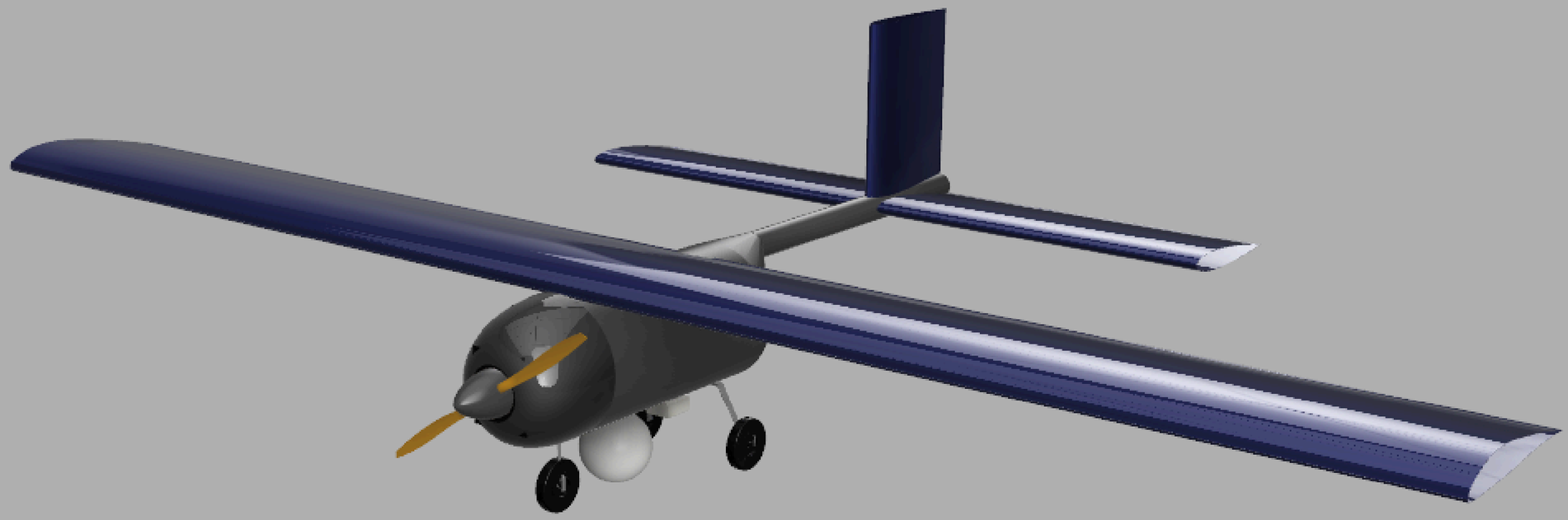
Second Weight Estimate

$$W_o = \frac{W_{payload} + W_{powerplant}}{1 - \frac{W_{empty}}{W_o}}$$

$$\frac{W_{empty}}{W_o} = 1.206 * W_o^{-0.3}$$

Based on previous data and adding the powerplant weight, the second weight estimate is 8.8 kg.

