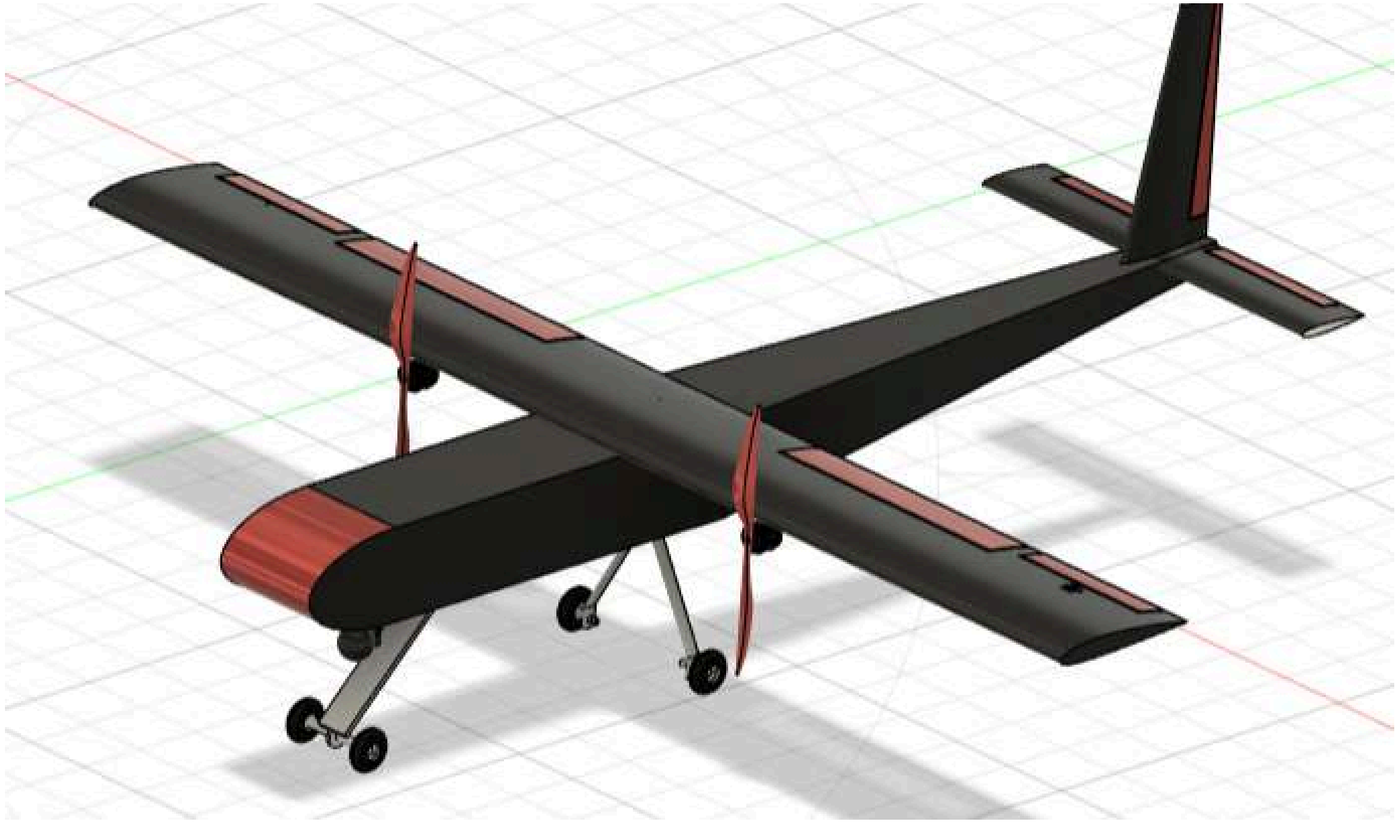
UAV-For Forest Surveillance

AS5213
Group-9
Members

AE21B001 - ABEL VIJI GEORGE
AE21B048 - NISANKAM PHANINDRA KUMAR
AE23M019 - KARTHICK M
AE23M028 - ROHAN ANAND
AE23M043 - SWITHIN DONDAPATI
AE23M003 - SUSHANT KUMAR THAKUR

Objectives



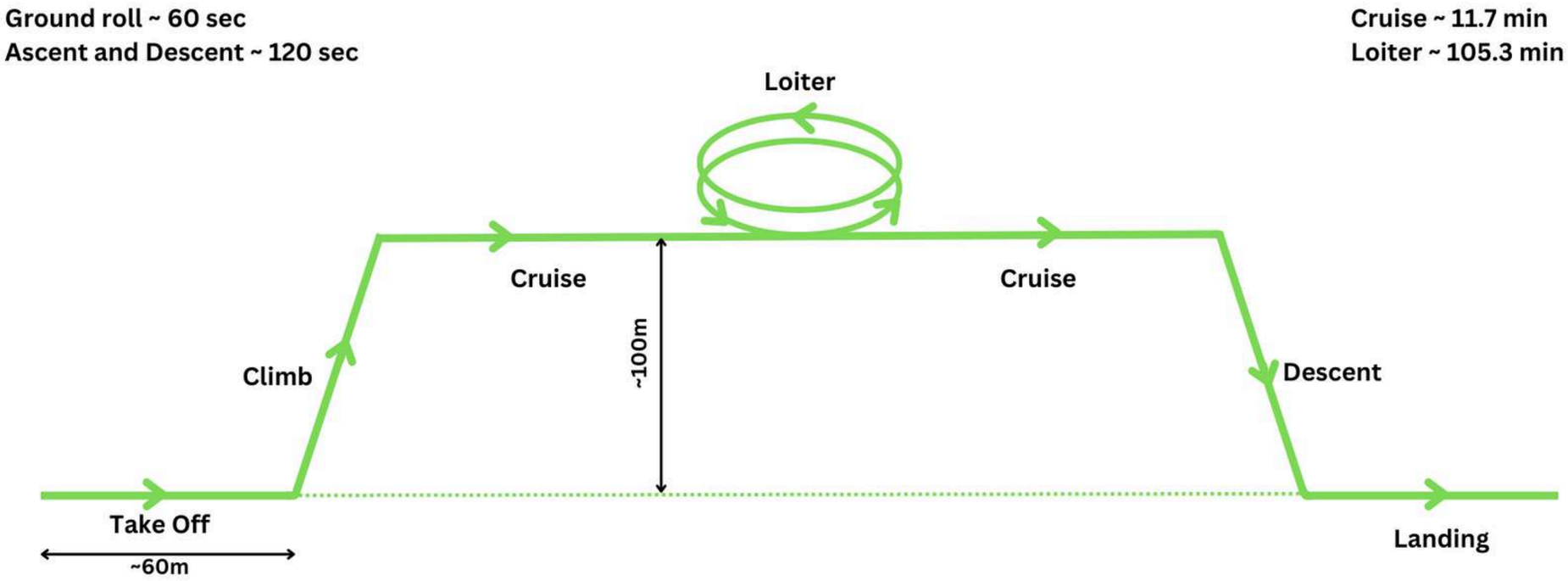
Surveillance and Monitoring

Continuous surveillance over large forest areas, helping to detect events that could lead to wildfires.

Early Detection

UAV is equipped with high--resolution cameras and sensors can monitor remote areas.

MISSION PROFILE



Mission Profile

PREVIOUS AIRCRAFT DATA

Sl No	Aircraft	MTOW (kg)	Empty Wt (kg)	Cruise Speed (m/s)	Wing Span (mm)	Wing Area (m^2)	Aspect Ratio	Battery
1	Believer UAV	5.5	2.4		1960	0.31	12.39	2 × x 14000mAh
2	Raven B UAV	2.2	1.82	9	1400	0.286	6.85	
3	Talon GT UAV	2.0	1.722	15	1000	0.14	7.14	Li-ion 4 S2P 14.4 V
4	Puma LE UAV	10.7			4600	0.68	13.6	
5	Bormatec Explorer UAV	4.0			2200			
6	Albatross UAV	10	4.4	19	3000	0.68	13.6	LiPO AS 8Ah
7	Bormatec MAJA	3.0			1800/2200			
8	Sirius PRO	2.7	1.7	18.06	1630	0.324	8.2	LiPo 800 gWt
9	Mini Shark UAV	5.5	2.8	15.28	2600	0.43	15.72	2100 mAh
10	Lockheed Martin Desert Hawk	4.0	2.0	25.56	1200	0.22	6.45	1.5 kg Battery
11	AR3 Tekever	22	14	33.33	3200			

Talon GT

Albatross

Desert Hawk

Believer

Data collected from studies of similar UAVs, helped in getting an initial idea of UAV Design

