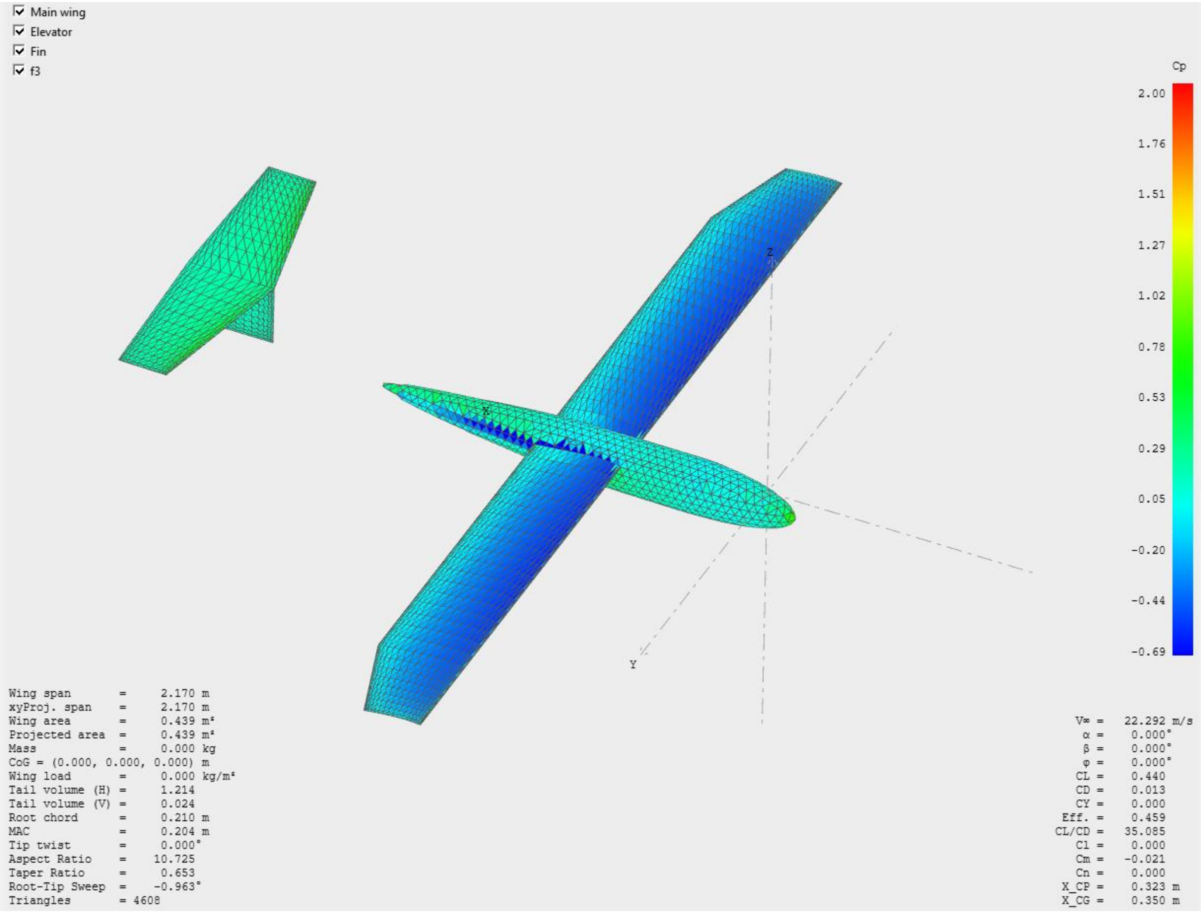
DESIGN OF UAV

One of the challenges of this project is to design a 3d Printed uav that can carry the required payload of 1 kg.

Design requirement

A high wing mounted uav was designed.

Design process starts with determining the wing loading of the UAV. Wing loading is important parameter that decides the cruise speed of an aircraft, and it affects important parameters.



Preliminary sizing

The initial sizing of the aircraft is started with the wing loading concept. First, we will do a rough weight estimation for their aircraft weight.

Subsystem	Weight
Flight controller + GPS	418
Radio + telemetry	124
FPV system	55
Motor + ESC	245
Servos (×4)	220
Airframe weight	2.5

Battery	2
Payload	1
Total	5.5

The estimated weight for the aircraft is coming to be around 5.5kg which can be rounded off to 6kg in total.