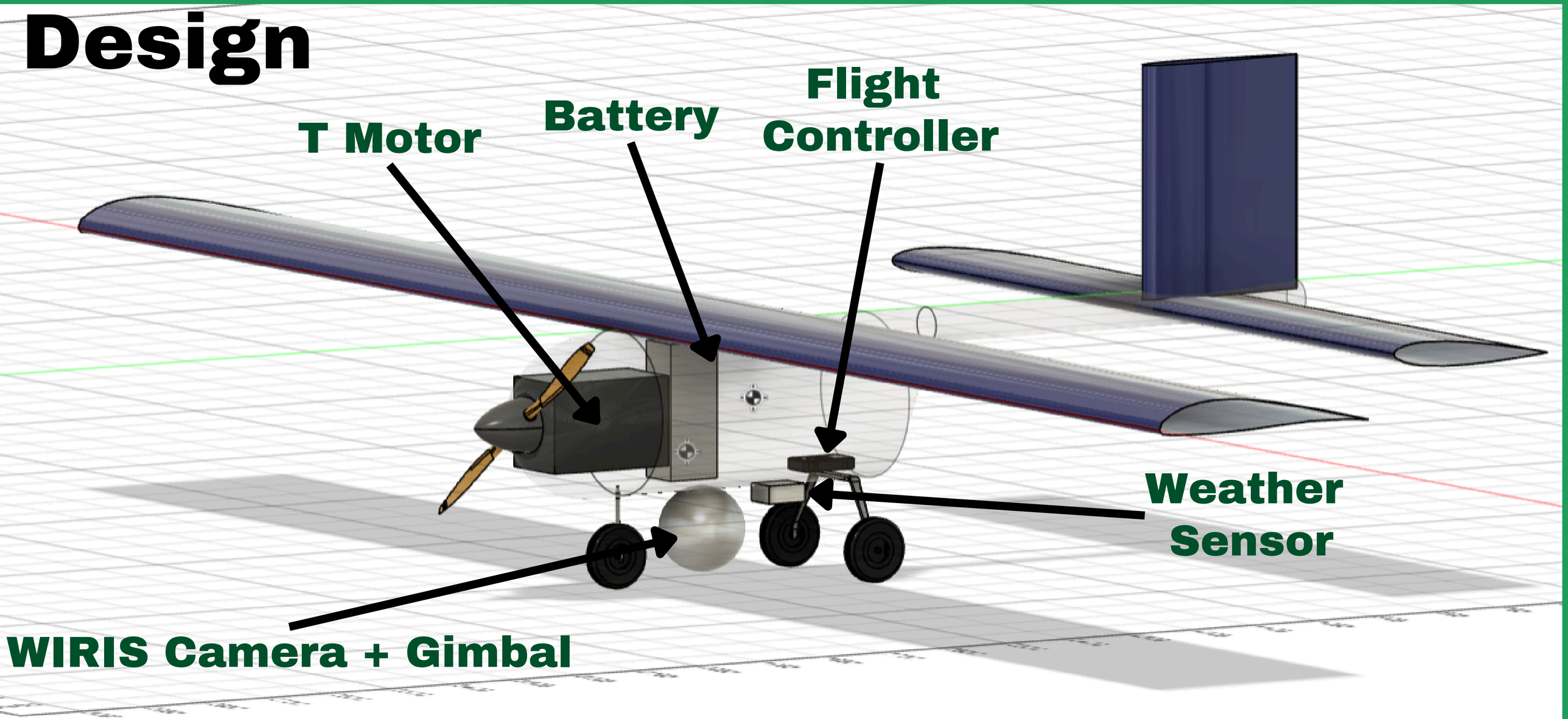




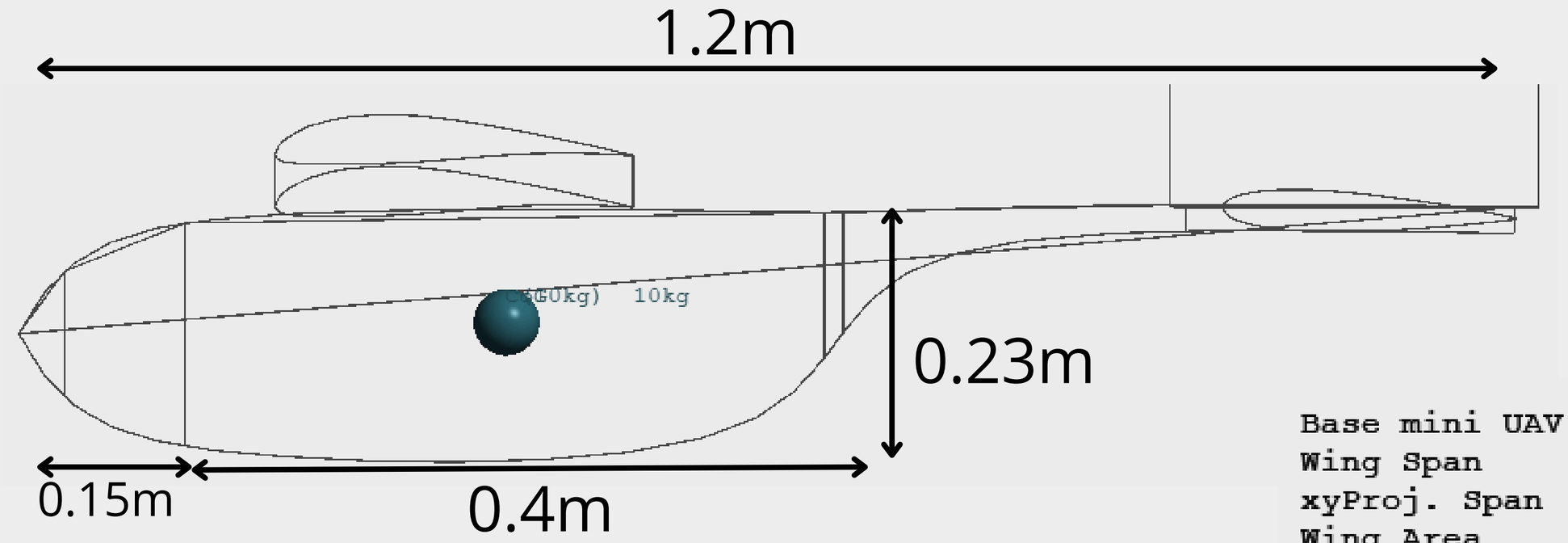
CAD Model

Centre of Gravity -
0.220 m behind and 0.109 m below wing leading edge

Fuselage Design



XFLR CAD Profile

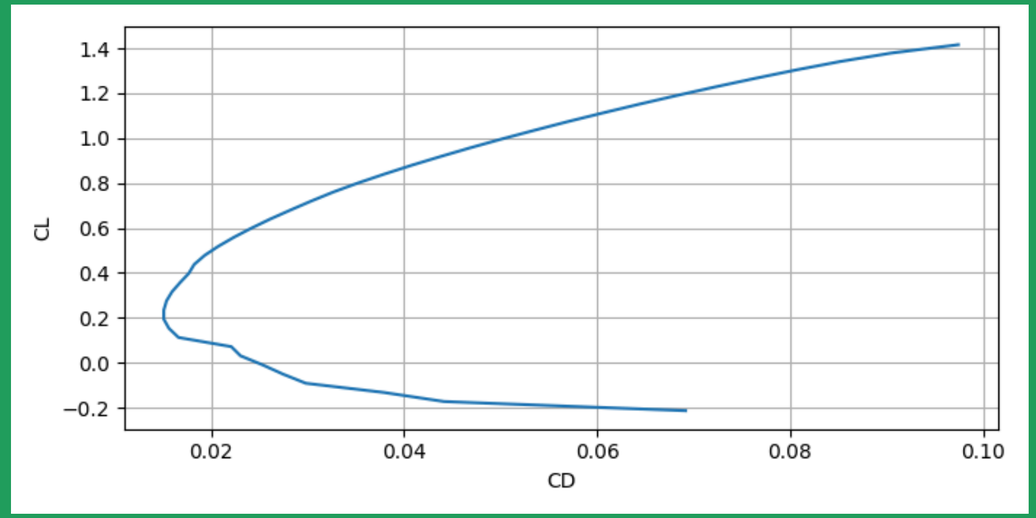


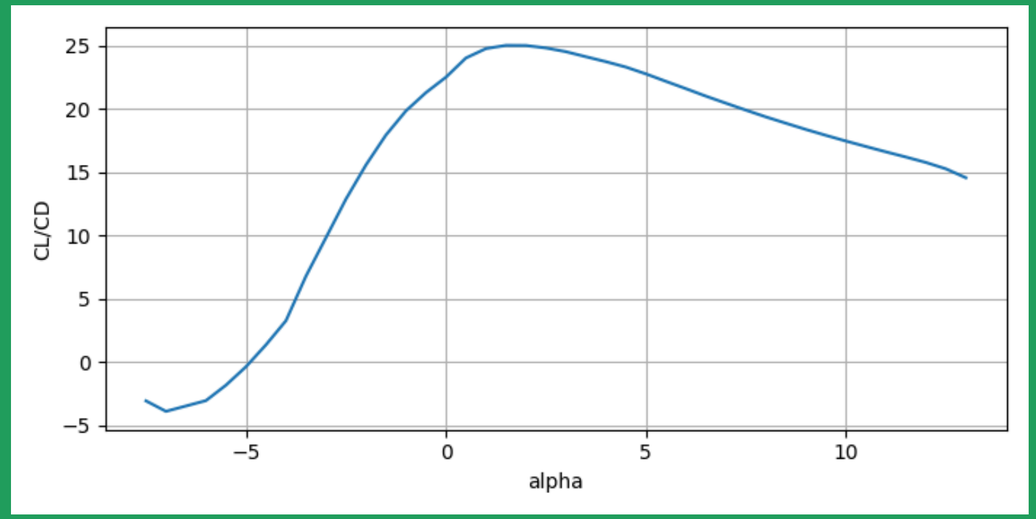

```
Base mini UAV Body 2 final
Wing Span       =     2.820 m
xyProj. Span    =     2.818 m
Wing Area       =     0.959 m²
xyProj. Area    =     0.958 m²
Plane Mass      =    10.000 kg
Wing Load       =    10.436 kg/m²
Tail Volume     =     1.141
Root Chord      =     0.340 m
MAC             =     0.340 m
TipTwist        =     0.000°
Aspect Ratio    =     8.294
Taper Ratio     =     1.000
Root-Tip Sweep  =     0.000°
```