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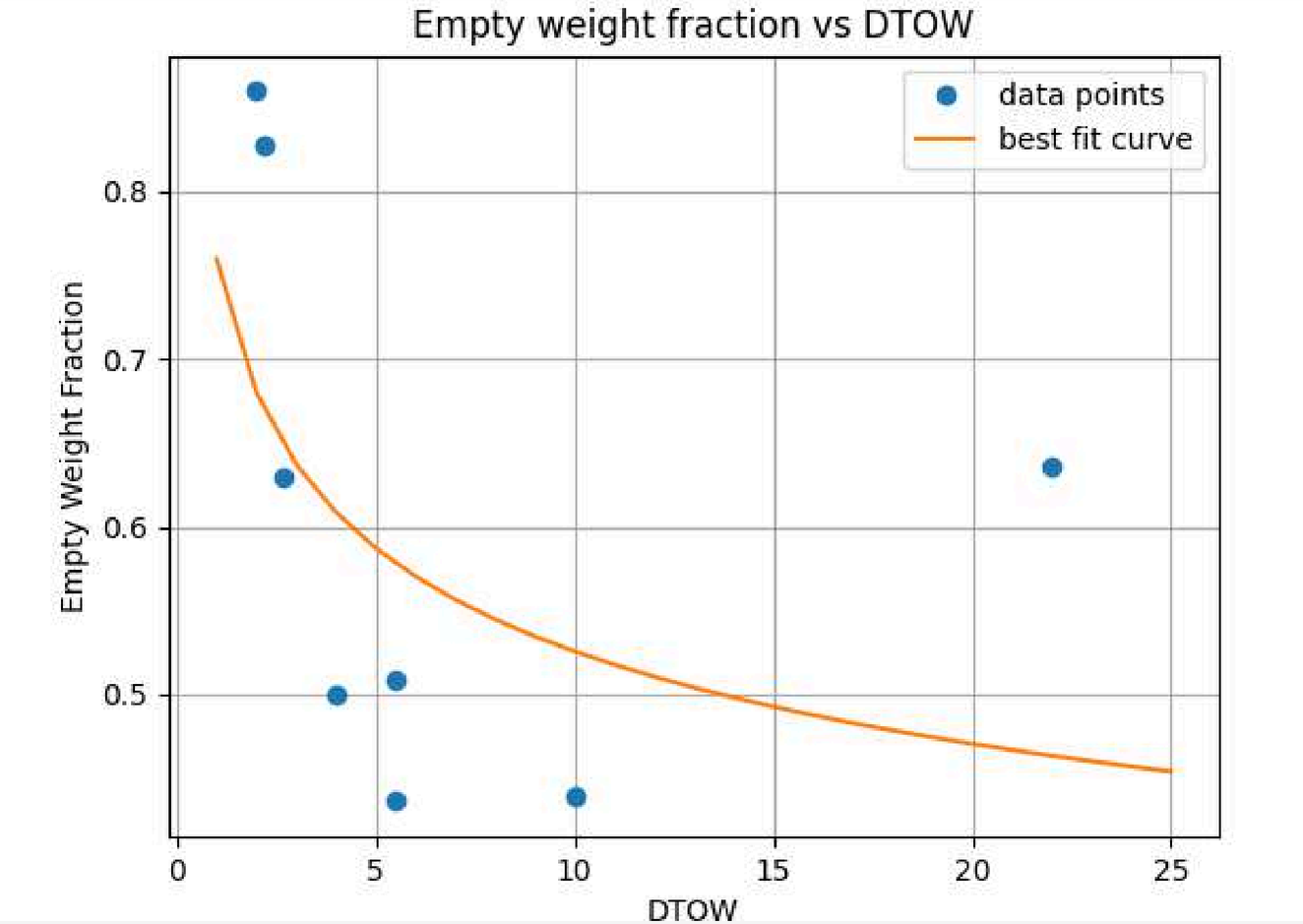
Preliminary estimate from literature survey

Cruise speed = 20 m/s

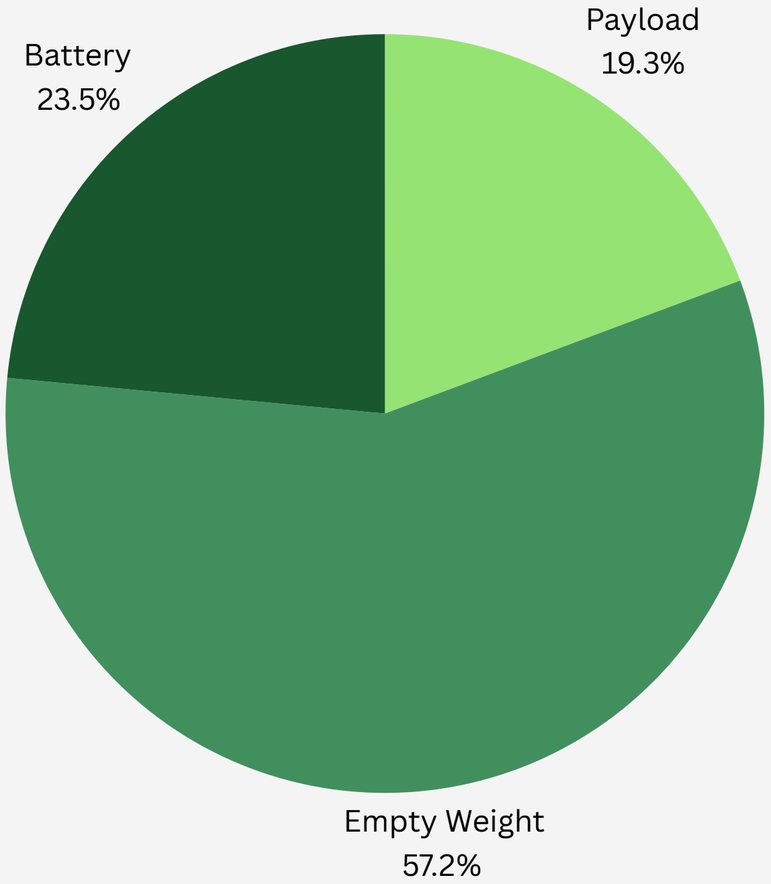
AR = 8 b = 2.5 m e = 0.8 C_{D0} = 0.04 C_{Lmax} = 1.2

FIRST WEIGHT ESTIMATE

- Empty Weight = 3.4 Kg
- Battery Weight = 1.4 Kg
- Payload Weight = 1.15 Kg
- DTOW = 5.95 Kg



$$\frac{W_e}{W_0} = 0.76 W_0^{-0.16}$$

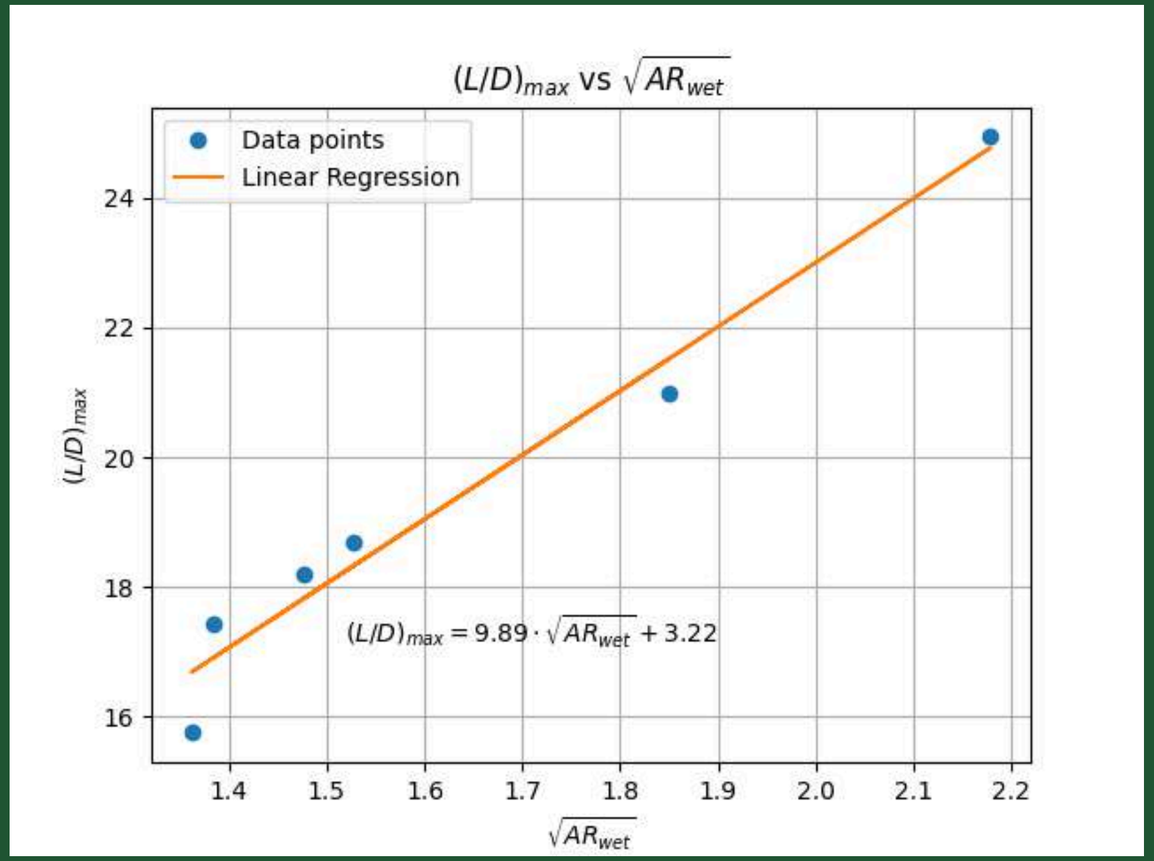


L/D Estimation

UAV	A_{Top} (m^2)	A_{Side} (m^2)	S_{Wet} (m^2)	AR_{Wet}
Believer	0.144	0.168	0.5304	7.24
Talon GT	0.063	0.054	0.1989	5.03
Albatross	0.482	0.028	0.867	10.38
Sirius Pro	0.111	0.128	0.4063	6.54
Mini Shark UAV	0.11	0.103	0.3621	18.67
Desert Hawk III	0.045	0.103	0.2516	5.72

Data for chosen aircrafts

- e = 0.816 using AR= 8
- C_{D_0} = f(Swet, Cfe)
- Cfe = f(Re,M)



$(\frac{L}{D})_{max}$ = 17.83

Battery, Payload and Power Plant

STAGE	TIME	THRUST	POWER	ENERGY
Ground Roll	60 s	2.56 N	16.46 W	1.975 KJ
Climb	120 s	10 N	140.8 W	17 KJ
Cruise	11.7 mins	3.27 N	65.4 W	45.91 KJ
Loiter	105.3 mins	4.72N	94.4 W	596.42 KJ

