HINDUSTAN
INSTITUTE OF TECHNOLOGY & SCIENCE
(DEEMED TO BE UNIVERSITY)
CHENNAI

TEAM NAUTILUS

NAUTILUS
BEYOND THE SKY

TEAM ID : ADC20220181

TEAM NAUTILUS - ADC20220181


Mr Dinesh Kumar
(Faculty Advisor)


Akshat Jani


Sarath Chandra


M. Ashwin


Pavan Kumar


Ayush Koul


Mufaddal Lokhandwala


Pratik Patil

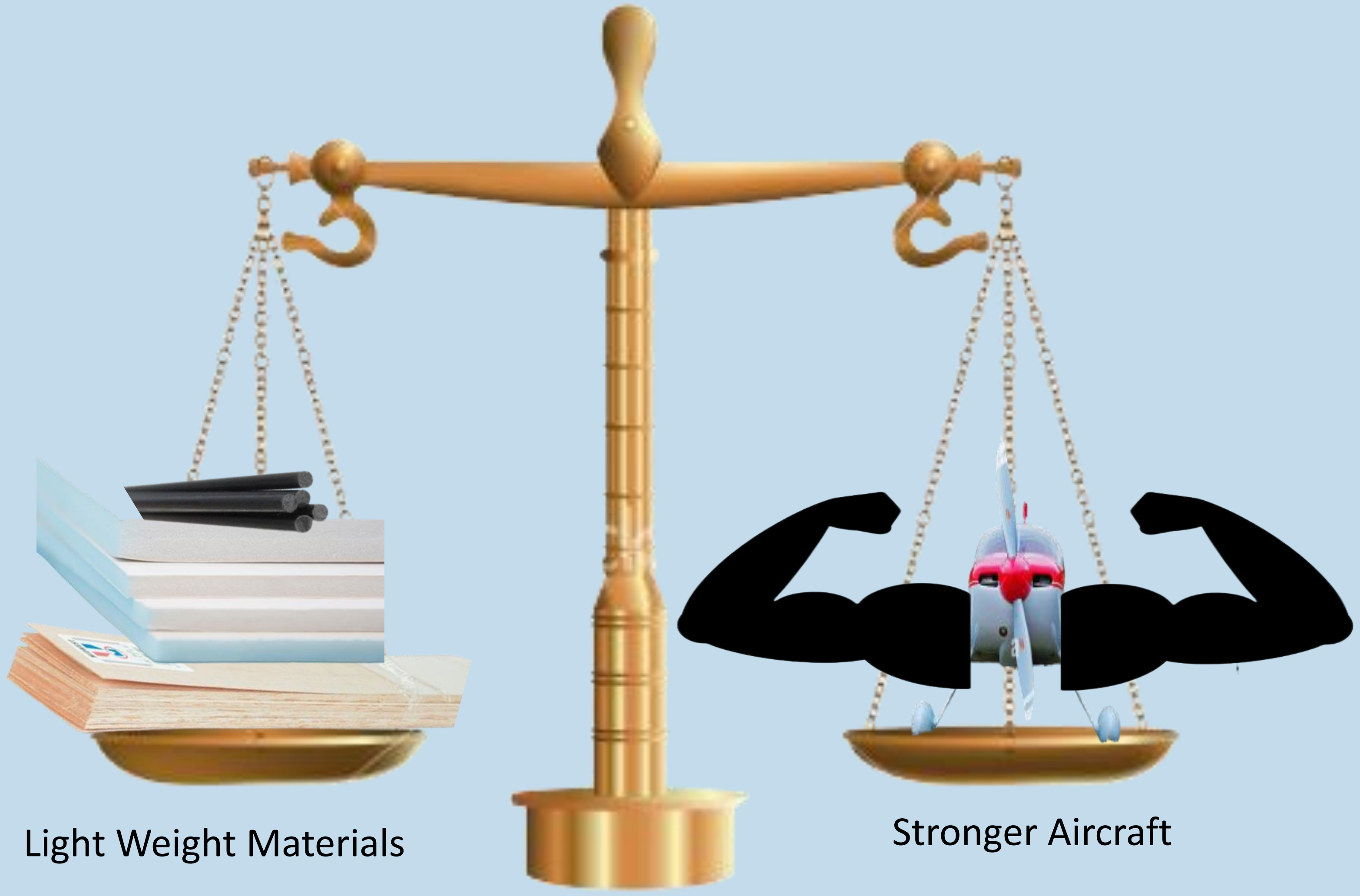
Strategy

Our main aim during the entire design process was

1. To keep the lowest empty weight possible (so that payload with maximum weight can be carried on given thrust)

2. To make the model robust enough without much compromising in weight
   So we came up with some light but durable materials like balsa wood, carbon rods etc.

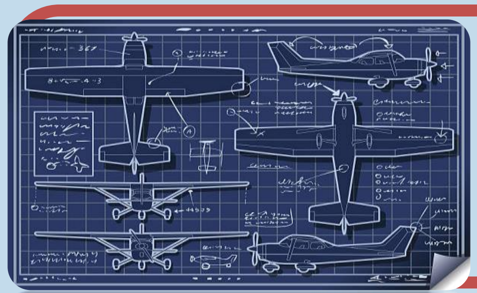
3. Payload Release Mechanism capable of releasing payload from as high as 10 metres without much compromise in the aircraft efficiency