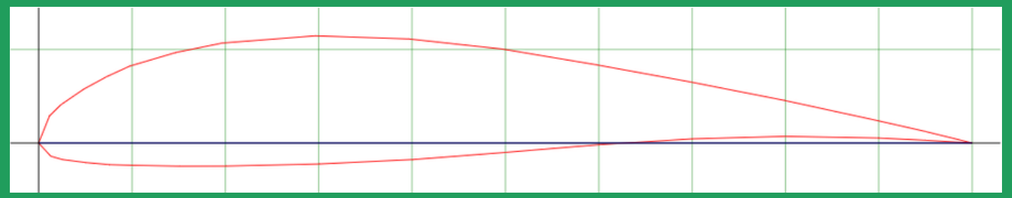
Wing Design

CL cruise	0.5
CL stall	1.35-1.48
CL to	1.21
CL climb	1.31

Chord	0.32m
Span	2.82m
Sweep	0°
Taper Ratio	1



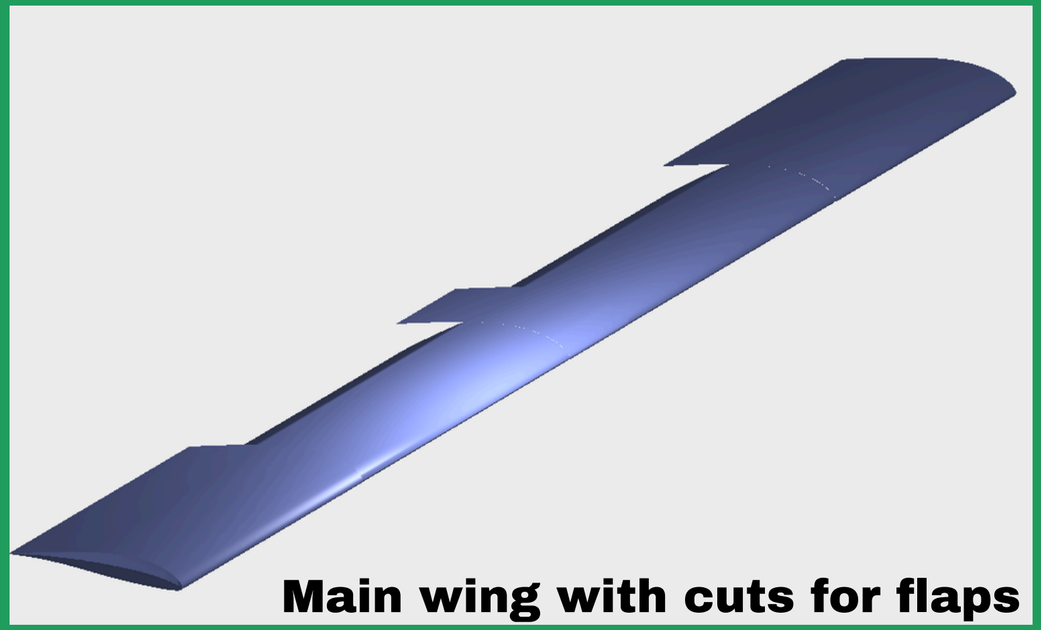




GOE 553

Geometric Characteristics	Value	Aerodynamic Characteristics	Value
Camber	4.7% of chord	$C_{l_{max}}$	1.52
Chord Length	0.34 m	α_{stall}	14°
Location of maximum camber	39.6% of chord from LE	$(L/D)_{max}$	100
Maximum Thickness	13.7% of chord		

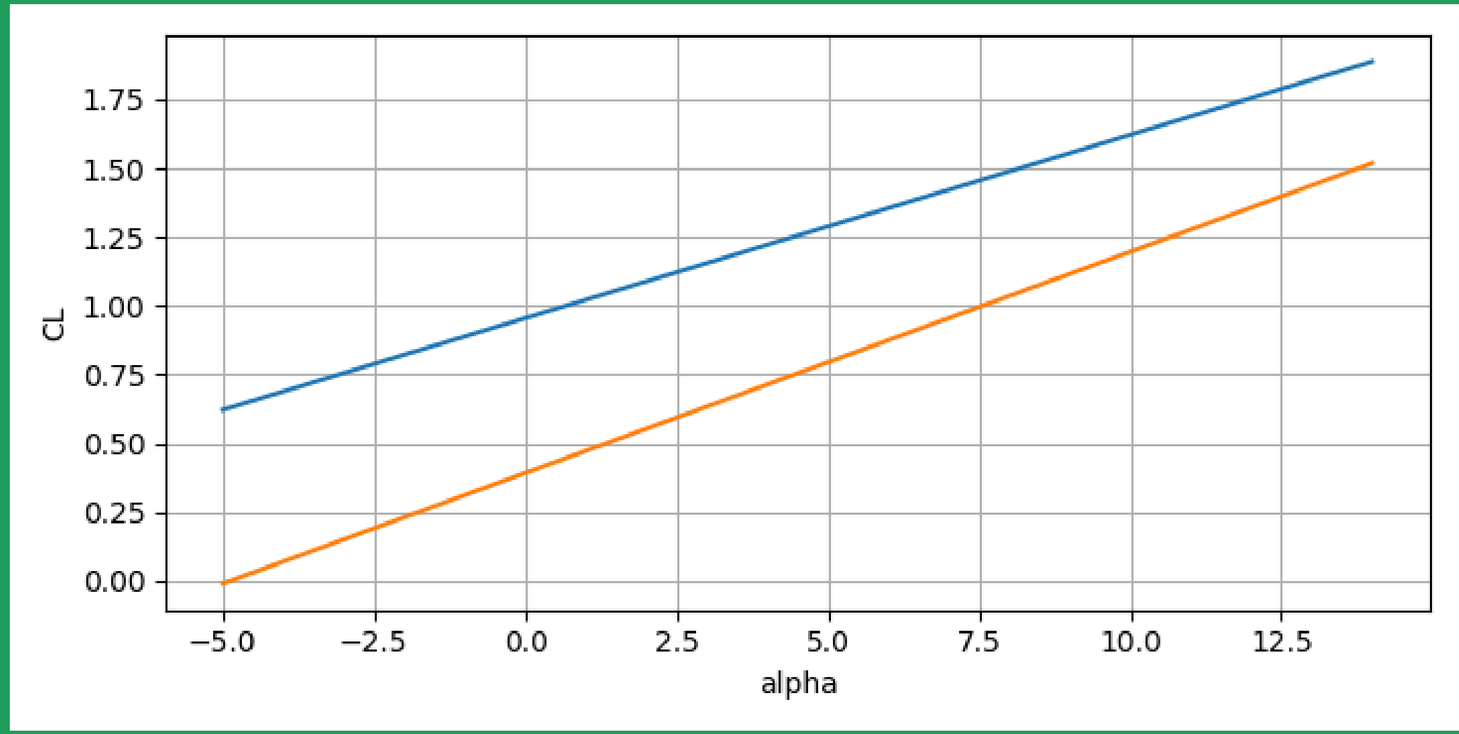
Wing Design



Main wing with cuts for flaps

Aileron dimensions

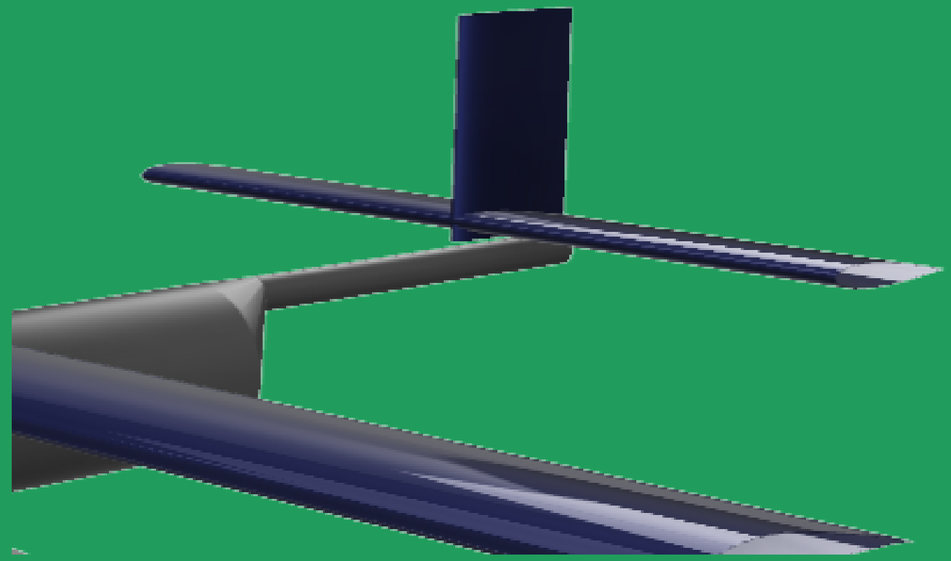
$$
\begin{aligned}
S_a/\mathrm{S} = 0.05 \quad &\rightarrow \quad S_a = 0.048\ m^2 \\
b_a/\mathrm{b} = 0.2 \quad &\rightarrow \quad b_a = 0.564\mathrm{m} \\
c_a/\mathrm{c} = 0.25 \quad &\rightarrow \quad c_a = 0.085\ \mathrm{m} \\
b_{ai}/\mathrm{b} = 0.6 \quad &\rightarrow \quad b_{ai} = 1.692\ \mathrm{m} \\
&\rightarrow \quad \delta_{A_{max}} = \pm 30°.
\end{aligned}
$$