- Energy required = 661.305 KJ
- Max. Power for any phase = 140.8 W
- Battery Weight is estimated to be 1.25 Kg

Orange NMC 18650 11.1V 10000mAh 3C 3S4P Li-Ion Battery Pack

U5 Power Type UAV Motor

- Twin propeller configuration

P15*5 Propellers

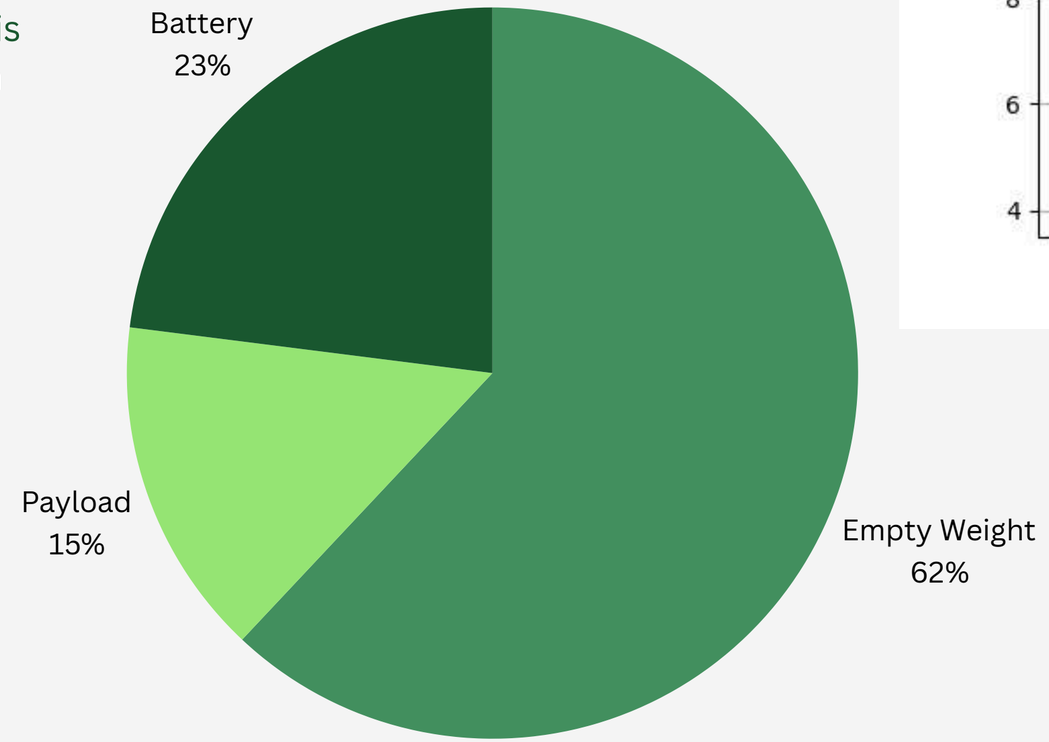
Q10T Gimbal Camera

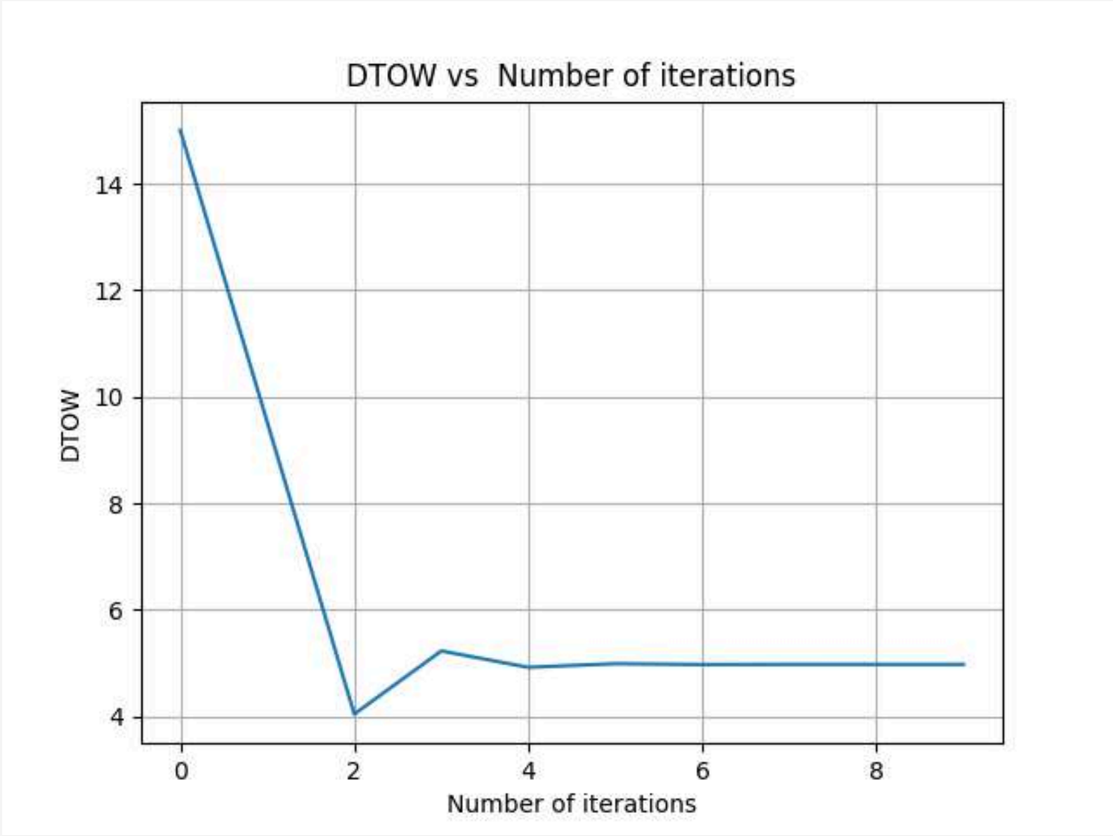
Second Weight Estimate

Wing Loading

Flight Condition	Wing Loading (N/m^2)
Takeoff	161.51 - 178.51
Climb and Descent	252.92 - 279.54
Cruise	146.02 - 161.39
Loiter	252.92 - 279.54
Stall	161.79 - 178.83
Maximum Speed	210.27 - 232.41
Maximum Ceiling	123.5 - 136.5
Landing	220.73 - 243.97

- Optimum Wing Loading is chosen as 127.76 N/sq.m

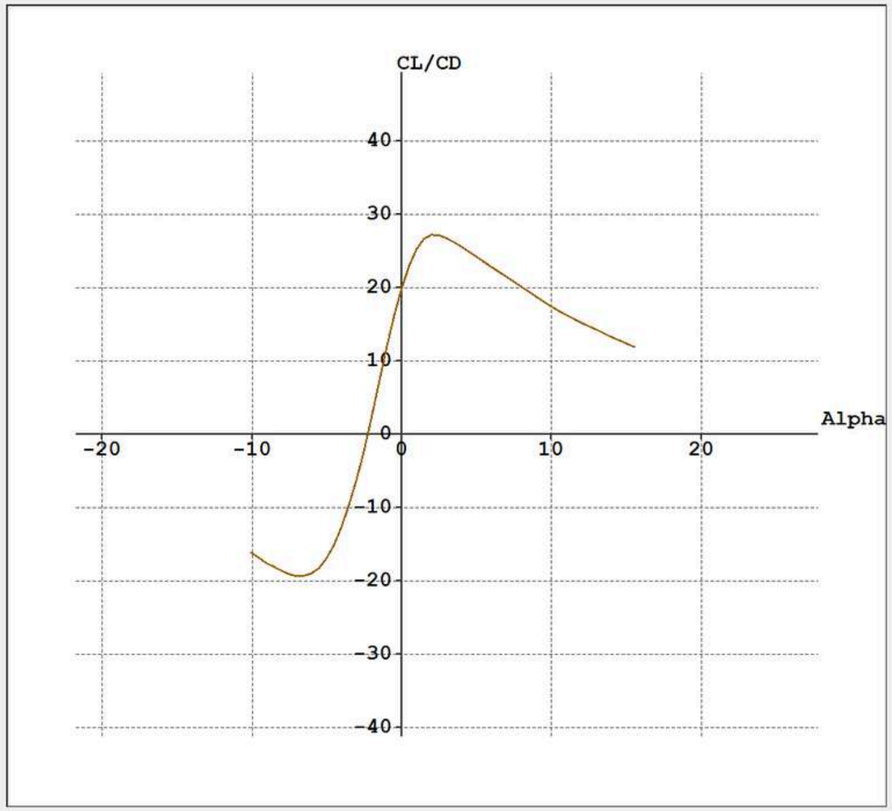




- Empty Weight = 3.4 Kg
- Battery Weight = 1.25 Kg
- Payload Weight = 0.82 Kg
- DTOW = 5.47 Kg

Wing Parameters

- Rectangular wing with no taper or sweep => Manufacturing ease
- High Wing location => Payload, landing gear