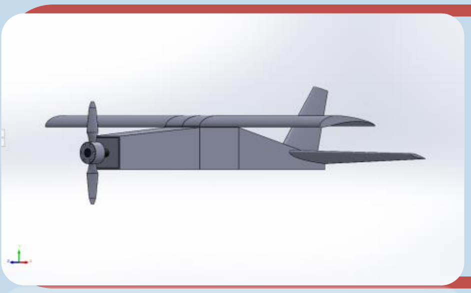
Design Process

Literature Review

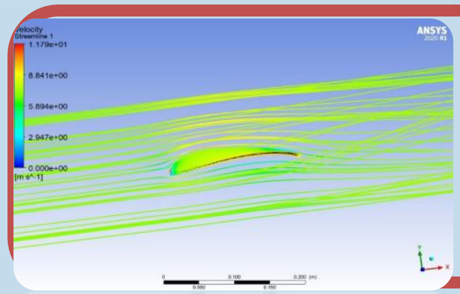
Concept Generation & Calculation



2-Dimensional Blueprint

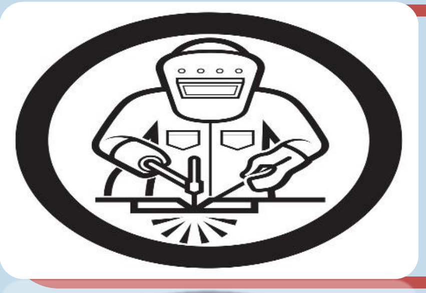


3-Dimensional CAD MODEL



Aerodynamics & Structural Analysis

Design Report



Fabrication

Flight Test

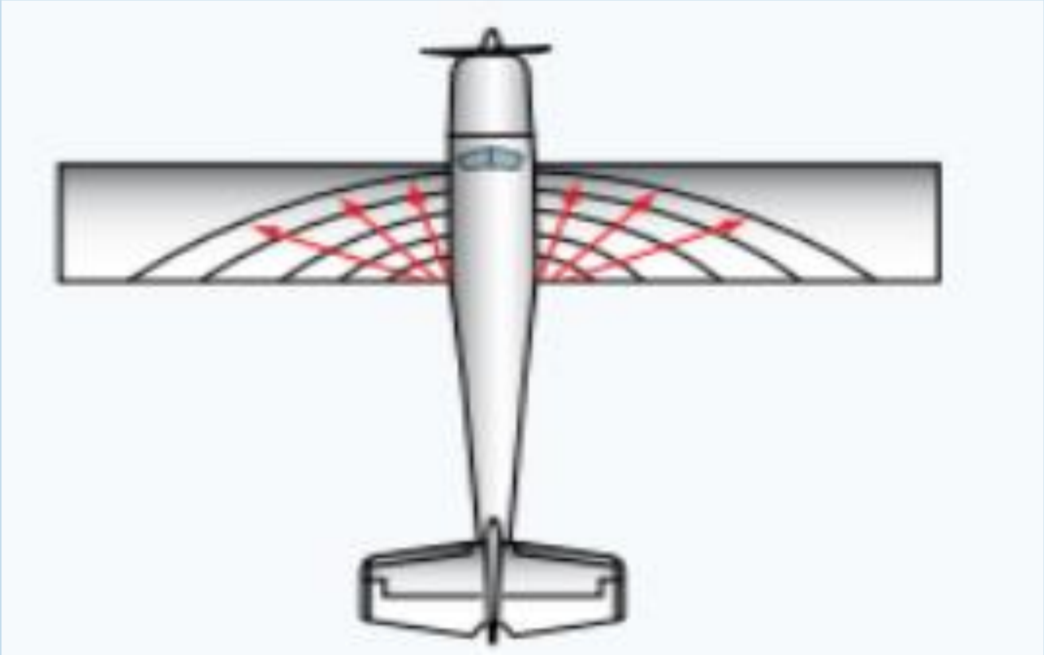
Payload Release Test

Final Flight

Model Configuration

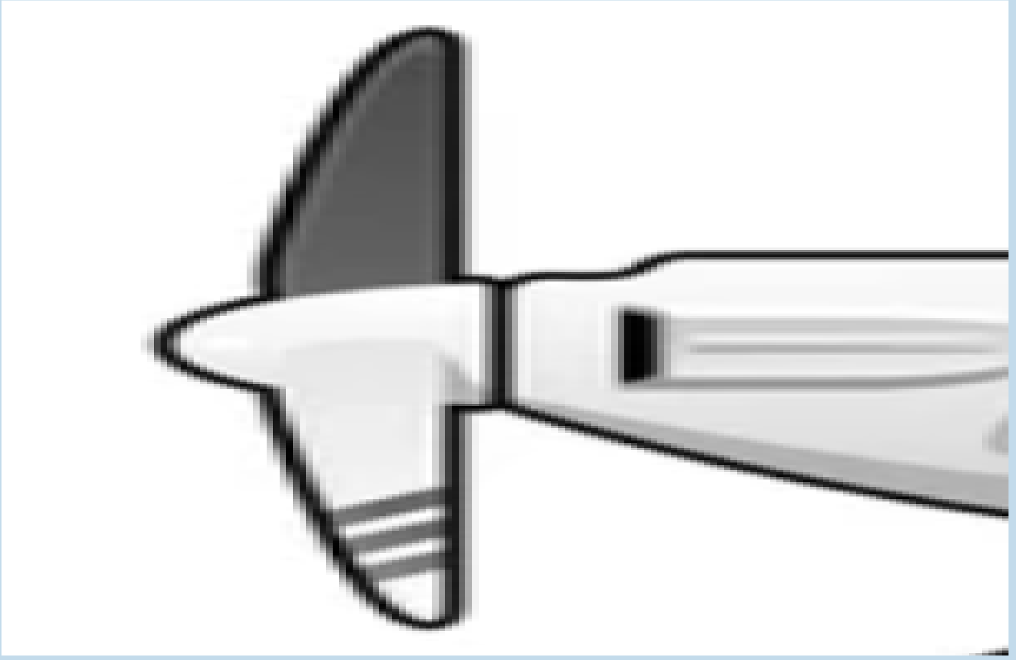
High-Wing

- More Lateral Stability
- Facilitates ease access of payload