The first step is figuring out the wing area, which can be figured out by picking up a wing loading based on the cruise/stall speed requirement of 20m/s.

The selected wing loading for this uav is around 200N/m^2.

The wing area = UAV MTOW(N)/200 = 0.3m2.

The required CL 0.8(which is very high).

So, a xflr5 model was generated with the given areas. The value for aspect ratio was maximized.

Here the results from xflr5 model.

iter	MTOW(kg)	CL	CD	V(m/3)	S
1	6	0.411	0.0338	26.01987213	0.345
1	5.5	0.411	0.0338	24.91213092	0.345
2	6	0.44	0.031	22	0.439

With a wing loading of 200N/m2 a thrust to weight ratio of 0.3 was selected.

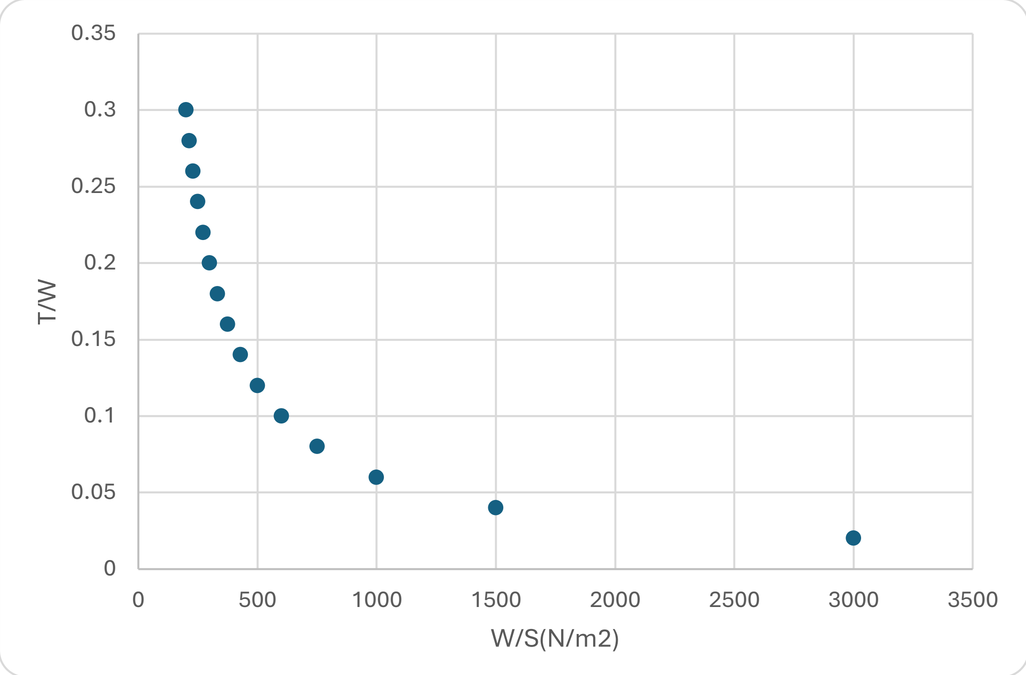


Figure 1. Wing loading graph

Finalized dimensions

This section highlights the design parameters of each component.

1.Wing

	y (m)	chord (m)	offset (m)	dihedral°	twist°	foil
0	0	0.21	0	0	0	Optimized_1
1	0.85656	0.21	0	0	0	Optimized_1
2	1.08498	0.13705	0		0	Optimized_1

2.Vertical Tail

	y (m)	chord (m)	offset (m)	dihedral°	twist°	foil
0	0	0.18	0	0	0	NACA 0012
1	0.15	0.18	0		0	NACA 0012

3.Horizontal Tail

	y (m)	chord (m)	offset (m)	dihedral°	twist°	foil
0	0	0.207895	0	0	0	NACA 0012
1	0.386528	0.115497	0.08		0	NACA 0012

4.Relative position

	Type	Name	x (m)	y (m)	z (m)	Rx(°)	Ry(°)
0	MAINWIN	Main wing	0.33	0	-0.01	0	2
1	ELEVATO	Elevator	1.2	0	0.149	0	-1
2	FIN	Fin	1.2	0	0	-90	0
3	FUSE	f3	0.2	0	0.01	0	0

Aircraft preliminary analysis & Stability

Based on initial aerodynamics simulation in Flow5(xflr5). The weight of UAV is assumed to be 6kgs (Based on previous calculation). The finalized values for CL,CD,Cm is given in following figures.