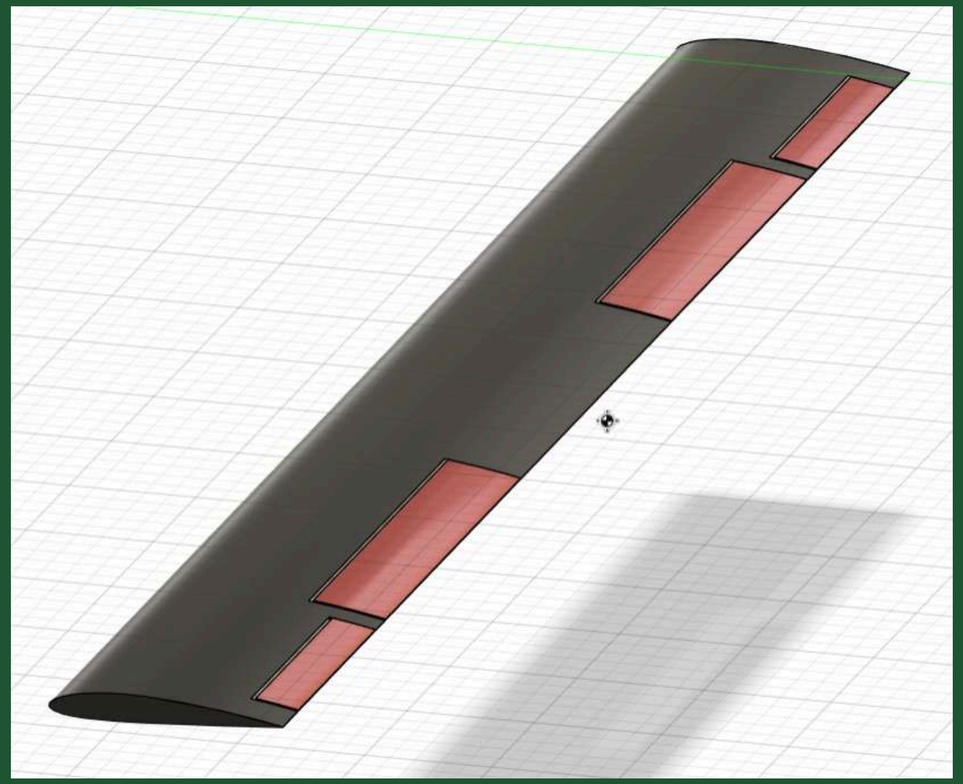


C_L / C_D vs AOA

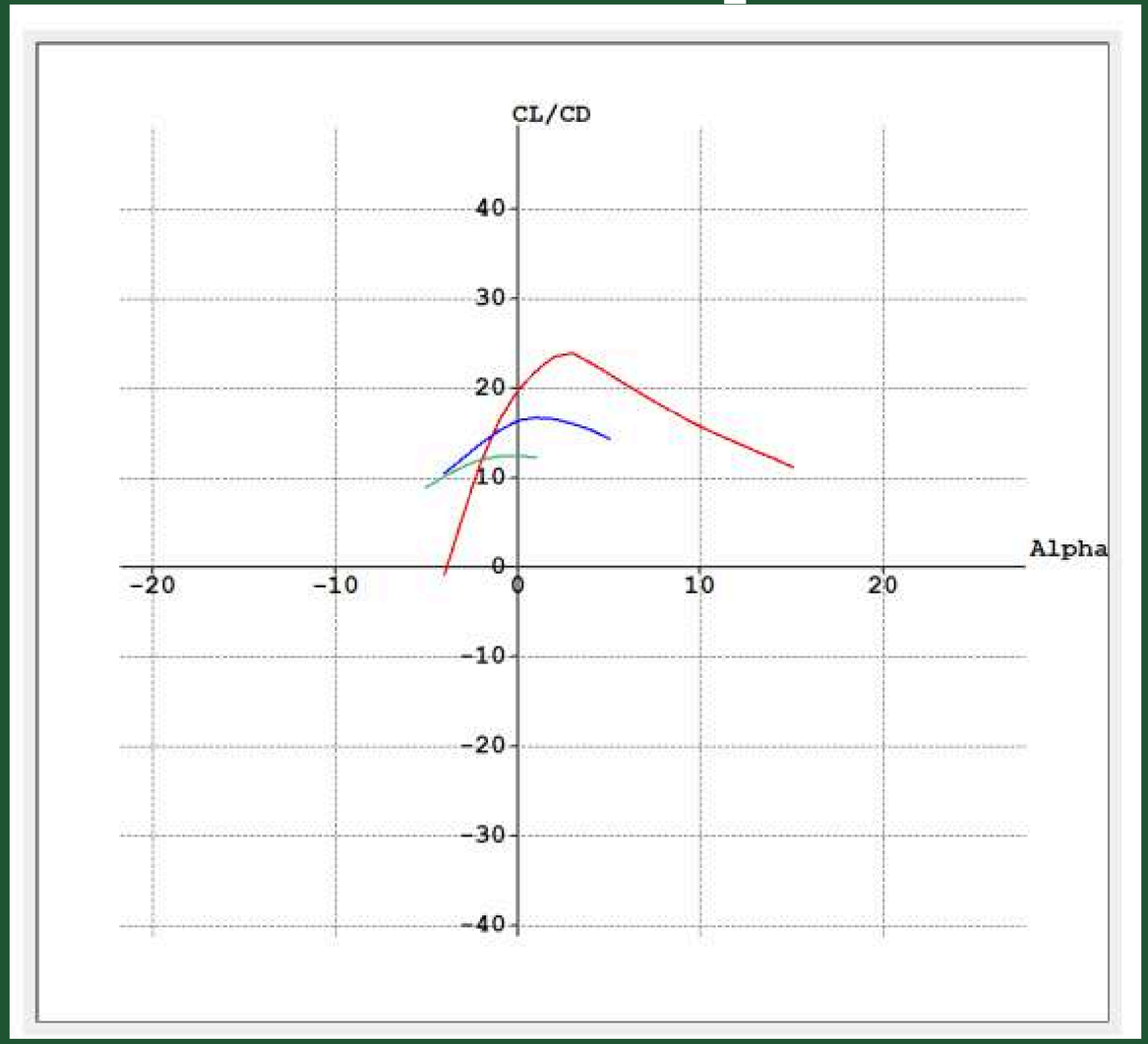
Parameter	Value	Unit
AR	8	
Taper Ratio	1	
Cruise C_L	0.53	
Winspan	1.84	m
Wing Chord	23	cm
Airfoil	NACA2412	
C_L_max	1.43	
C_L_min	-1.24	
Wing Area	0.42	sq.m
Lift Curve Slope	6.81	per rad
Twist	0	deg
Sweep	0	deg
Zero Lift AOA	-2.23	deg
Dihedral	0	deg
Wing Setting Angle	0.612	deg

Wing Parameters - Flaps

- More Lift at lower airspeeds
  => Take off and Landing



CAD Model Of Wing

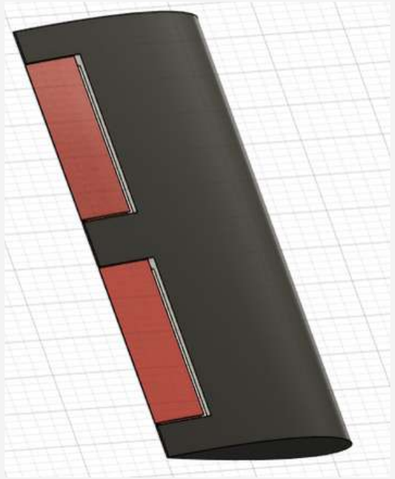


C_L vs C_D with flaps

Tail Design

Parameter	Value	Unit
HTVR	0.685	
Taper Ratio	1	
AR	5.33	
Sweep	0	deg
Tail setting angle	-0.012	deg
Area	0.069	sq.m
Span	60.6	cm
Chord	11.37	cm
Tail Arm	96.3	cm
Airfoil	NACA0012	
Lift Curve slope	6.79	per rad

Horizontal Tail Parameters



CAD model of Horizontal Tail

- **Conventional Tail Configuration is chosen**

Parameter	Value	Unit
VTVR	0.05	
Taper Ratio	0.5	
AR	5.33	
Sweep	0	deg
Airfoil	NACA0012	
Area	0.04	sq.m
Span	60.6	cm
Chord	11.37	cm
Tail Arm	96.3	cm