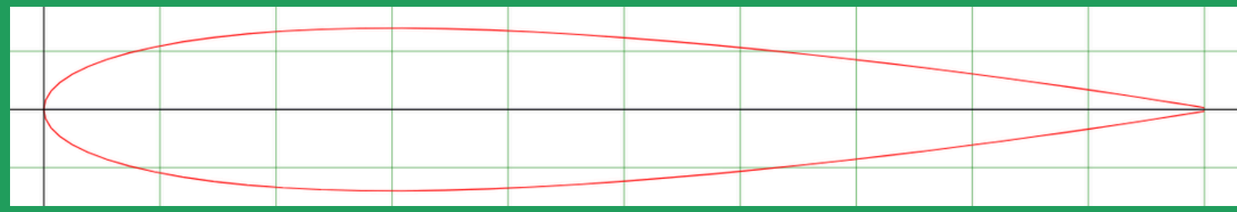
Coefficient of Lift for Wing vs Angle of Attack with and without flaps

Horizontal Tail Design

Moment Arm	**1.159m**
Horizontal Tail Area	**0.27m^2 - 0.45m^2**
Horizontal Tail Chord	**0.23-0.3**
Horizontal Tail Span	**1.16-1.5**
Elevator Area	**0.105 m2**
Elevator Span	**1.5 m**
Elevator Chord	**0.07 m**



Low Tail or Conventional tail configuration



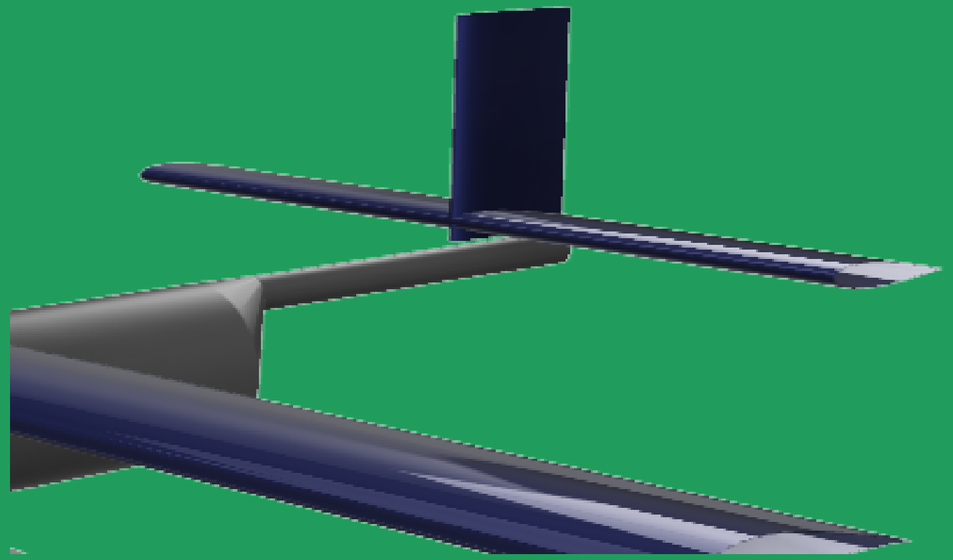
NACA 0014

$$S_e/S_t : 0.15 - 0.4$$
$$b_e/b_t : 0.8 - 1$$
$$c_e/c_t : 0.2 - 0.4$$

Elevator dimensions

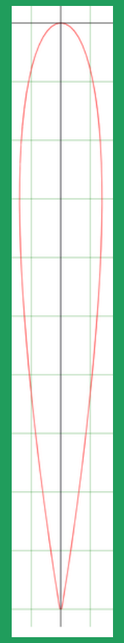
Vertical Tail Design

Moment Arm	**1.159m**
Vertical Tail Area	**0.13m2**
Vertical Tail Chord	**0.4**
Vertical Tail Span	**0.325**
Rudder Area	**0.042 m2**
Rudder Span	**0.4 m**
Rudder Chord	**0.105 m2**



Low Tail or Conventional tail configuration

NACA 0014

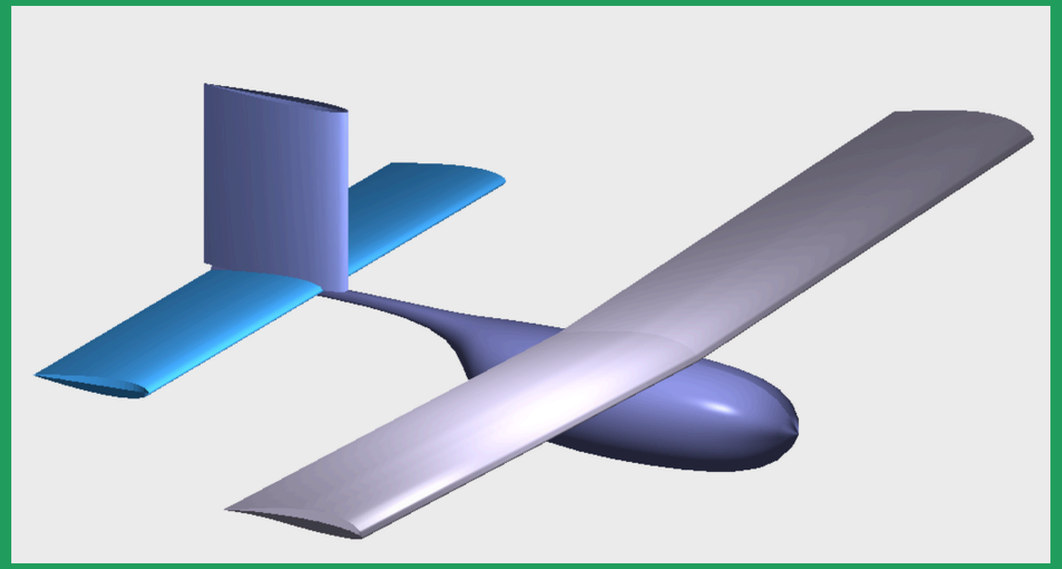


$$S_r/S_v : 0.15 - 0.35$$
$$b_r/b_v : 0.7 - 1$$
$$c_r/c_v : 0.15 - 0.4$$

Rudder dimensions

Stability Analysis

Parameters	Value
Wing Area	0.96 m^2
Wing Span	2.82 m
Taper Ratio	1
Root Chord	0.34 m
Tip Chord	0.34 m
Aspect Ratio	8.3
Twist Angle	0 Deg
Sweep Angle	0 Deg
Dihedral Angle	2 Deg
Wing Setting Angle	1 Deg
Aerofoil	GOE 553
Alieron Area	0.048 m^2
Alieron Chord	0.085 m
Alieron Span	0.564 m