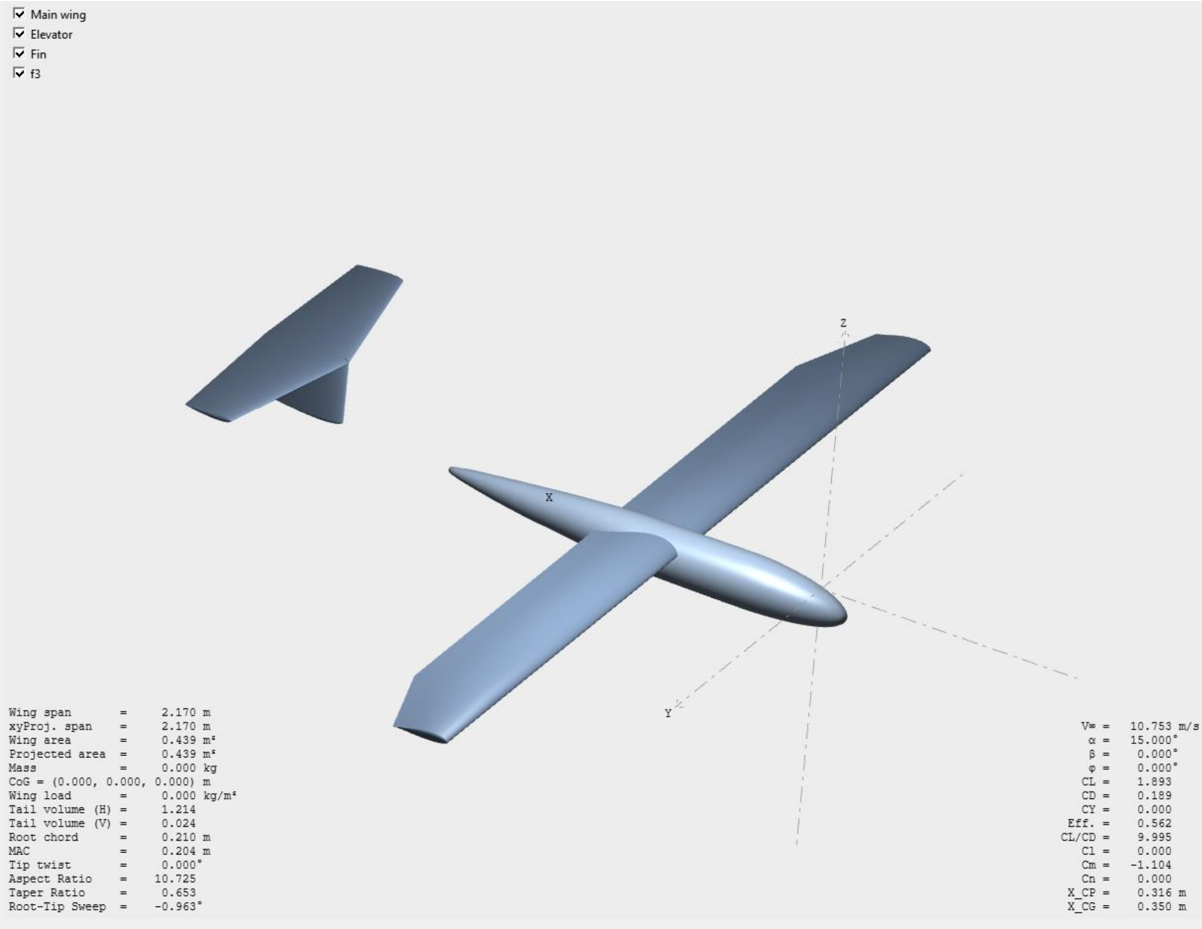


Figure 2. The panel model in Flow5