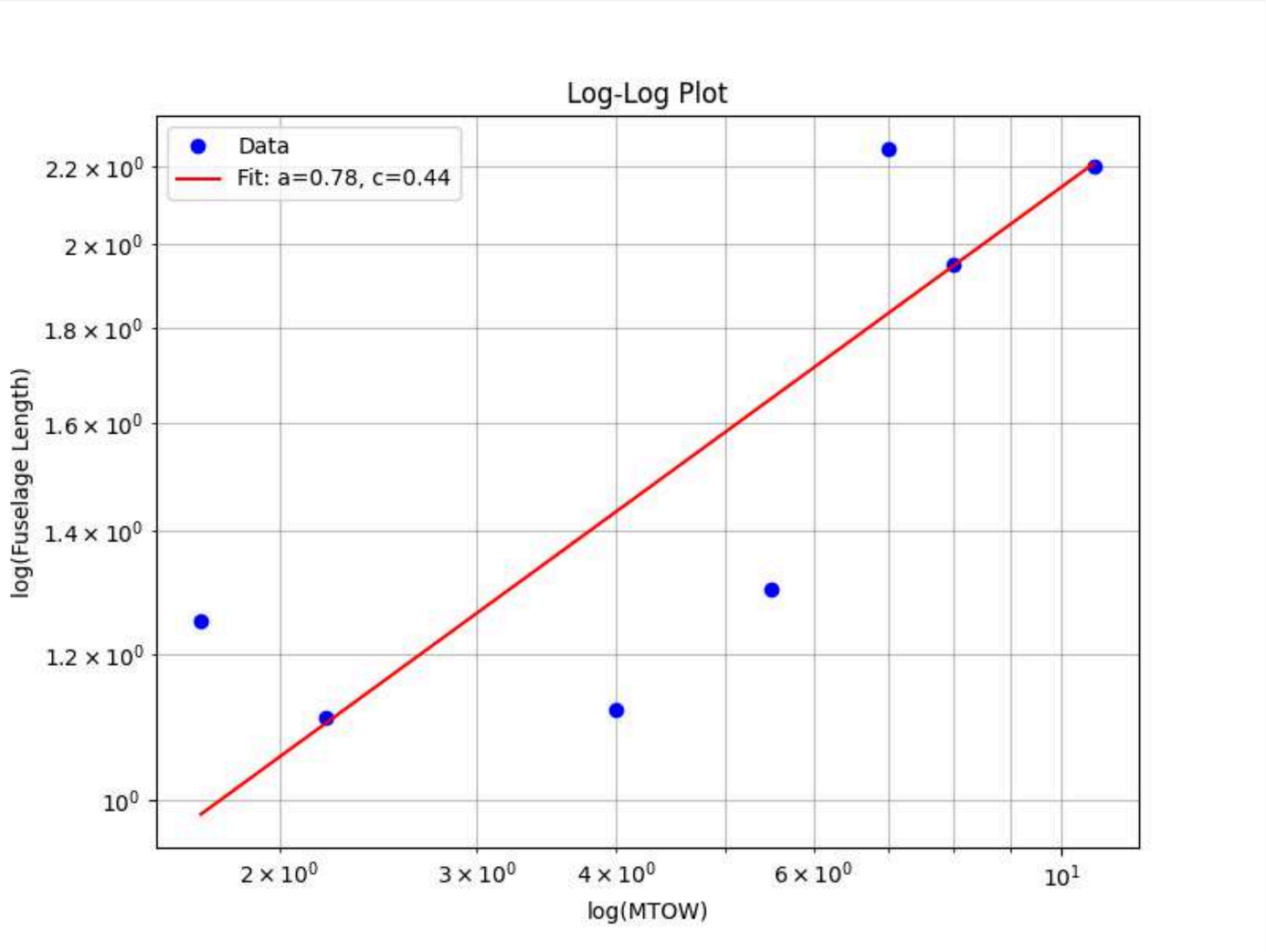
Vertical Tail Parameters

CAD model of Vertical Tail

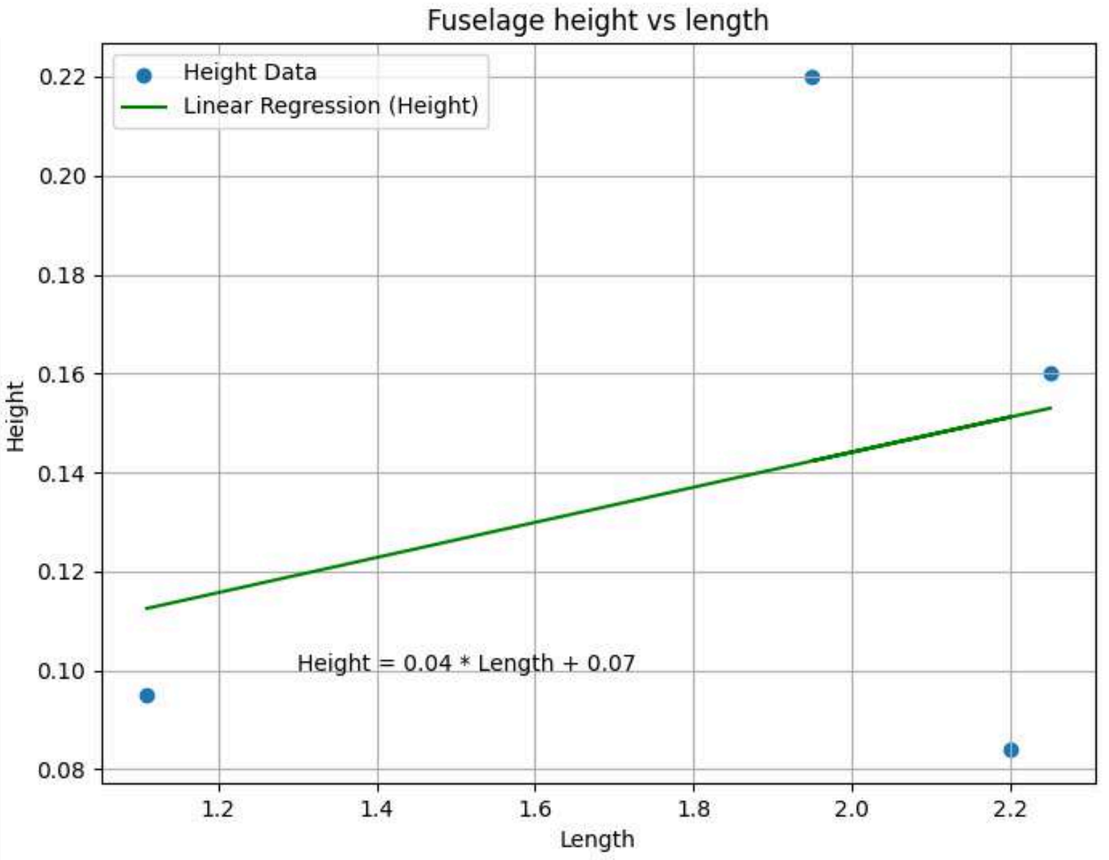
Fuselage Design

- Fusleage Length is found from previous aircraft data following the relation $L = aW^{c}$
- a = 0.78, c = 0.44
- For W = 5.47 Kg, we get L = 1.69m

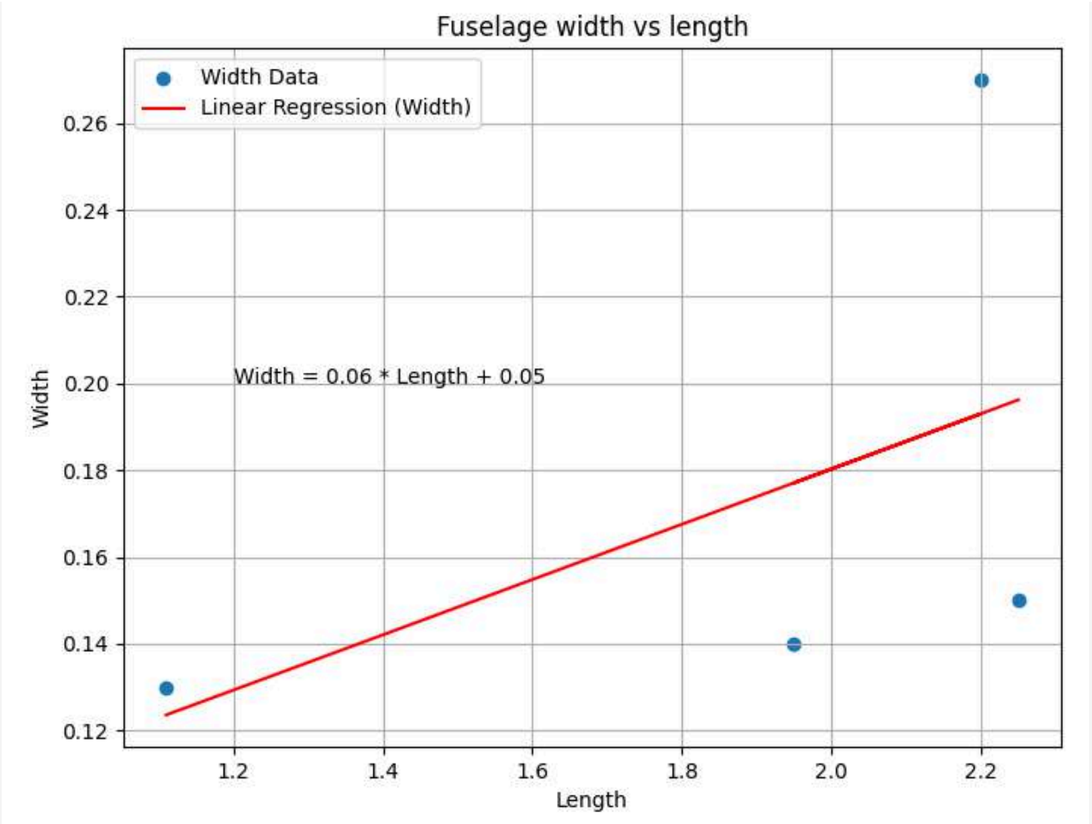
UAV	MTOW (W_0) (Kg)	Length (m)
Raven B	2.2	1.1
Puma LE	10.7	2.2
Elbit Skylark I	7	2.25
Horus FT100	8	1.95
Sirius Pro	1.7	1.25
Mini Shark	5.5	1.3
Desert Hawk III	4	1.11



Fuselage Design Contd.