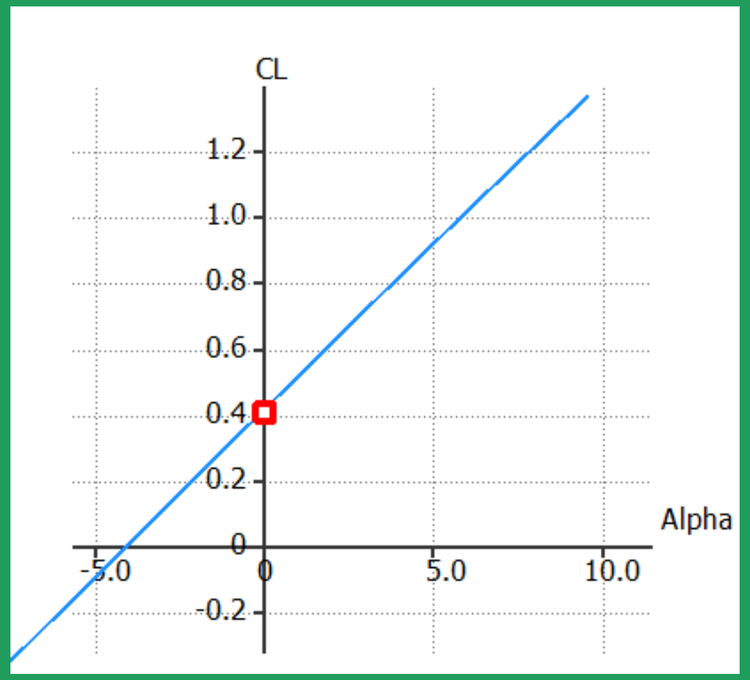


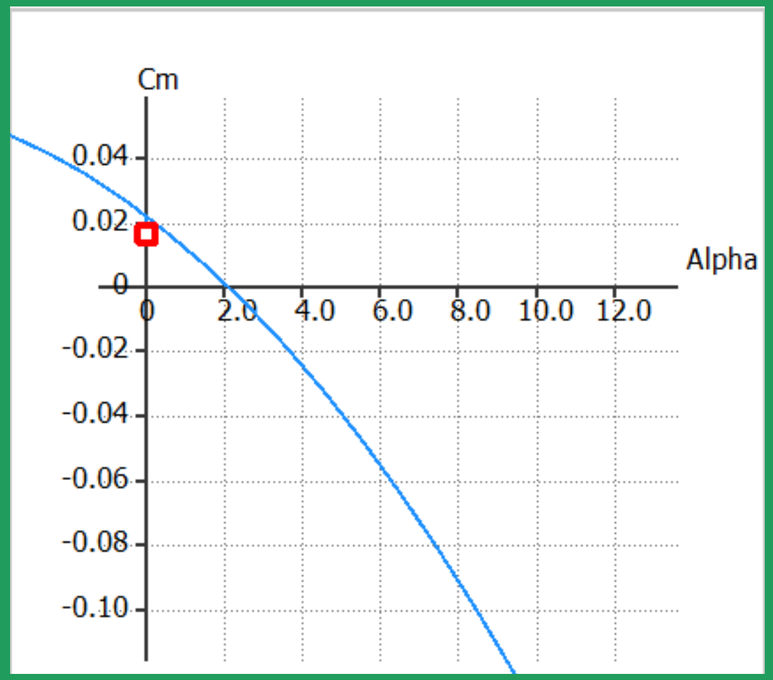
XFLR5 Model used for Stability Analysis

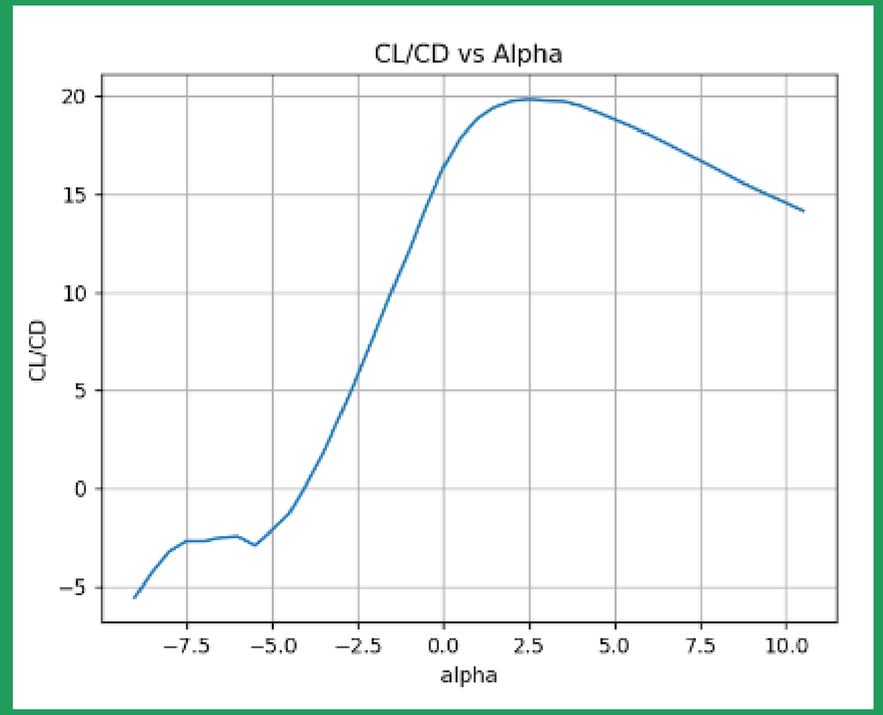
Parameters	Value
Tail Area	0.42 m^2
Tail Span	1.5 m
Taper Ratio	1
Root Chord	0.28 m
Tip Chord	0.28 m
Aspect Ratio	5.0
Twist Angle	0 Deg
Sweep Angle	0 Deg
Dihedral Angle	0 Deg
Tail Setting Angle	2 Deg
Aerofoil	NACA 0014
Elevator Area	0.105 m^2
Elevator Chord	0.07 m
Elevator Span	1.5 m

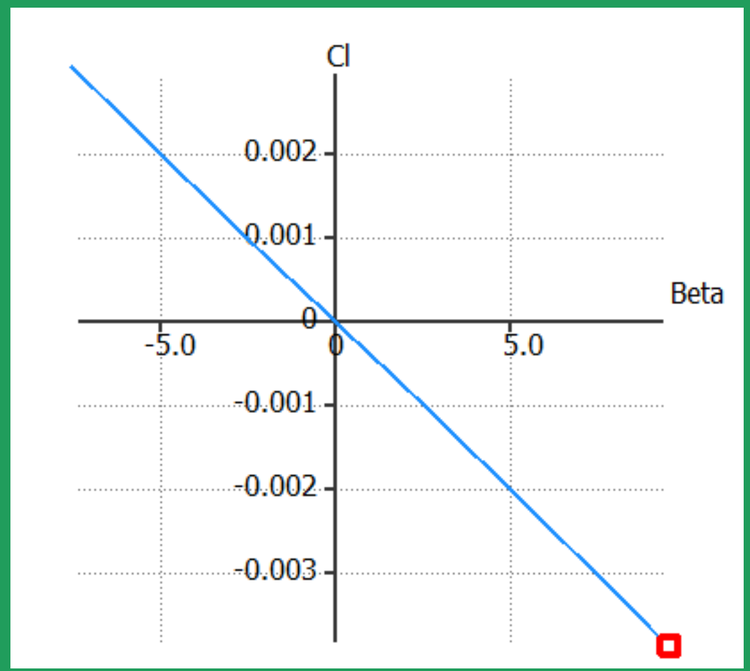
Parameters	Value
Tail Area	0.14 m^2
Tail Span	0.4 m
Taper Ratio	1
Root Chord	0.35 m
Tip Chord	0.35 m
Aspect Ratio	1.14
Twist Angle	0 Deg
Sweep Angle	0 Deg
Dihedral Angle	0 Deg
Tail Setting Angle	0 Deg
Aerofoil	NACA 0014
Rudder Area	0.042 m^2
Rudder Chord	0.105 m
Rudder Span	0.4 m