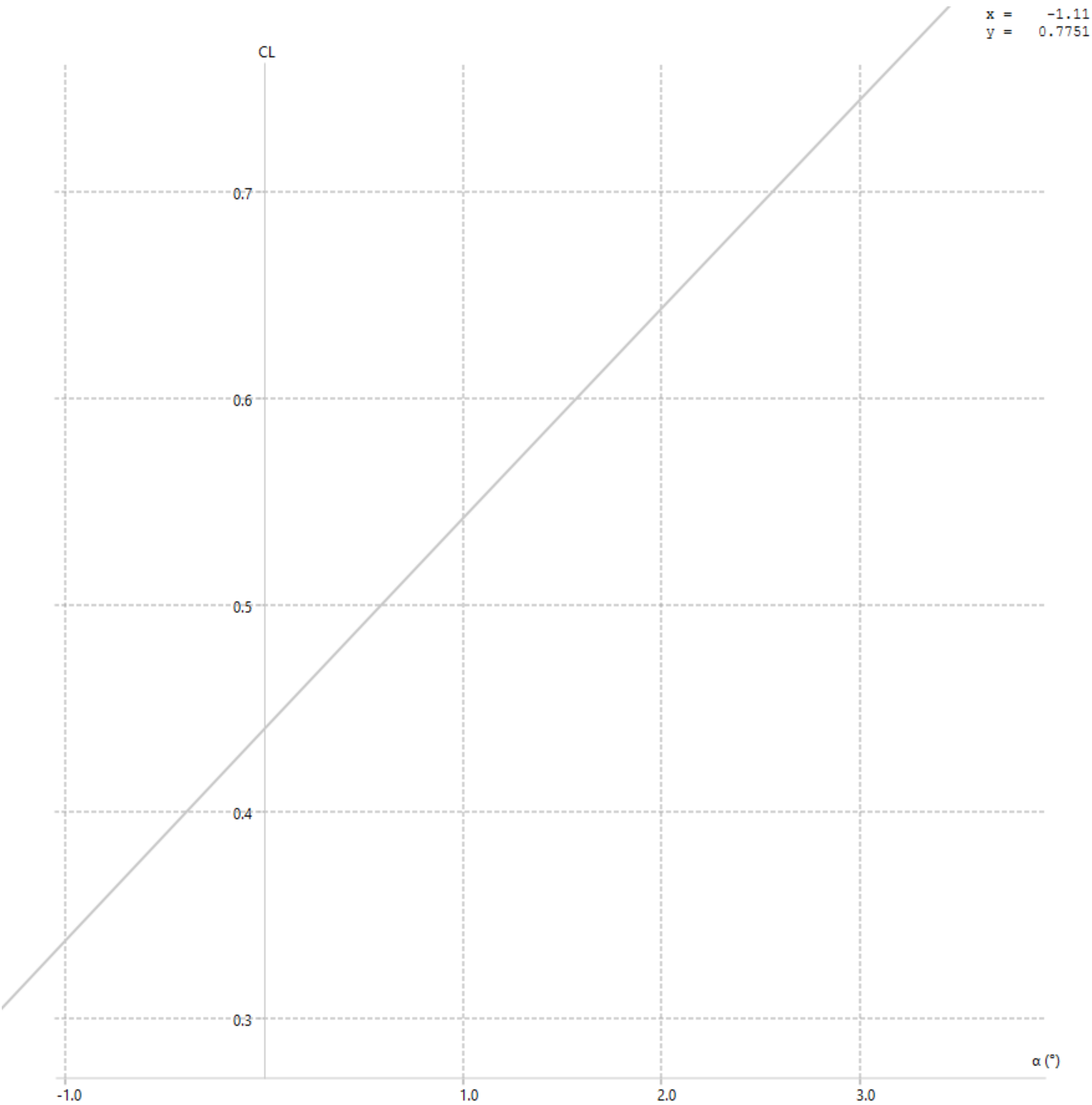


Figure 3. CL vs Alpha(deg)