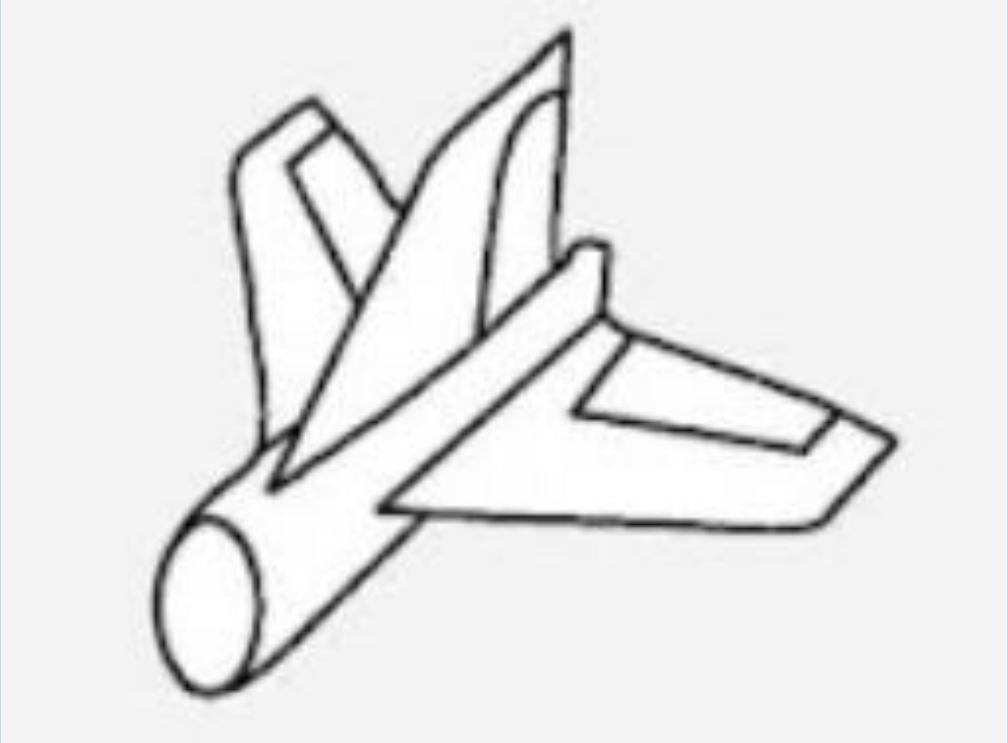
Rectangular Wing Surface

- Simpler to Design & Manufacture
- Quick Stall Recovery



Single Engine with Propeller

- No Disruptions in Air Flow
- Induces a cooling effect to the other systems



Conventional Emphanage

- Better Longitudinal Stability
- Ease Stall Recovery

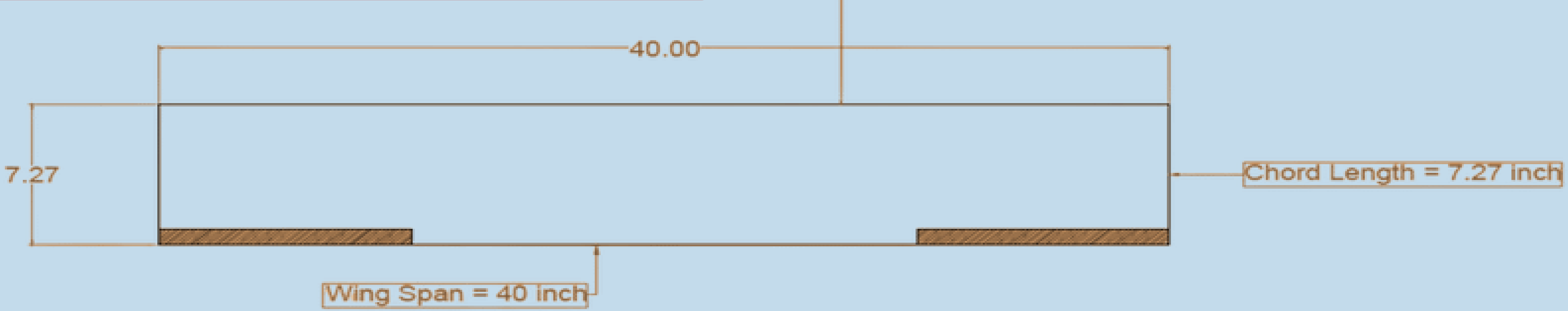
Rectangular Tapered Fuselage

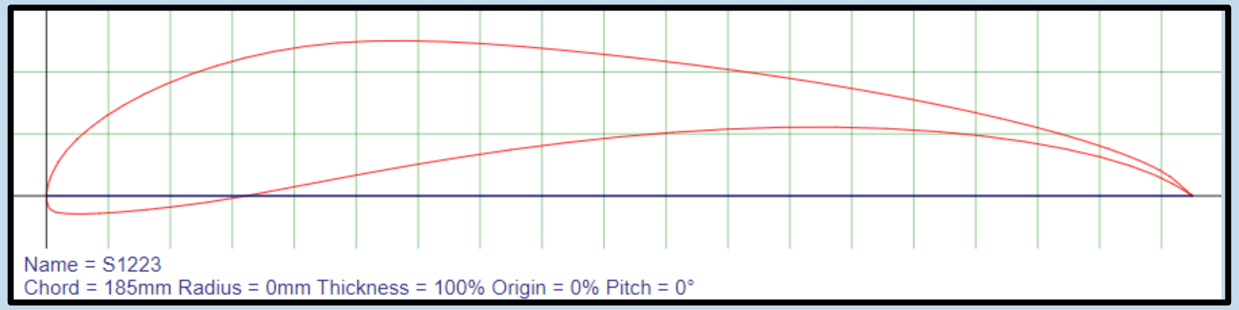
- Easy to Manufacture
- More surface area to accommodate other parts, equipment or payload.