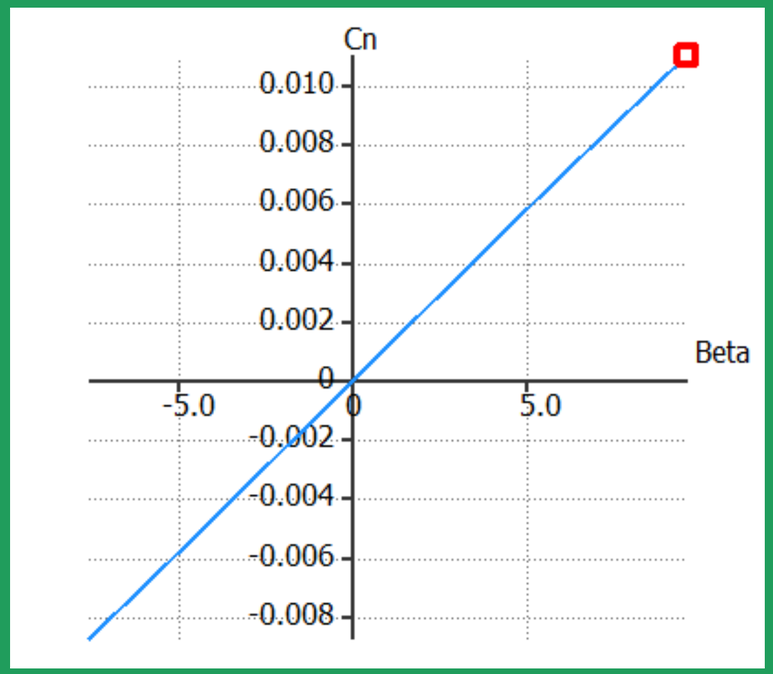
- **A dihedral angle of 2° was given**
- **The tail arm length was optimized**
- **The horizontal stabilizer was given a 2.2° tail setting angle**











Design α = 2°
Trim α = 2°

SM = 0.08

From wing
CG = 0.22 m
NP = 0.26 m

$$\frac{\partial C_n}{\partial \beta} = 0.0153\, rad^{-1}$$

$$\frac{\partial C_l}{\partial \beta} = -0.0076\, rad^{-1}$$

$$C_{m_\alpha} = -1.089\, rad^{-1}$$

Landing Gear

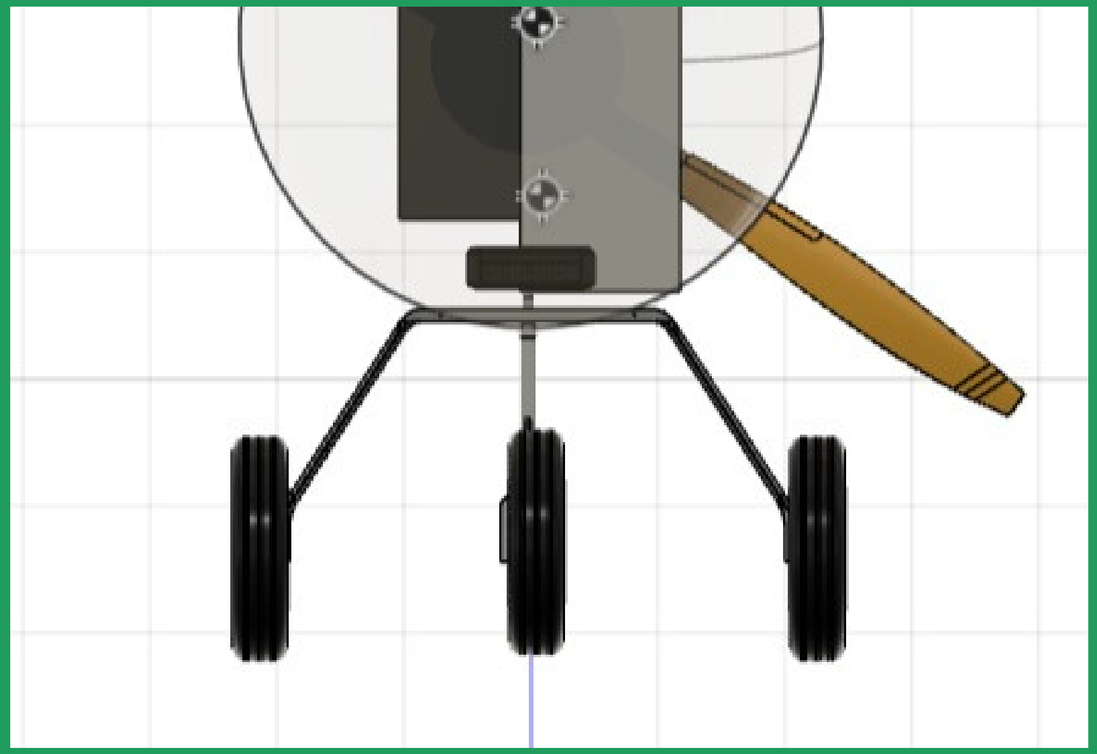
- Requirement of LG
- Design Specifications
  - Configuration
  - Retractability
  - Geometry
  - Load on Each LG
- Tire Selection