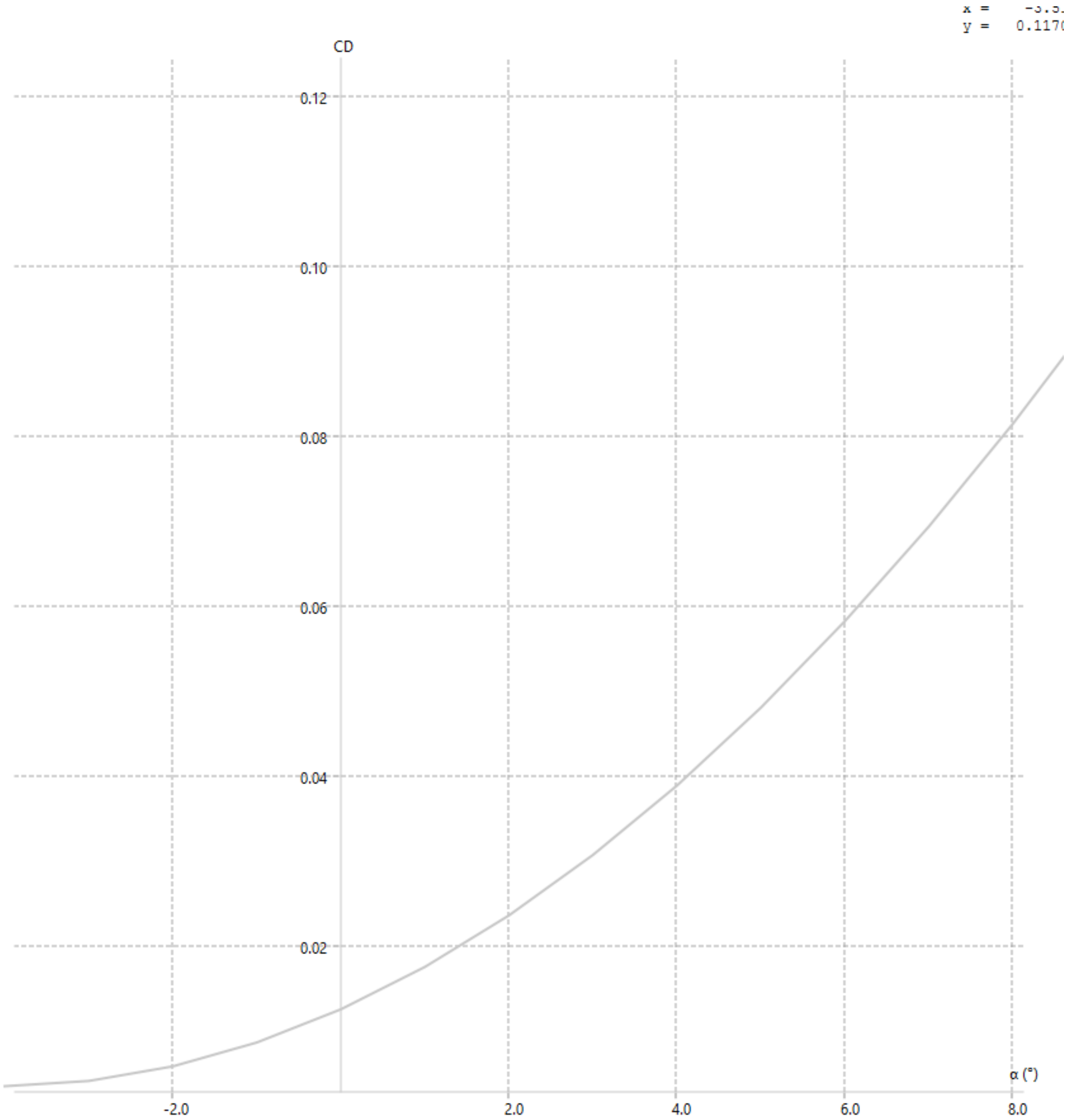


Figure 4. CD vs Alpha(deg)

Static stability

Static stability of an aircraft is divided into three categories.

1.Longitudnal stability

Longitudinal stability is defined as the tendency of an aircraft to resist any changes /or return to its original angle of attack after a wind gust or disturbance. An aircraft needs to have the slope of Cm vs Alpha to be negative in order to be stable. The require CG for the design needs to be at 0.323m from the nose.