Payload Release Mechanism

- Ease transportation of Payload from point A to B
- Provides access to the area where aircraft operations isn't possible

Wing Configuration/Airfoil Selection

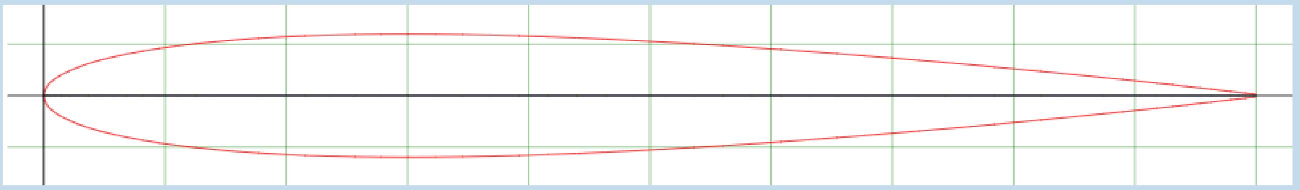




SELIG 1223, Cambered Airfoil (Wings)

S1223 produces far more lift than any of the other airfoils, and hits its most efficient point (maximum lift for minimum drag) at a very high lift coefficient.

NACA 0012, Symmetrical Airfoil (Emphanage)



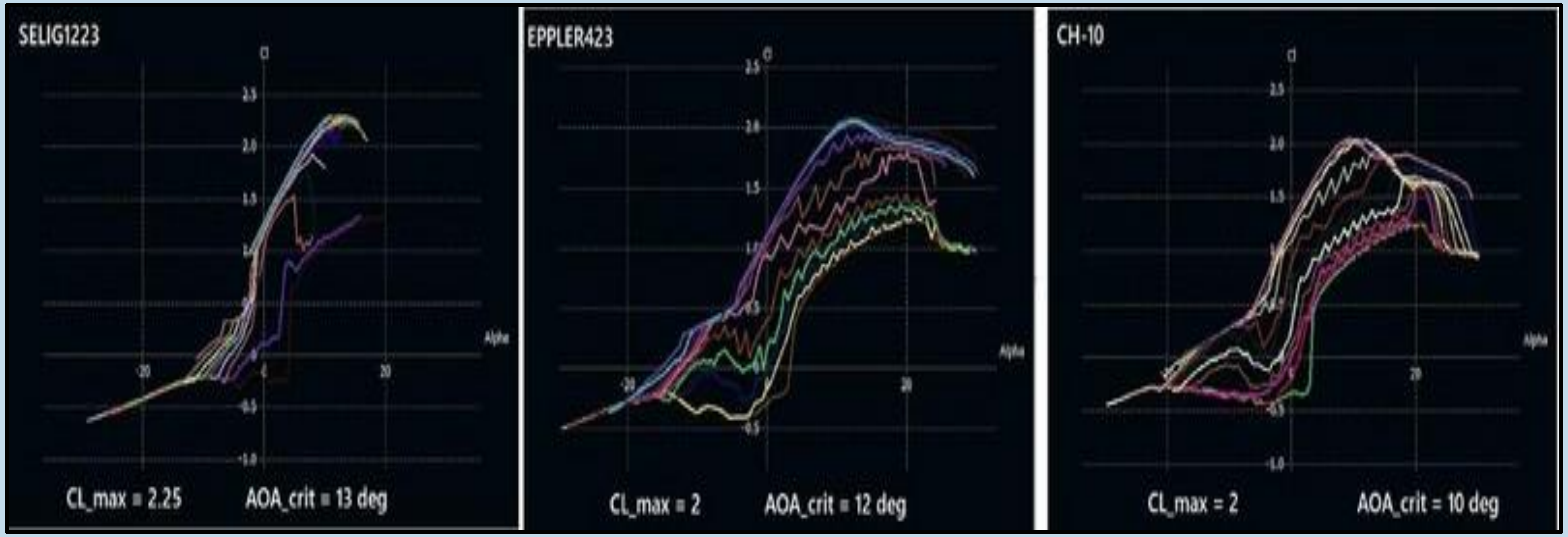


Fig (i) : Comparison of Cl vs α curves for three airfoils

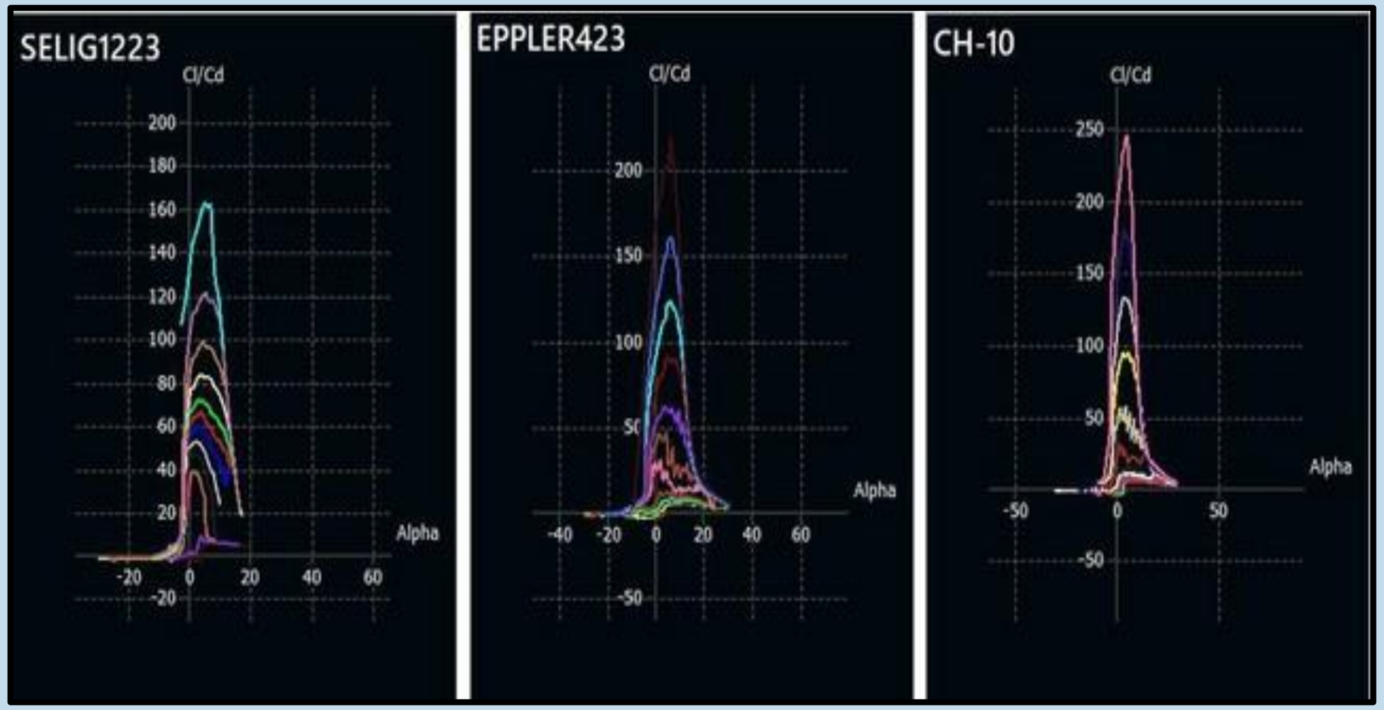


Fig (ii) : Comparison of Cl/Cd curves for three airfoils

Calculations

C_l value from the C_l vs α curve for SELIG1223 airfoil

Maximum Take-Off Weight (with payload)
2kg
(Limit as per Rulebook)

Steady & Level Flight Eqn
Thrust (T) = Drag (D)
Lift (L) = Weight (W)

Lift Force = 16.5N

$L = \frac{1}{2}\rho v^2 S C_l$

Min Velocity = 8 m/s (Stall Speed)

Surface Area of 290.8 sq inch

$S = b * c$

Assuming chord length (c) of 7.27 inches

Typical Aspect Ratio for Trainer Category RC-Airplanes = 5.5

$AR = \frac{b^2}{S}$

Wing Span 40 inch

$WCL = \frac{MTOW\ (in\ oz)}{\left(\frac{Wing\ Area\ (sq\ in)}{144}\right)^{1.5}}$

Wing Cube Loading = 8

Calculate the Dimensions of your Plane based on the drawings above:
By courtesy of Douglas Morris

Enter Wingspan	Wing Aspect Ratio	Stab Area % of Wing Area	Elevator Area % of Stab Area	Rudder Area % of Fin Area
40	5.5 :1	15%	20%	33%

Click to Calculate

Avg. Wing Chord	Wing Area	Aileron Length	Aileron Width	Strip Aileron Width
7.27	290.8	10	1.82	0.91
Fuselage Length (F)	**Fuse ahead of Wing (F1)**	**Wing TE to Elev. Hinge (F2)**	**Fuselage Height (F3)**	**Balance Point from Wing LE**
30	10.91	18.17	10% 3 / 15% 4.5	25% 1.82 / 33% 2.4
Stab Area	**Avg. Stab Width (S1)**	**Stab Length (S2)**	**Elevator Area**	**Avg. Elevator Width (E1)**
43.62	3.81	11.45	8.72	0.76
Fin Area	**Avg. Fin Width (R1)**	**Fin Height (R2)**	**Rudder Area**	**Avg. Rudder Width (R3)**
14.39	2.19	6.57	4.75	0.72

Clear

Calculate Wing Loading & Wing Area:

	inches	mm
Wingspan:	40	1016
	inches	mm
Wing Root Chord:	7.27	185
	inches	mm
Wing Tip Chord:	7.27	185
	inches	mm
Or Average Chord:	7.3	185
	sq.in	sq.dm
Or Wing Area:	292	18.8
	ounces	grams
Aircraft Weight:	45.9	1300