LANDING GEAR	DISTANCE FROM NOSE
NOSE LG	0.15 m
MAIN LG	0.5 M

PROPERTY	VALUE
WHEEL BASE	0.35m
WHEEL TRACK	1.5m
GROUND CLEARANCE	0.275m

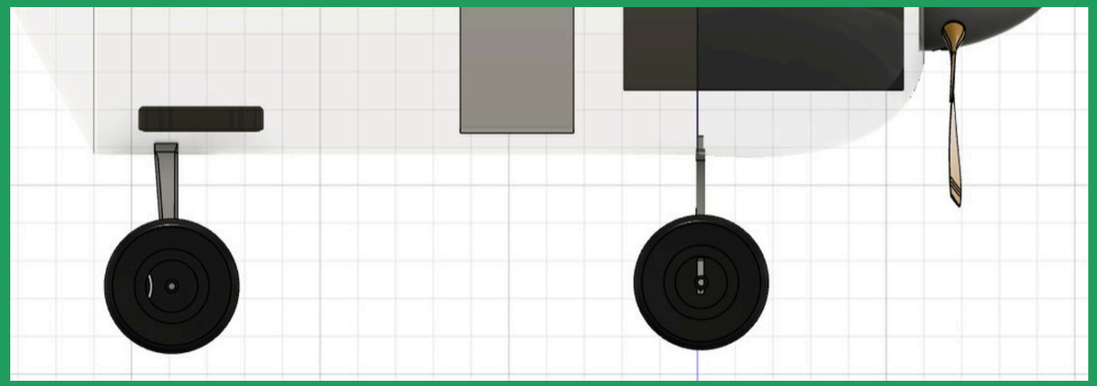
Loads on LG

LANDING GEAR	LOAD
NOSE	13.81 N
PORT MAIN	36.26 N
STBD MAIN	36.26 N

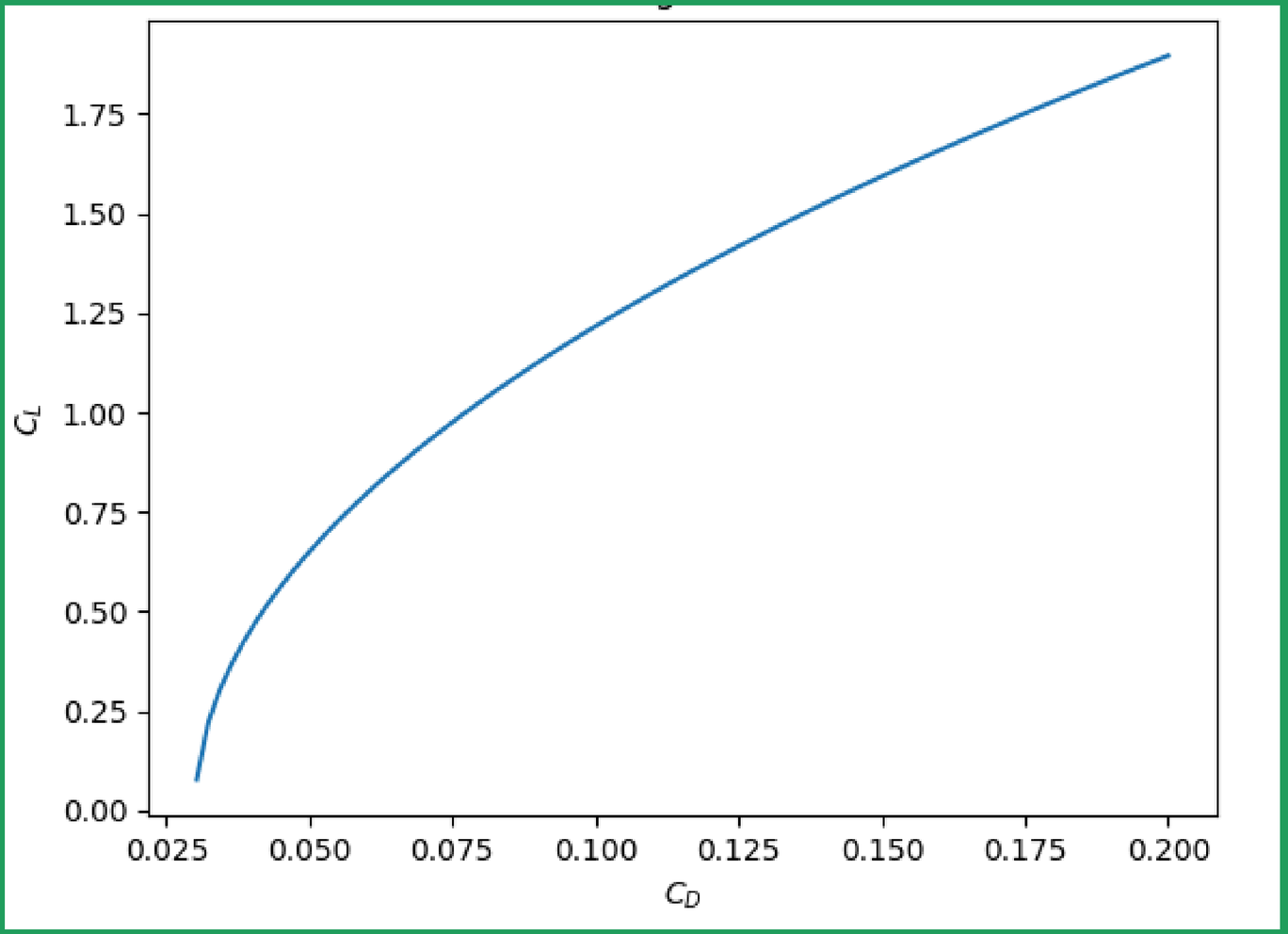


Tire Selection

- 3.5 Inch PU Wheels



Performance

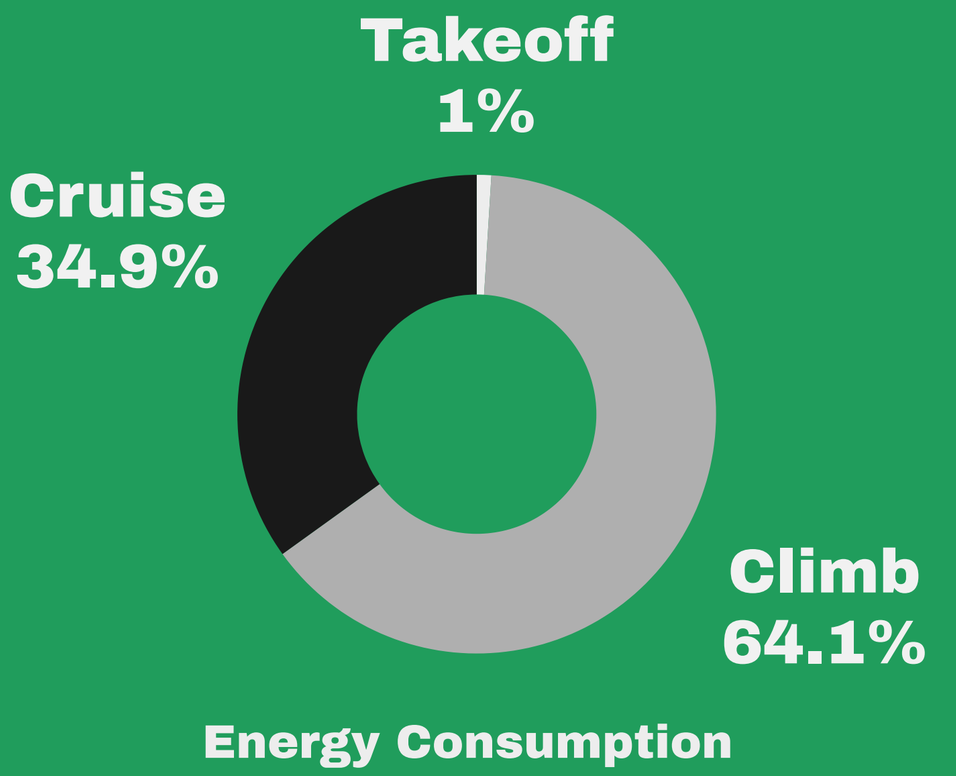


AR = 8.3

$$C_{D_o} = \frac{C_f \cdot S_{wet}}{S_{ref}} = 0.03$$

$$e = \frac{1}{1.05 + 0.007 \cdot \pi AR} = 0.8113$$

$$C_f = \frac{0.074}{Re^{1/7}} = 0.0116$$

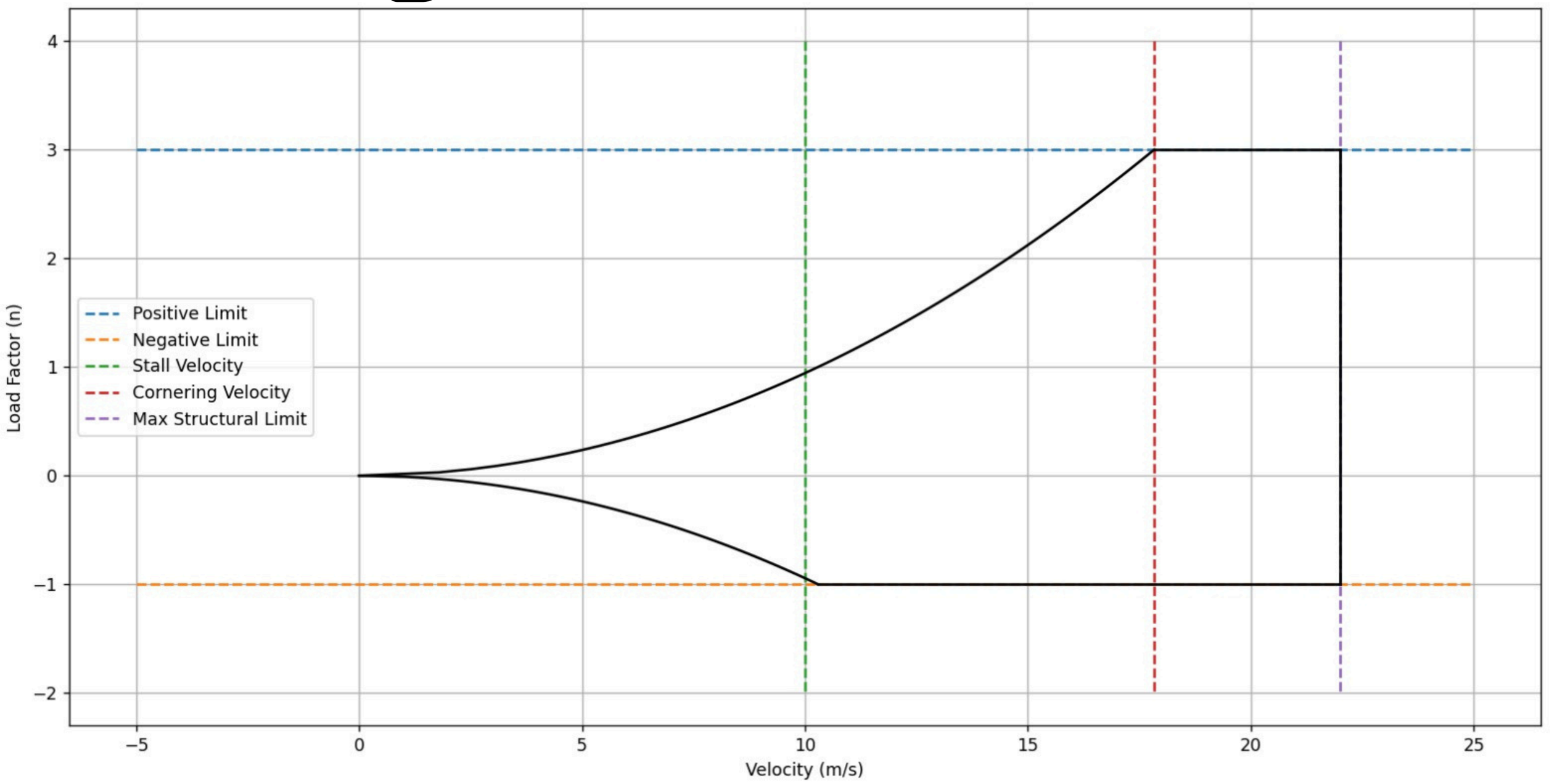


Drag Polar

$$C_D = C_{D_o} + \frac{1}{\pi e AR} C_L^2$$

V - n Diagram

$$n = \frac{L}{W} = \frac{1}{2}\frac{\rho v^2 S C_{L_{max}}}{W}$$



THANK YOU

DATASHEET

PROPERTY	VALUE
Cruise Speed	18 m/s
Max Speed	20 m/s
Stall speed	10 m/s
Rotation Speed	11 m/s
Climb Speed	11.51 m/s
Max Climb Rate	2 m/s
Max Climb Angle	12 Deg
Absolute ceiling	100m
L/D	19.48
Battery Capacity	18000 mAH

PROPERTY	VALUE
Wing Area	0.96 m2
Wing Span	2.82 m
Chord	0.34 m
Aspect Ratio	8.34
Dihedral	2 Deg
Wing Setting Angle	1 Deg
Wing Aerofoil	GOE 553
Alieron Area	0.048 m2
Alieron Chord	0.085 m
Alieron Span	0.564 m

PROPERTY	VALUE
HT Area	0.42 m2
HT Span	1.5 m
HT Chord	0.28 m
HT Aspect Ratio	5.0
HT Setting Angle	2 Deg
HT Dihedral Angle	0 Deg
HT Aerofoil	NACA 0014
Elevator Area	0.105 m2
Elevator Chord	0.07
Elevator Span	1.5m

PROPERTY	VALUE
Vertical Tail Area	0.14 m^2
Vertical Tail Span	0.4 m
Vertical Tail Chord	0.35 m
VT Aspect Ratio	1.14
VT Setting Angle	0 Deg
VT Dihedral Angle	0 Deg
VT Aerofoil	NACA 0014
Rudder Area	0.042 m2
Rudder Chord	0.105 m
Rudder Span	0.4 m

PROPERTY	VALUE
Fuselage Length	1.2 m
Fuselage Diameter	0.250 m
Fuselage Width	0.2 m