Height vs length



Width vs Length

- Fuselage width = 16.81 cm
- Fuselage Height = 13.66 cm

Landing Gear Design

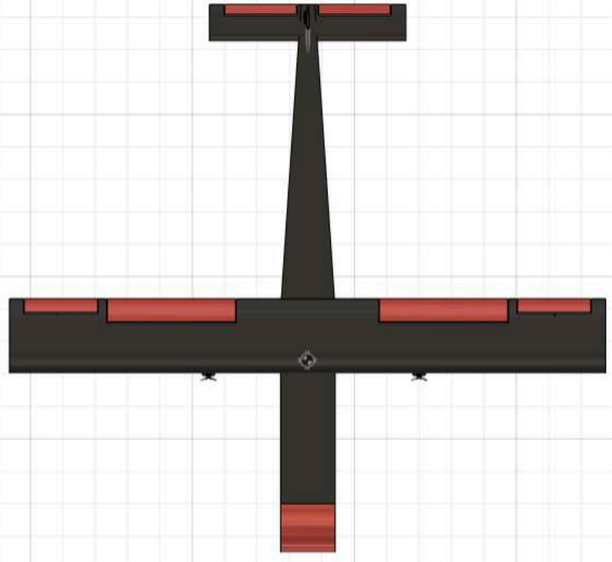
Parameter	Values
Wheel Base	55 cm
Wheel Track	20.1 cm
Height	21.56 cm
Clearance Angle	16°
Tire Diameter	6 cm
Tire Width	1.98 cm

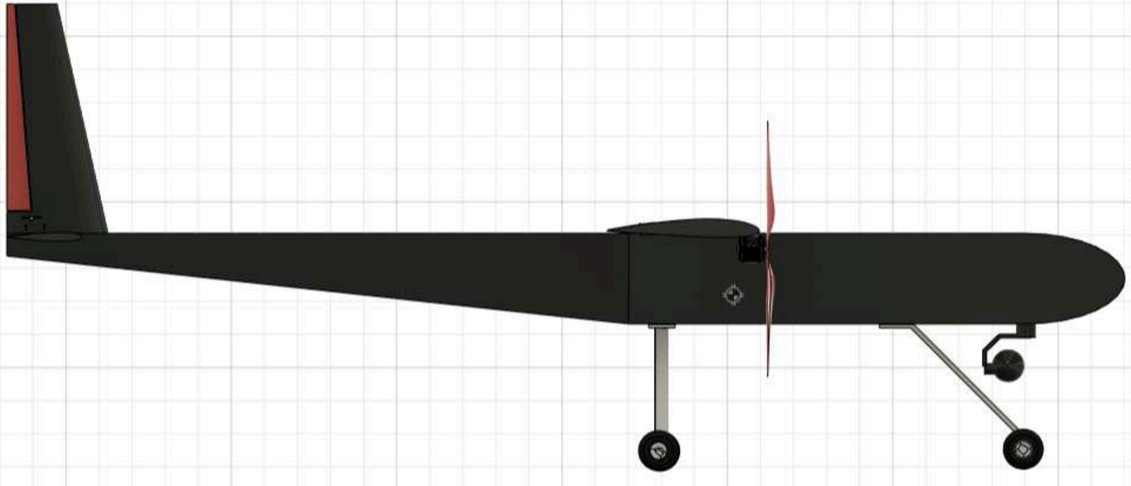
- **Tricycle (Conventional) Landing gear is chosen**

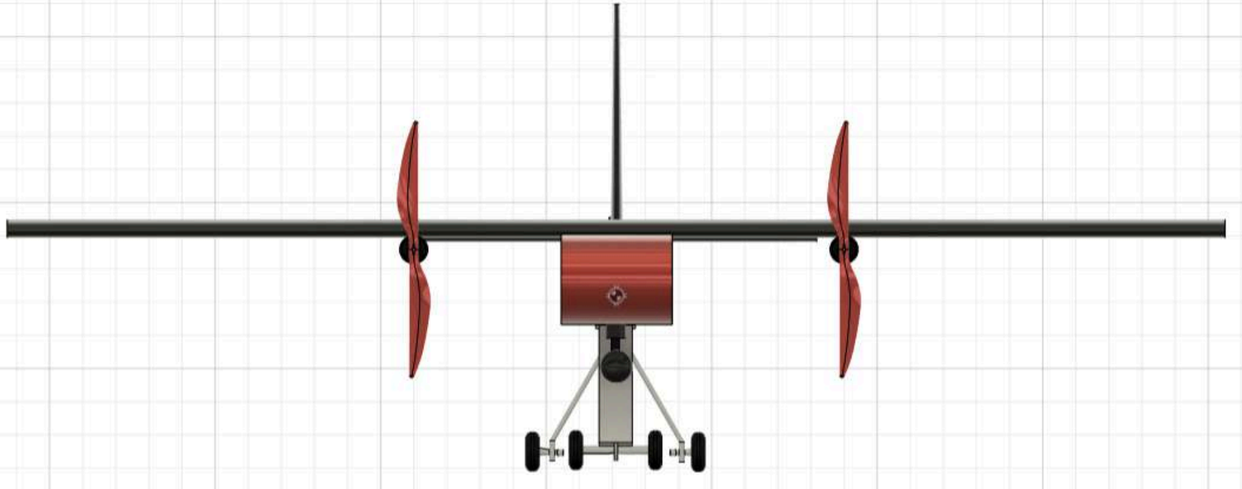
Weight of Components

- Wing weight = 1.1 Kg
- Horizontal tail weight = 0.58 Kg
- Vertical tail weight = 0.096 Kg
- Fuselage weight = 0.64 Kg
- Landing gear weight = 0.46 Kg
- Electronics weight = 2.6 Kg
- Total weight = 5.3 Kg