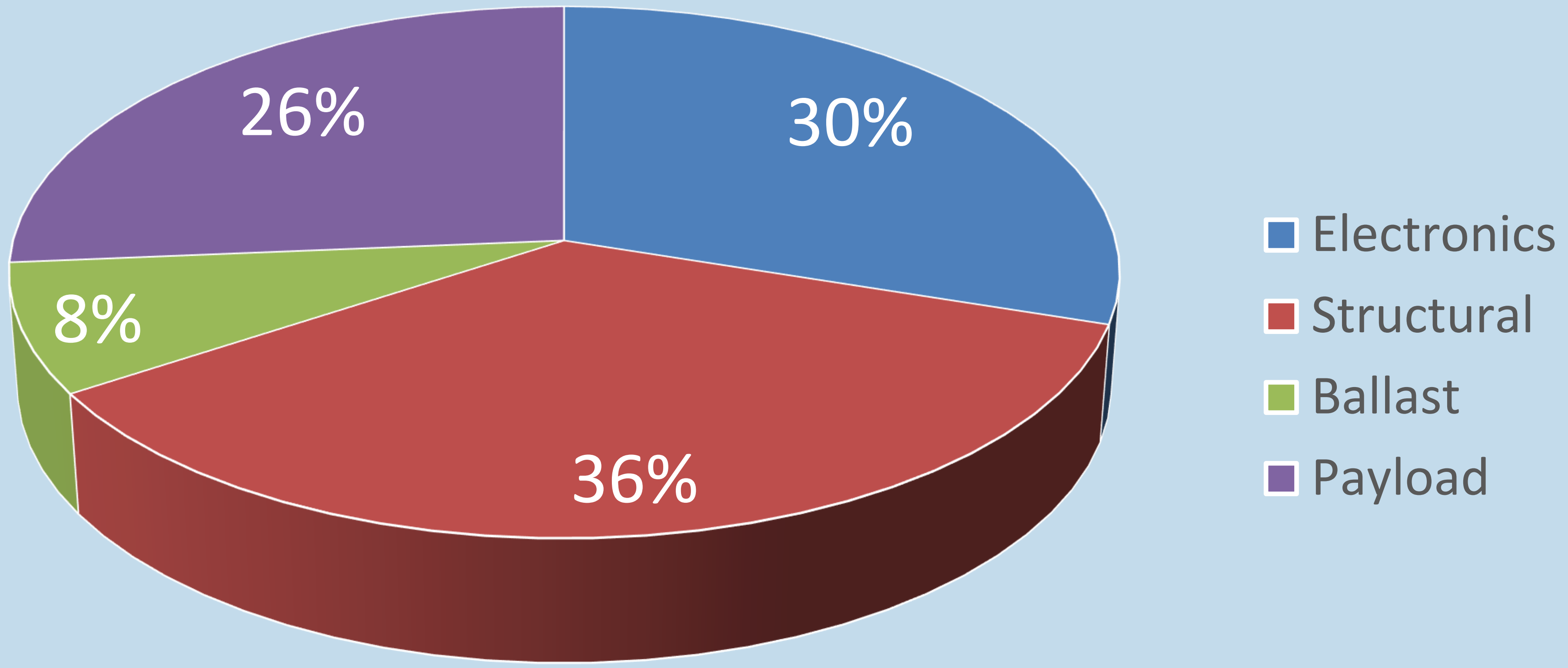
Calculate

	oz/sq.ft	g/sq.dm
WING LOADING:	22.64	69
	oz/cu.ft.	
CUBIC LOADING:	15.9	

Stabilizer Area ≈ 15% of Wing Area
Elevator Area ≈20% of Stabilizer Area
Rudder Area ≈33% of Fin Area
Fuselage Height ≈10 – 15% of Fuselage Length
Location of CG ≈25% of MAC

Weight Estimation

Sr No	Type of Weight	Value (in kg)
1	Empty Weight	1300 kg
2	Dry Weight	680 kg
3	Payload Weight	500 kg
4	Maximum Take-Off Weight (MTOW)	1800 kg
5	Payload Fraction	0.38 (38% of the empty wt)



Payload Selection

Galvanised Iron Tube

Qty Used : 1

Weight : 250g

It remains as fixed weight of 250g as payload

Iron Rod

Qty Used : 4

Weight : 120g (30 x 4 units)