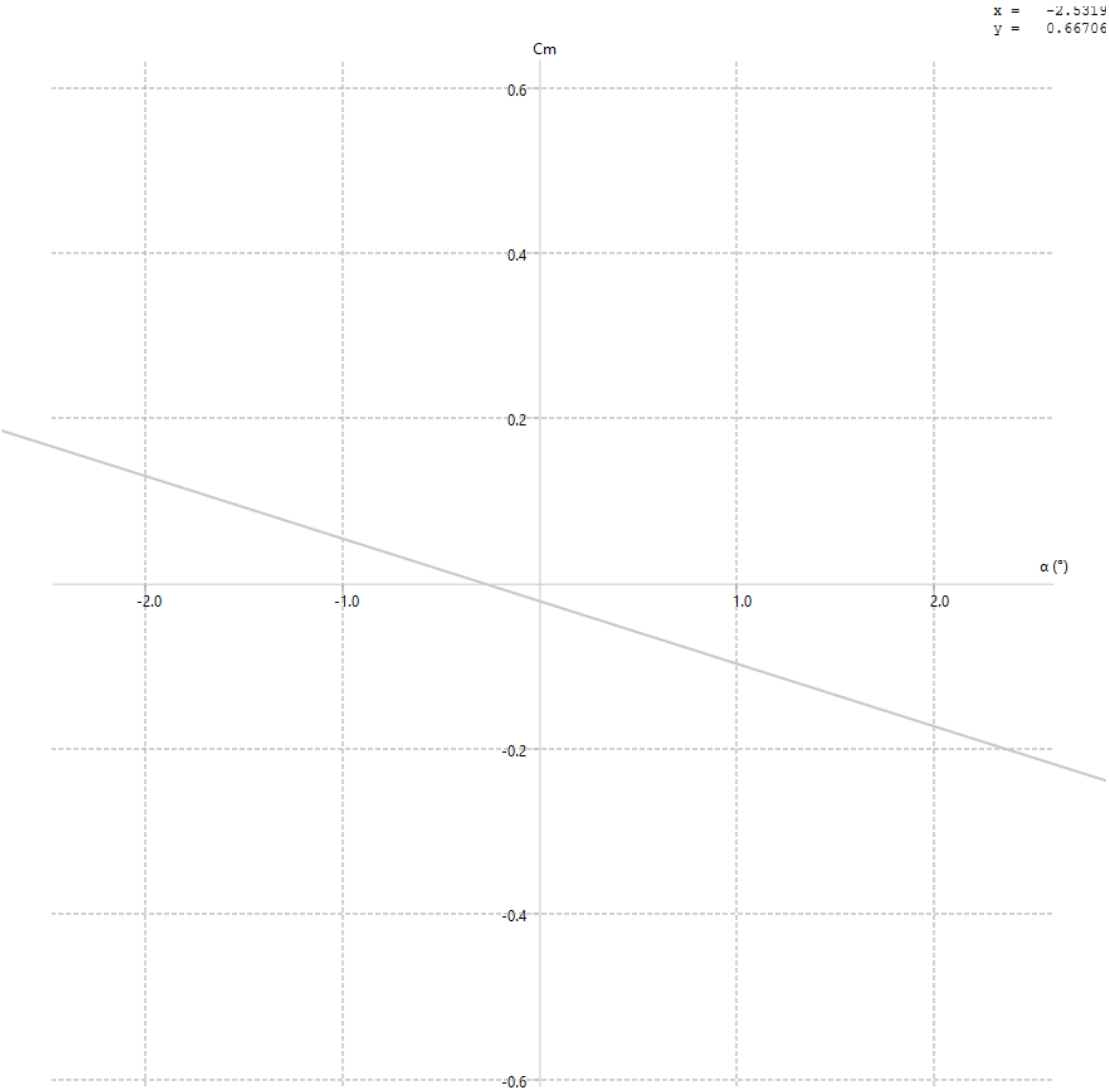


Figure 5. Cm vs Alpha(deg)

2. Lateral stability

The tendency of an aircraft to windvane. That is to turn to the direction of upcoming wind.

The lateral stability is denoted by coefficient of yaw (Cn).For an aircraft to be stable in yaw, the slope of Cn vs Beta(sideslip angle) needs to be positive.