MTOW	9.85 Kgs
Design payload Weight	1.5 Kgs
Max Payload Weight	2.0 Kgs
Powerplant weight	2.27 Kgs
CL Max	1.56
CD0	0.03
Wing Loading	90 N/m^2

Abhigyan AE21B002	• Second weight estimate • Airfoil selection latek writing, Angle of Incidence, Dihedral angle and aileron • Fuselage length and sizing coding and latek, Internal placement of components • Latex (equations) writing of tail design • Cad modelling and 3 view diagram • Latek writing for longitudinal, lateral and directional stability • Swet and Cdo for drag polar • Range and endurance • V-n diagram • Entire report formatting
Anish Konar AE23M008	• CL calculations, Airfoil Selection and XFLR5 analysis and report writing • Wing design with flaps and taper ratio with XFLR5 analysis and report writing • Horizontal Tail area estimation and Tail airfoil selection • Helped in conceptual design of the CAD Model • Modelled the UAV in XFLR5 and performed the stability analysis and calculations • Power Estimate Re-calculation

Vinu **AE23M004**	• Landing Gear Design • Control Surface sizing • Contributed to tail design • Report Presentation • Report Writing
Gautham **AE23M014**	• Wing configuration and tail configuration theory • Flight controller and GPS selection • Researched about control of control surface • Researched about sensors • Report writing and Data collection

Aditya **AE23M006**	• Control surfaces for the Tail • Correction of previous Power Calculations • Theory Behind Sweep Angle • Helped in Wing Configuration • Report Writing and Data collection • Theory behind the Tail configuration (advantages, disadvantages,)
Satyam **AE23M033**	• Wing Design • Vertical Tail Design • Control Surfaces for tail • Report Writing and Data collection