CAD Model of UAV

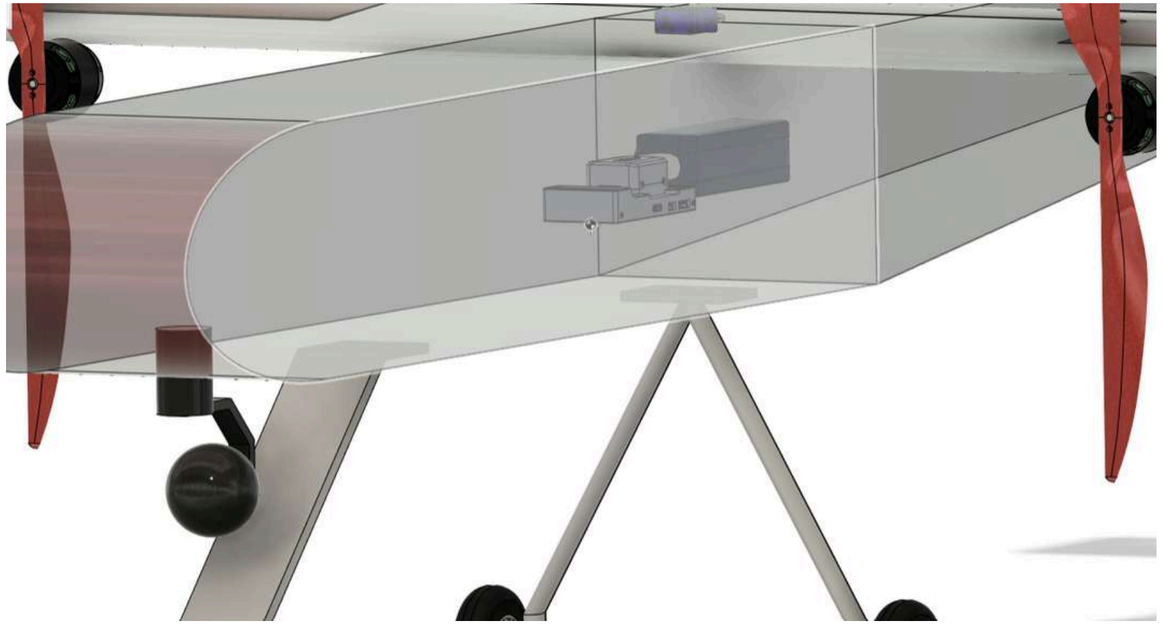


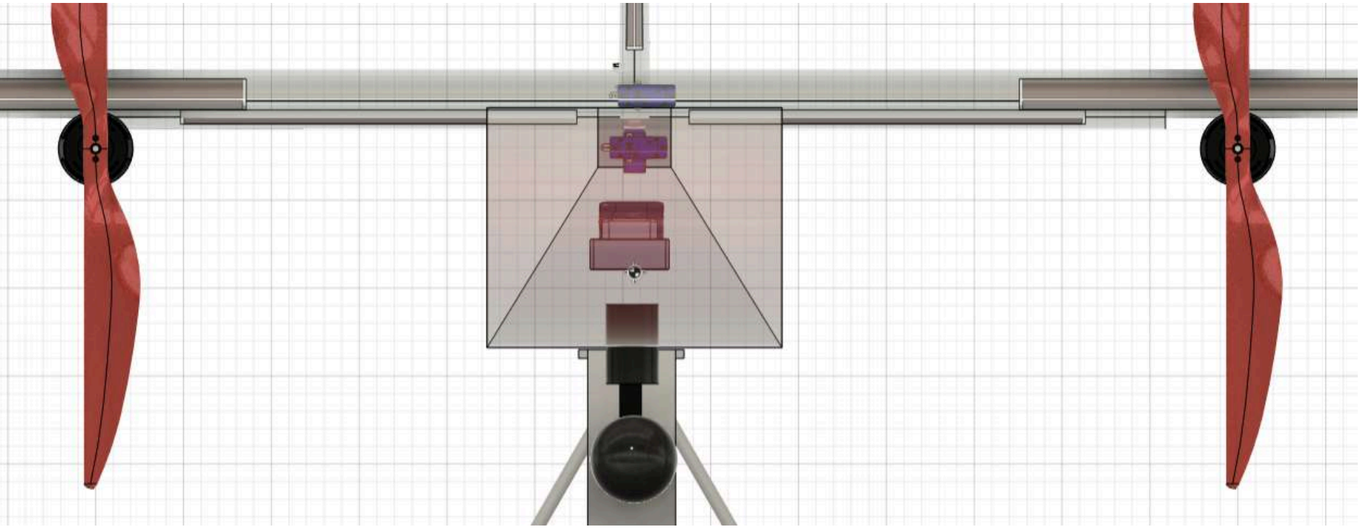


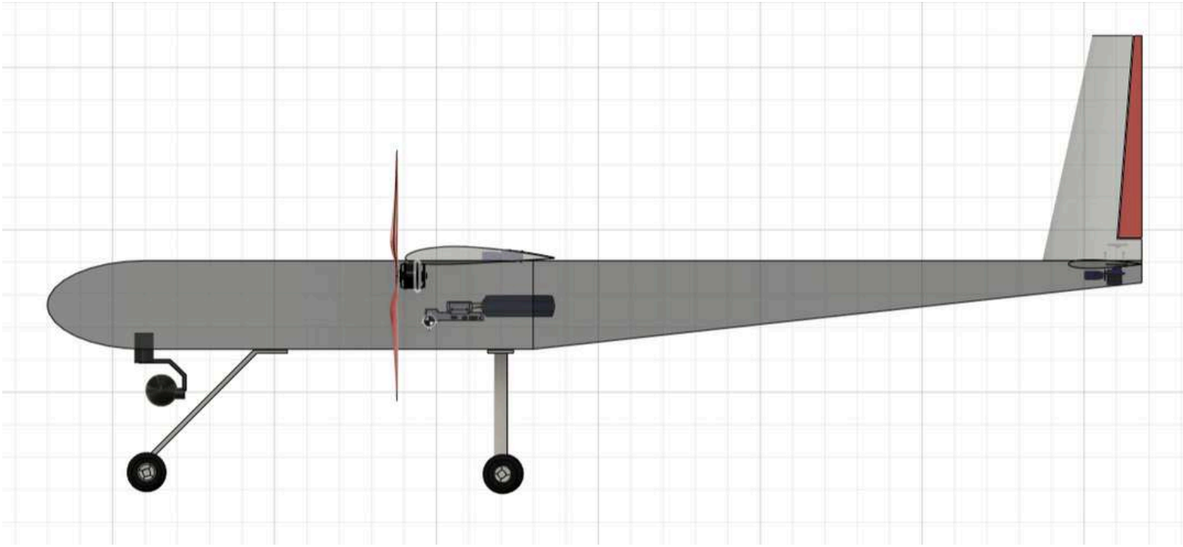


Internal Layout

Internal Layout showing the placement of camera, battery and Pixhawk

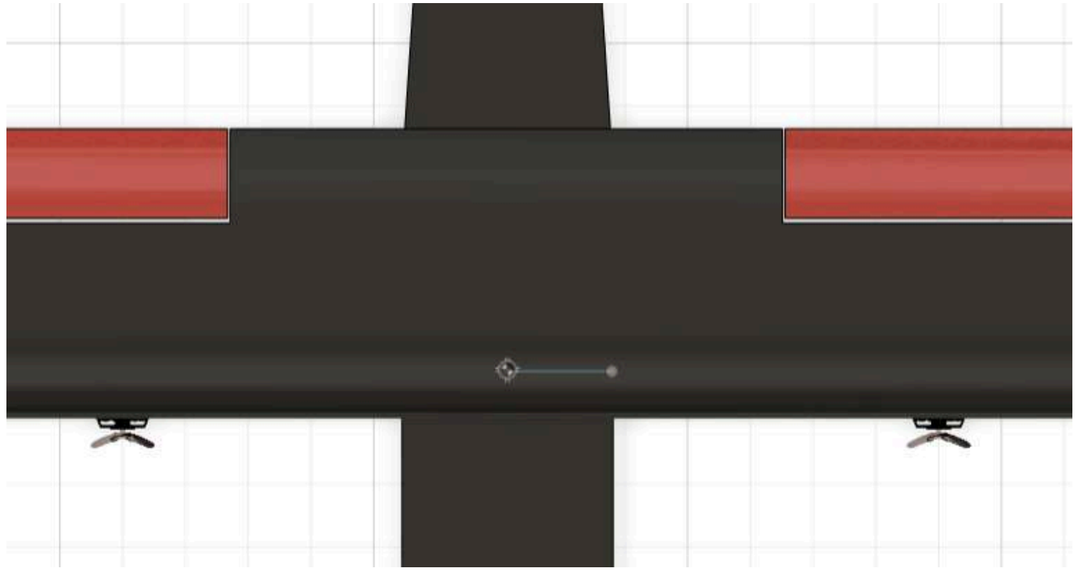


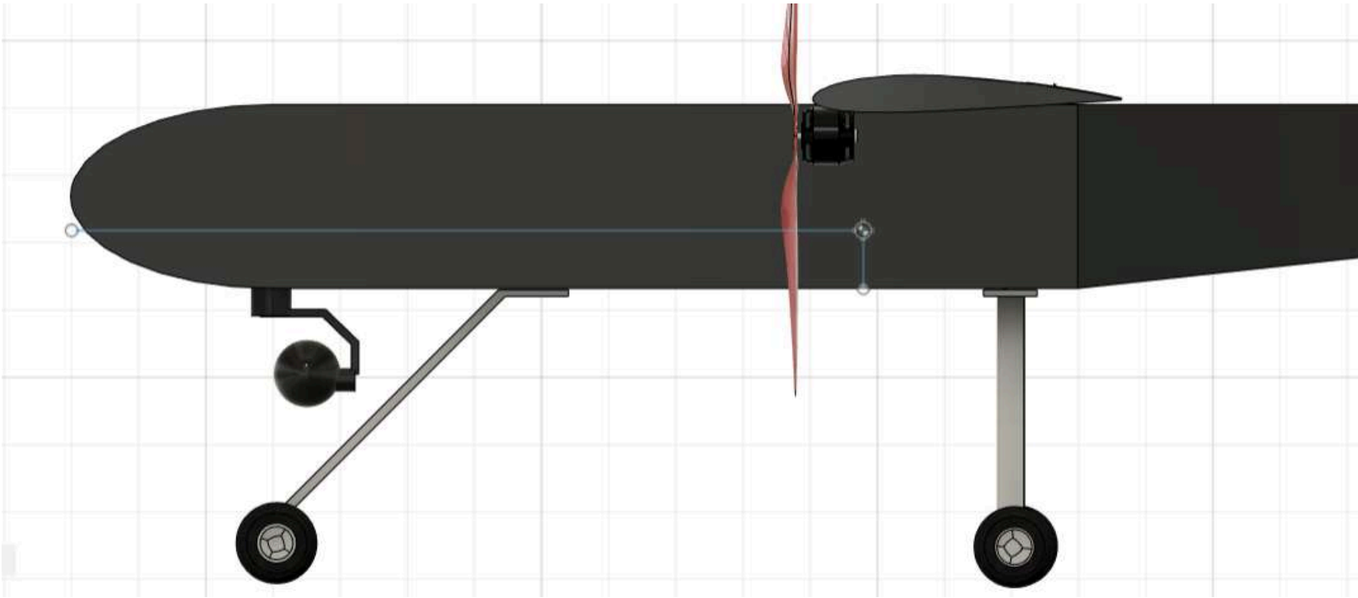




CG location

- Xcg = 63cm
- Ycg = 5.26 cm
- Zcg = 8.405 cm





* The location of CG is found directly from the CAD model in Fusion360.

Stability Analysis

- The preliminary design of the UAV is analyzed for Stability.
- The Tail and the Control surfaces are redesigned until required Stability Criterion are met.

Stability Derivatives	Values (per radians)
Longitudinal	-2.069
Lateral	-0.085
Directional	0.224

- Neutral Point = 0.695m from Nose
- Static Margin = 0.283

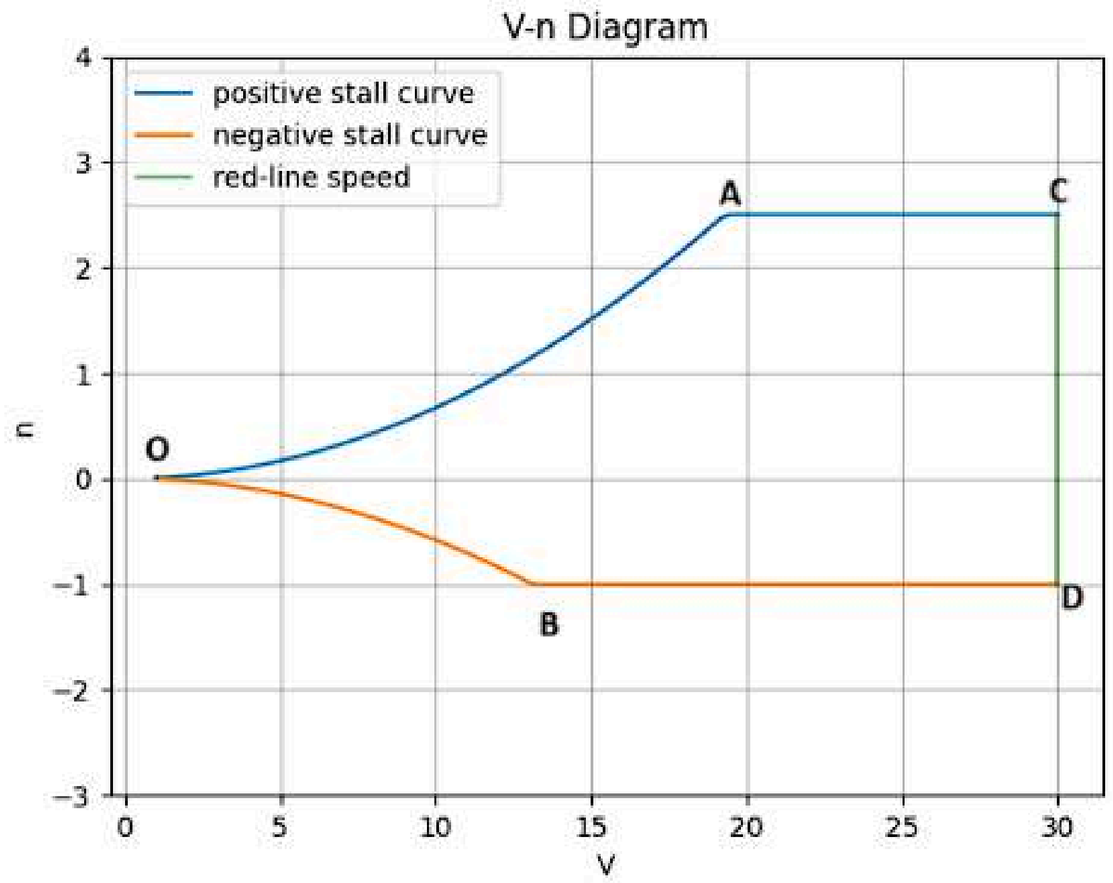
Control Surface	Chord (m)	Span(m)	Area (m^2)
Aileron	0.046	0.460	0.021
Elevator	0.045	0.533	0.024
Rudder	0.043	0.307	0.013
Flaps	0.046	0.736	0.034