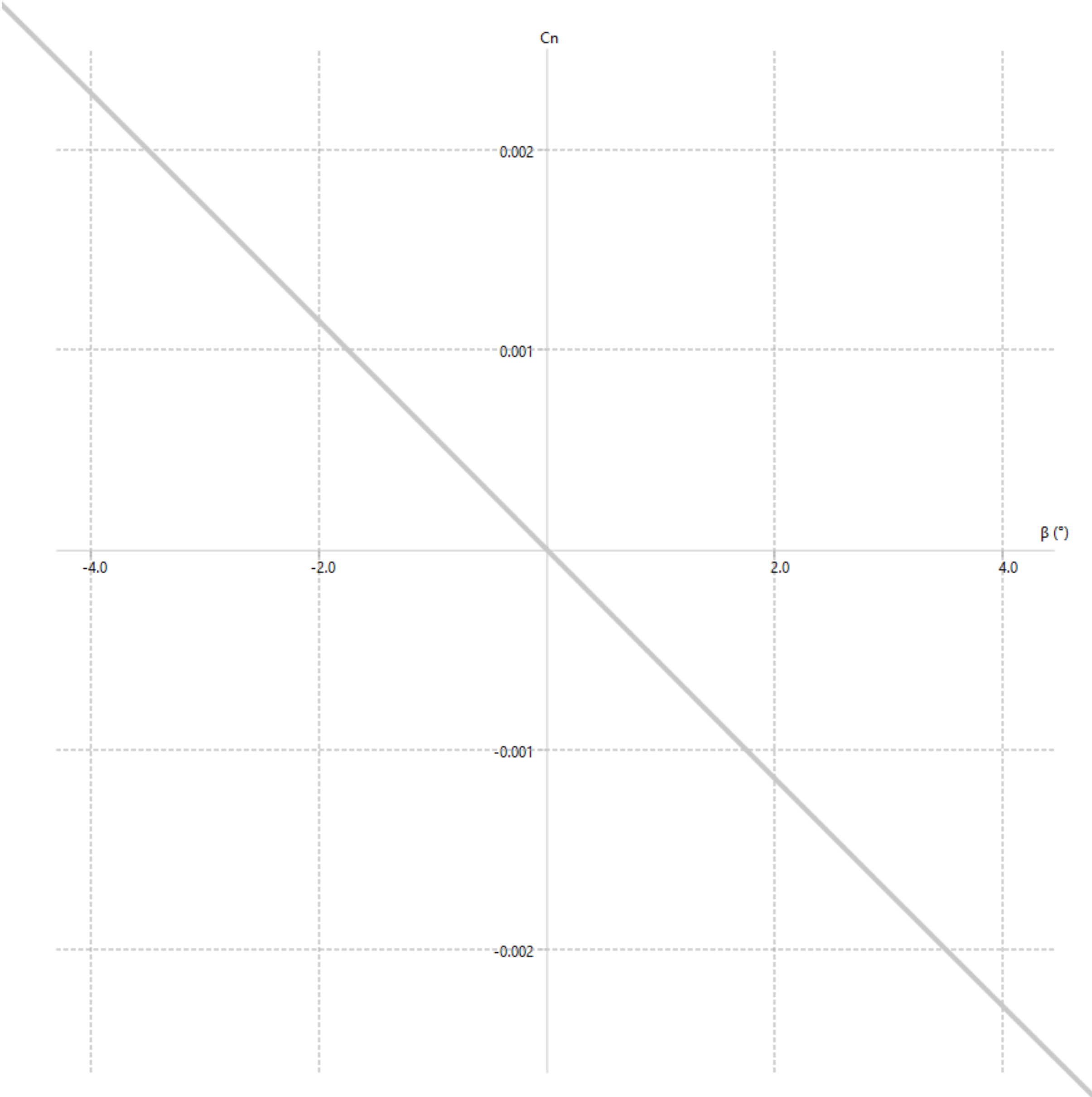


Figure 6.Cn vs Beta(deg). The notation for rotation is reversed so slope here is positive

3. The roll stability

The roll stability of an aircraft is defined by it's tendency to resist any change due to control input or disturbance around it's roll axis. The slope of Cl vs beta should be negative.Cl is called as coefficient of roll.