Provides an option to add 120g variable weights to carry maximum payload

Clay

Weight : 40-50 gms

Provides an option to do iterations for maximum payload weight

Actual Payload

Aerodynamic Analysis

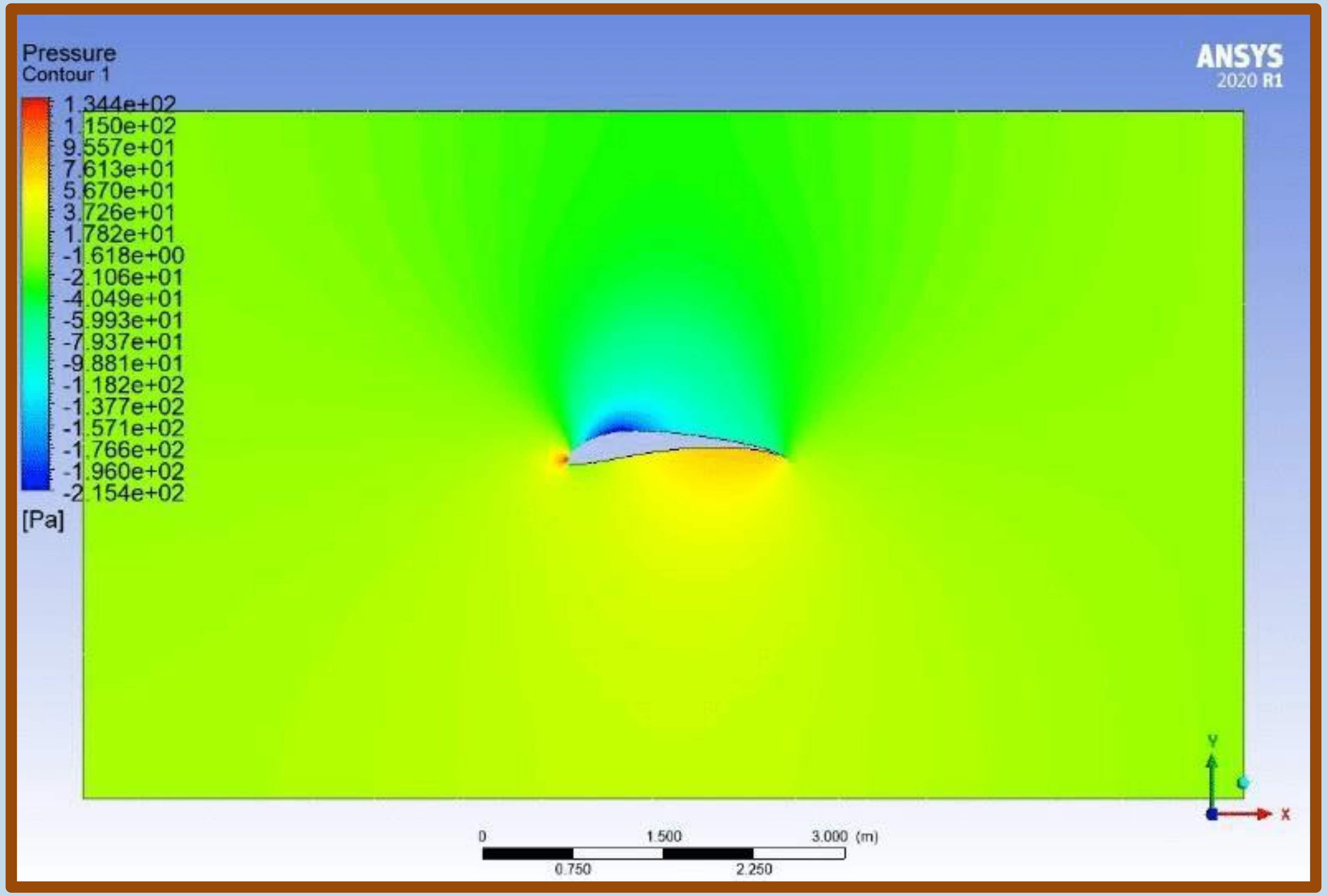


Fig 1 (a) - Pressure contour at 0 degree AOA