Performance Analysis

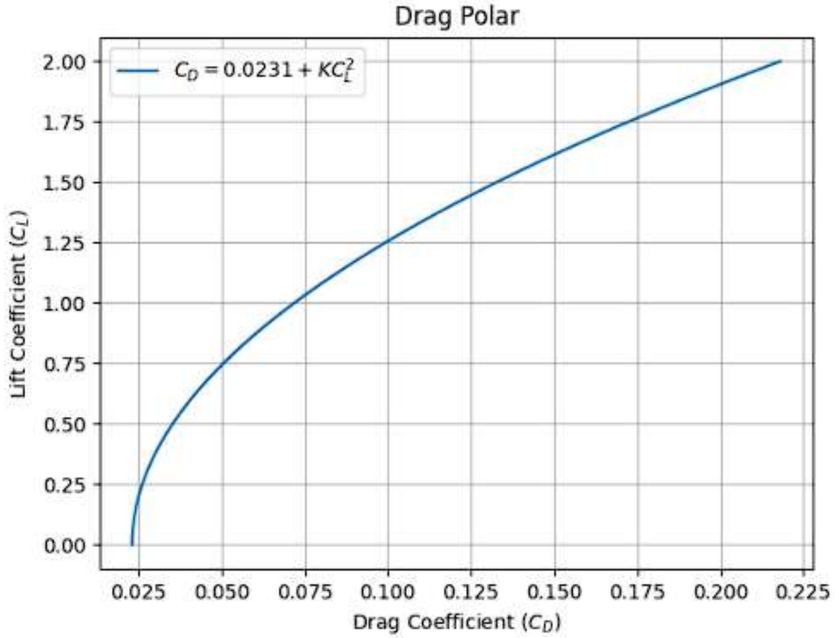
Component	Reynolds Number ($x 10^5$)	C_f
Wing	0.2984	0.0044
Fuselage	2.1924	0.0033
Horizontal Tail	0.1475	0.0053
Vertical Tail	0.155	0.0052

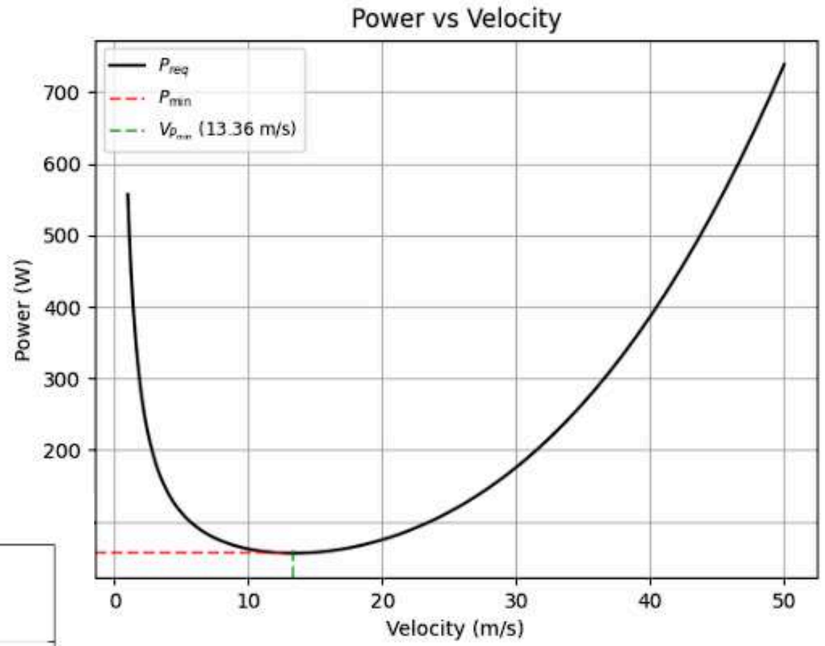
Performance Parameter	Specifications
Power Available	333W
Velocity for Minimum Power	13.35 m/s
Range	121.68 Km
Endurance	1.69 Hours

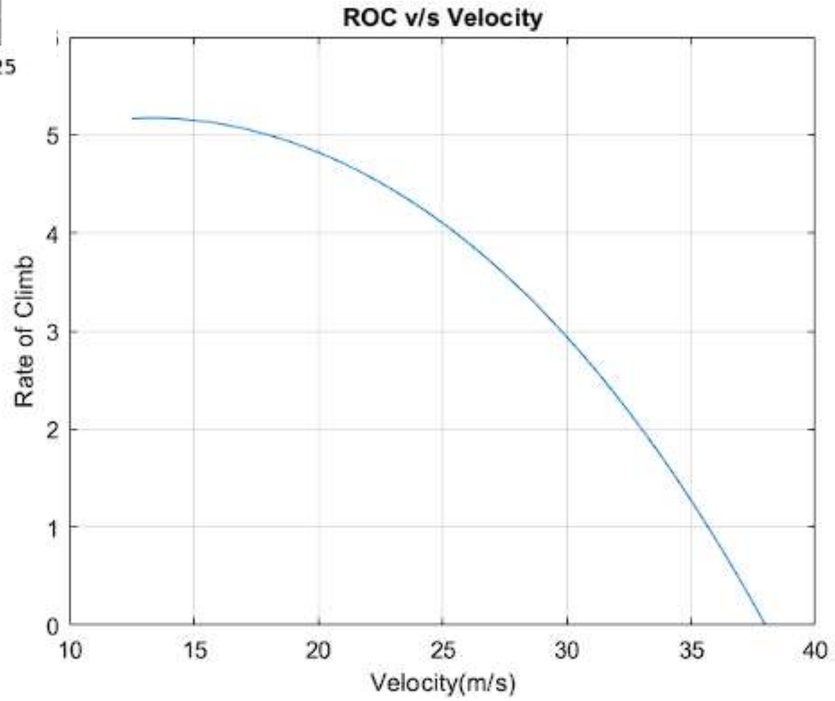
$C_{D_0} = 0.0231$



Performance Analysis - Contd.







- Corner velocity = 19.29 m/s
- Stall speed = 12.2 m/s
- Red line speed = 30 m/s

Contributions

AE21B001

Week	Contribution
1	Preliminary configuration, data collection
2	Code for iterations, Energy calculation for all phases, Literature review and data collection.
3	Code for the plot, energy and power calculation for all phases other than climb, batter, motor and propeller selection.
4	Wing loading for all phases apart from Climb
5	Code for the iterations
6	XFLR5 analysis of airfoils and finalizing one, XFLR5 analysis of wing, preliminary control, surfaces sizing, Wing incidence calculation
7	Tail configuration, Data collection, Horizontal Tail
8	Configuration of Landing Gear, Landing gear height, main landing gear position, ground, clearance and takeoff angle, Static and Dynamic Loading
9	Weights of components - theoretical weights of wing, Horizontal tail, fuselage, electronics,
	CAD for structure, estimation of CG, weight estimation of all components from CAD, report writing, formatting
10	Trim condition, Lateral Stability
11	CD0 estimation, P vs V plot, V-n diagram, Range and Endurance, final formatting, presentation work

Contributions

AE23M019

Week	Contribution
1	Propulsion system
2	Logic for code iterations
3	Energy and power calculation for climb
4	Wing loading for climb
5	Theory for the process of iterations
6	High Lift Devices and XFLR5 analysis on high lift devices
7	Vertical Tail, iterations for Fuselage length, width and height
8	Strut design
9	CAD model for landing gear and internal component placemen
10	Control Surface sizing
11	Presentation work

Contributions

AE21B048

Week	Contribution
1	Mission objective, mission profile
2	Looked up features of camera
3	
4	
5	
6	Choosing Wing Type
7	Component layout
8	Tire Sizing
9	
10	Longitudinal Stability
11	Power Requirement, Climb Rate and Climb Angle, final formatting

Contributions

AE23M003

Week	Contribution
1	
2	Looked up camera
3	
4	
5	
6	Theory for wing dihedral, sweep and taper ratio
7	
8	Preliminary calculations
9	
10	Aileron Theory
11	

Contributions

AE23M043

Week	Contribution
1	
2	Theory of method of iteration
3	Derivation of L/D relation
4	
5	
6	Airfoil selection
7	
8	Wheel Base
9	Theoretical weight estimation of landing gear and vertical tail
10	
11	

- internal layout in presentation

Contributions

AE23M028

- minor aligning in presentation

Week	Contribution
1	
2	
3	Theory for Flat plate skin friction coefficient
4	
5	
6	Wing Location
7	
8	Wheel Track
9	
10	
11	

THANK YOU !