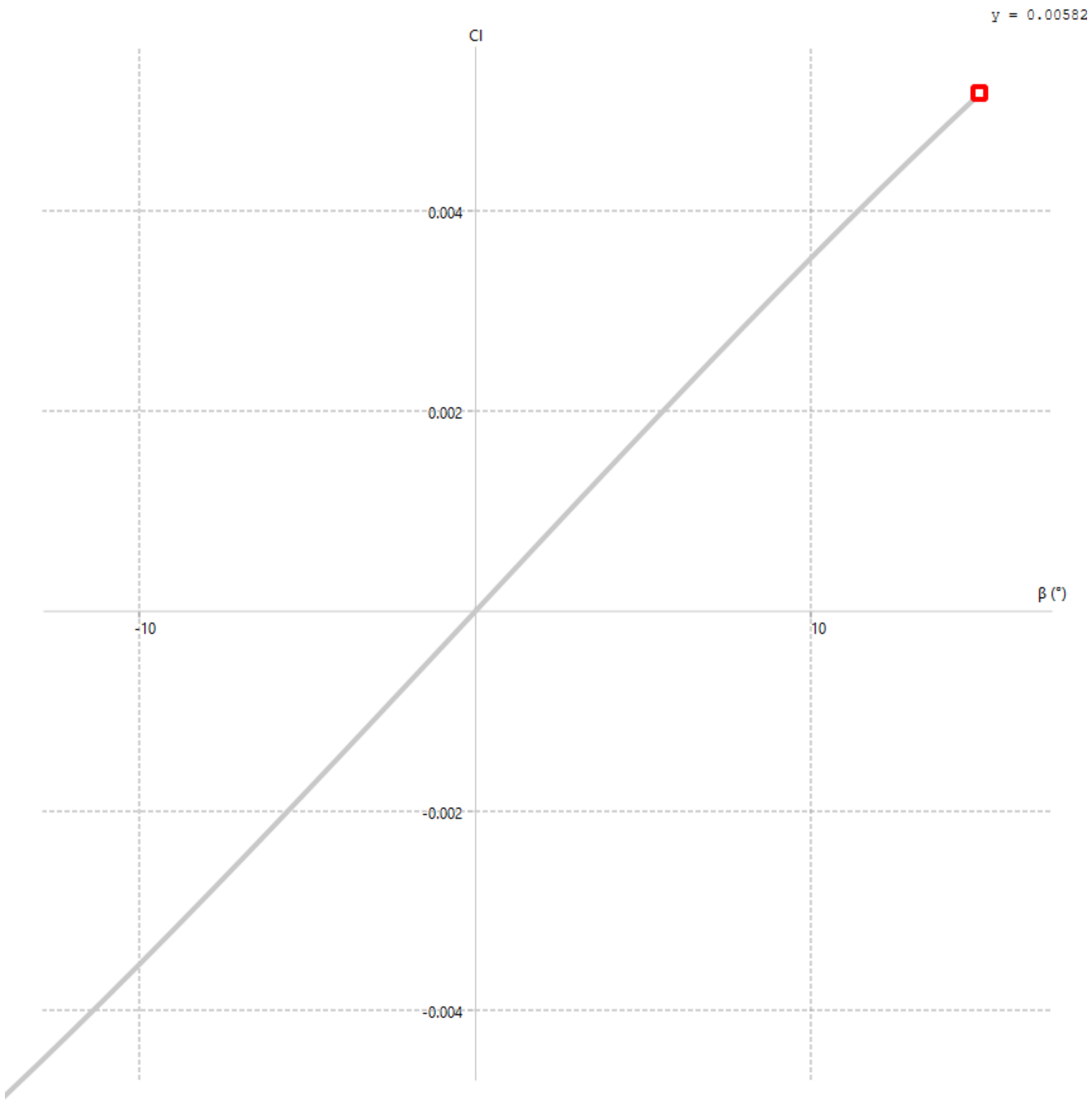


Figure 7Figure 6.Cl vs Beta(deg). The notation for rotation is reversed so slope here is positive

Aircraft performance

Now using the aerodynamic variables from xflr5 we can do a performance analysis for the design. The performance of current aircraft iteration surfaces 3 hours.

The basis of this analysis relies on the fact the power required to drive an aircraft is

Drag* V(cruise) / System efficiency (including motors,propeller,battery)

iter	MTOW(kg)	CL	CD	V(m/3)	S	rho	Lift(N)	Drag(N)	Power required(W)	Battery(W)	Flight time(Hrs)
1	6	0.411	0.0338	26.02	0.35	1.15	55.20	4.54	181.72	268.80	1.48

Produced by Eazyfluids (A registered trademark)

1	5.5	0.411	0.0338	24.91	0.35	1.15	50.60	4.16	159.49	268.80	1.69
2	6	0.44	0.031	22.29	0.44	1.15	55.20	3.89	133.39	358.40	2.69
4	5.5	0.44	0.031	21.34	0.44	1.15	50.60	3.57	117.07	358.40	3.06