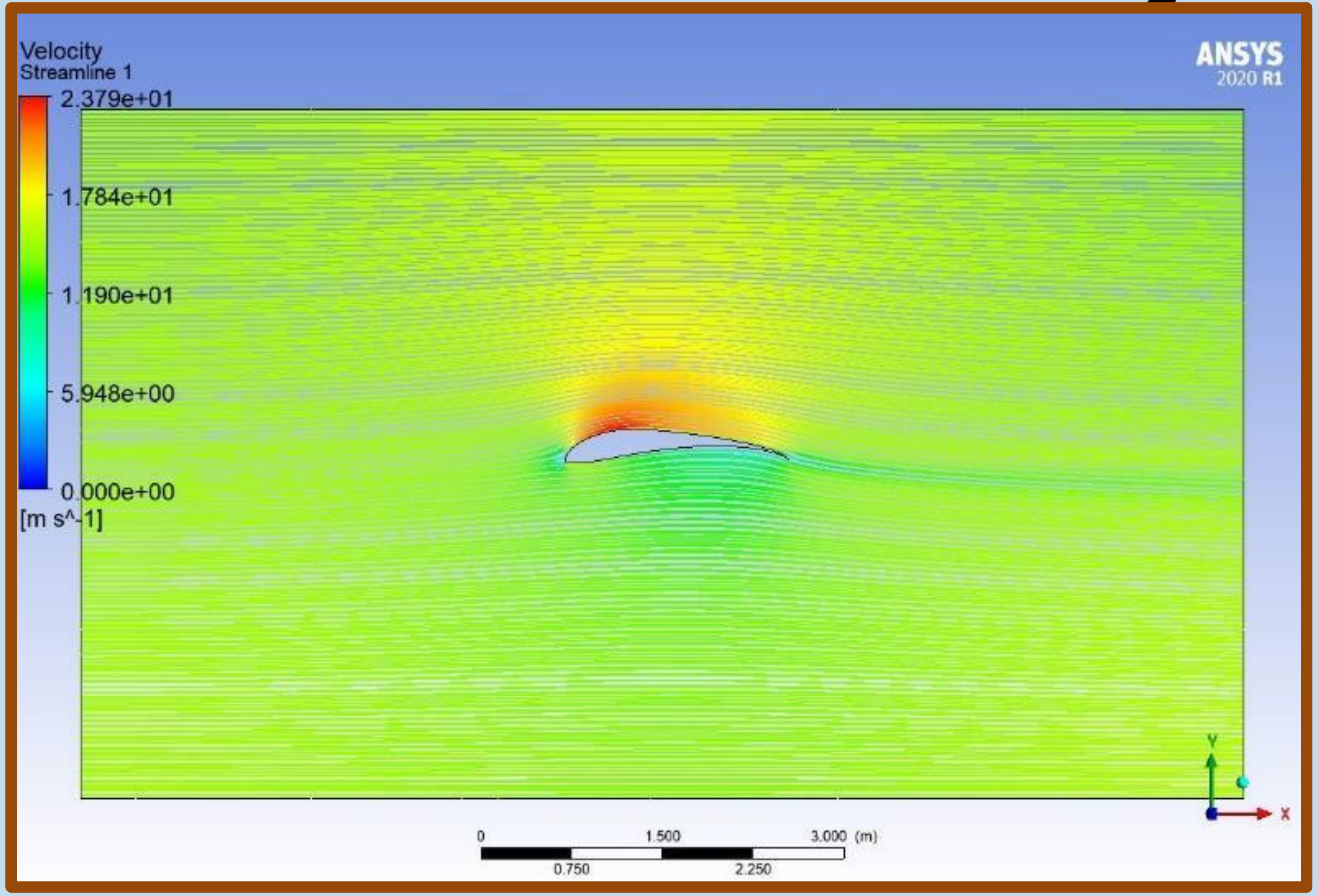
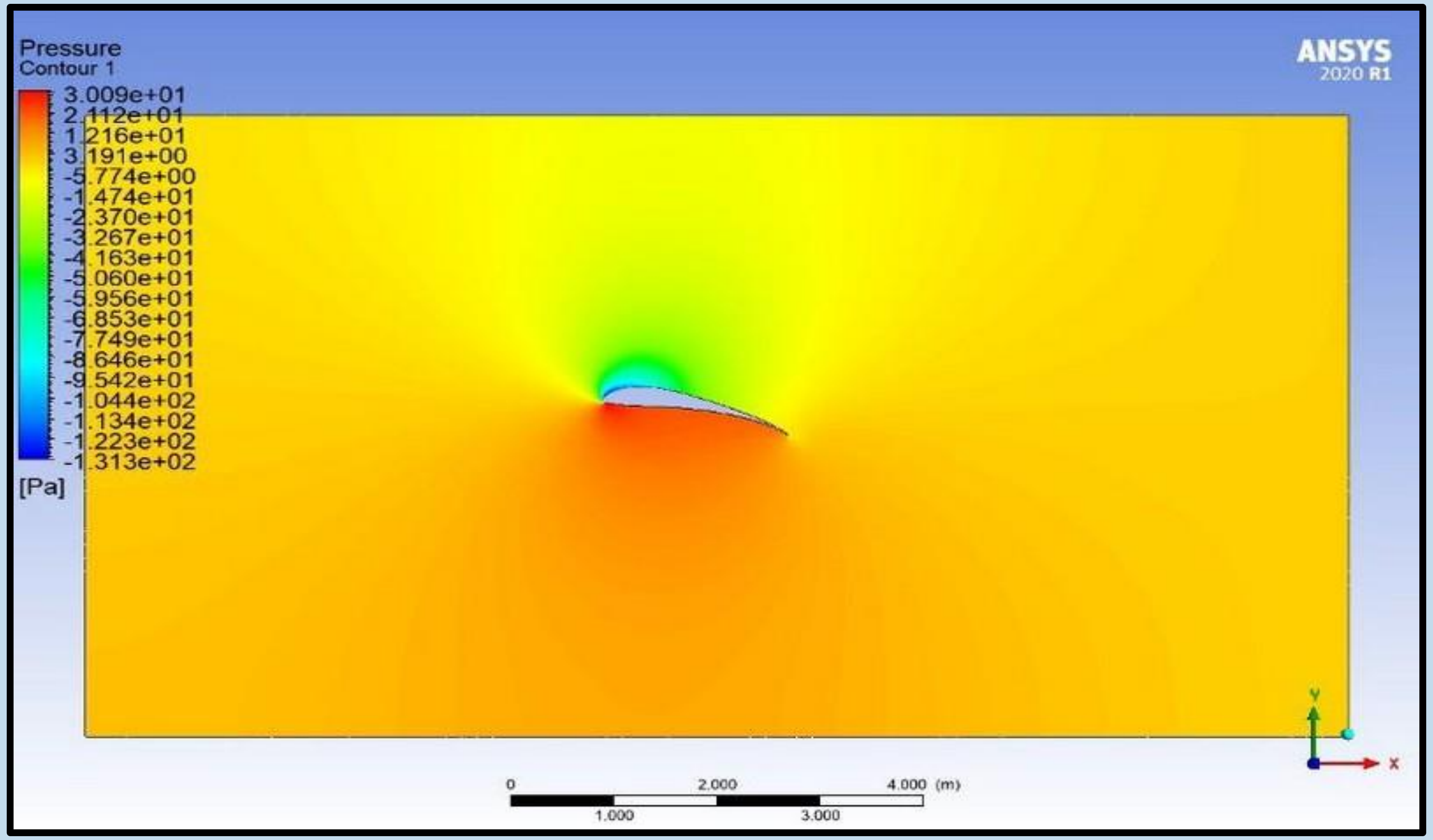
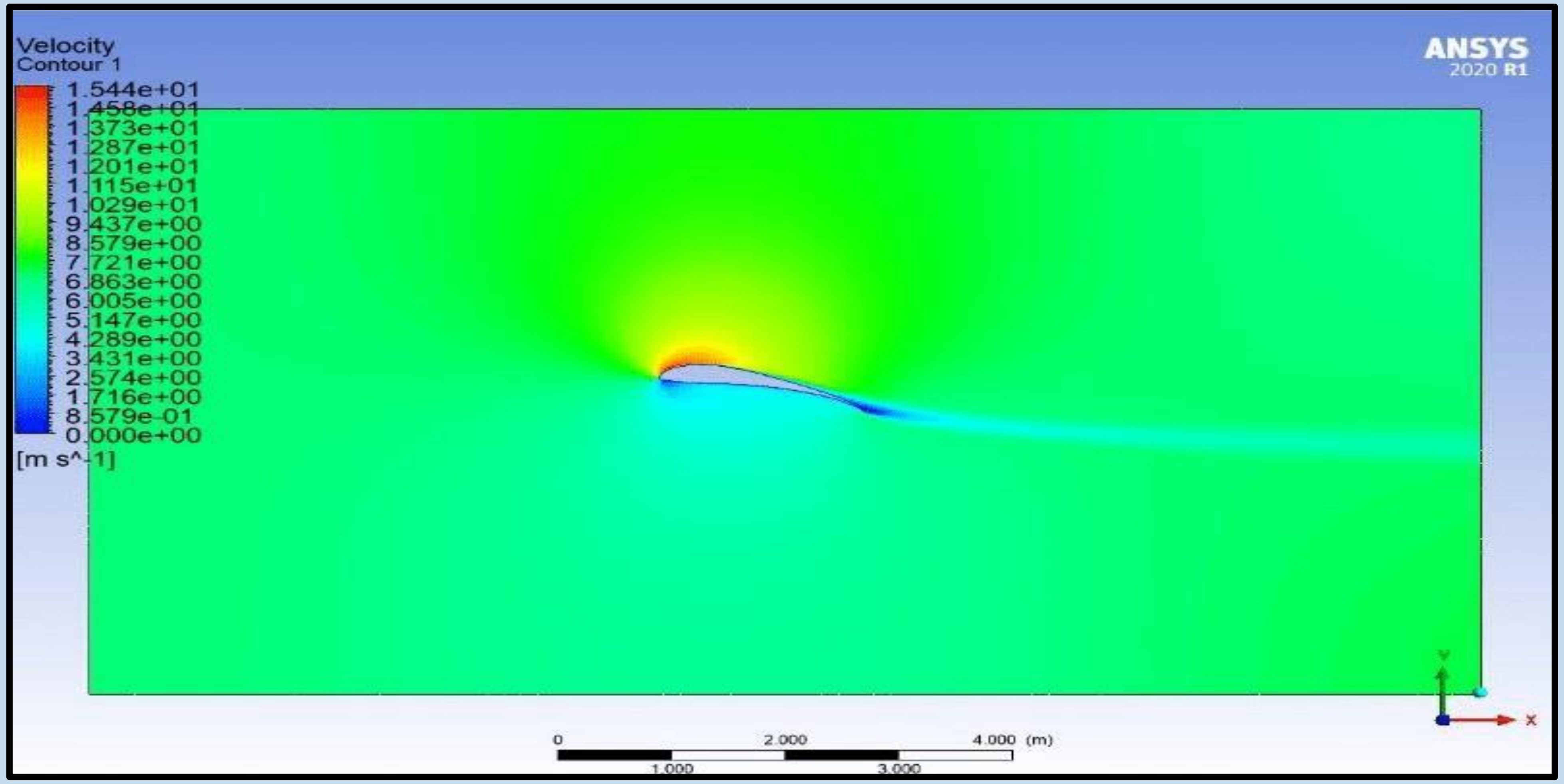


Fig 1 (b) - Stream line flow around the airfoil

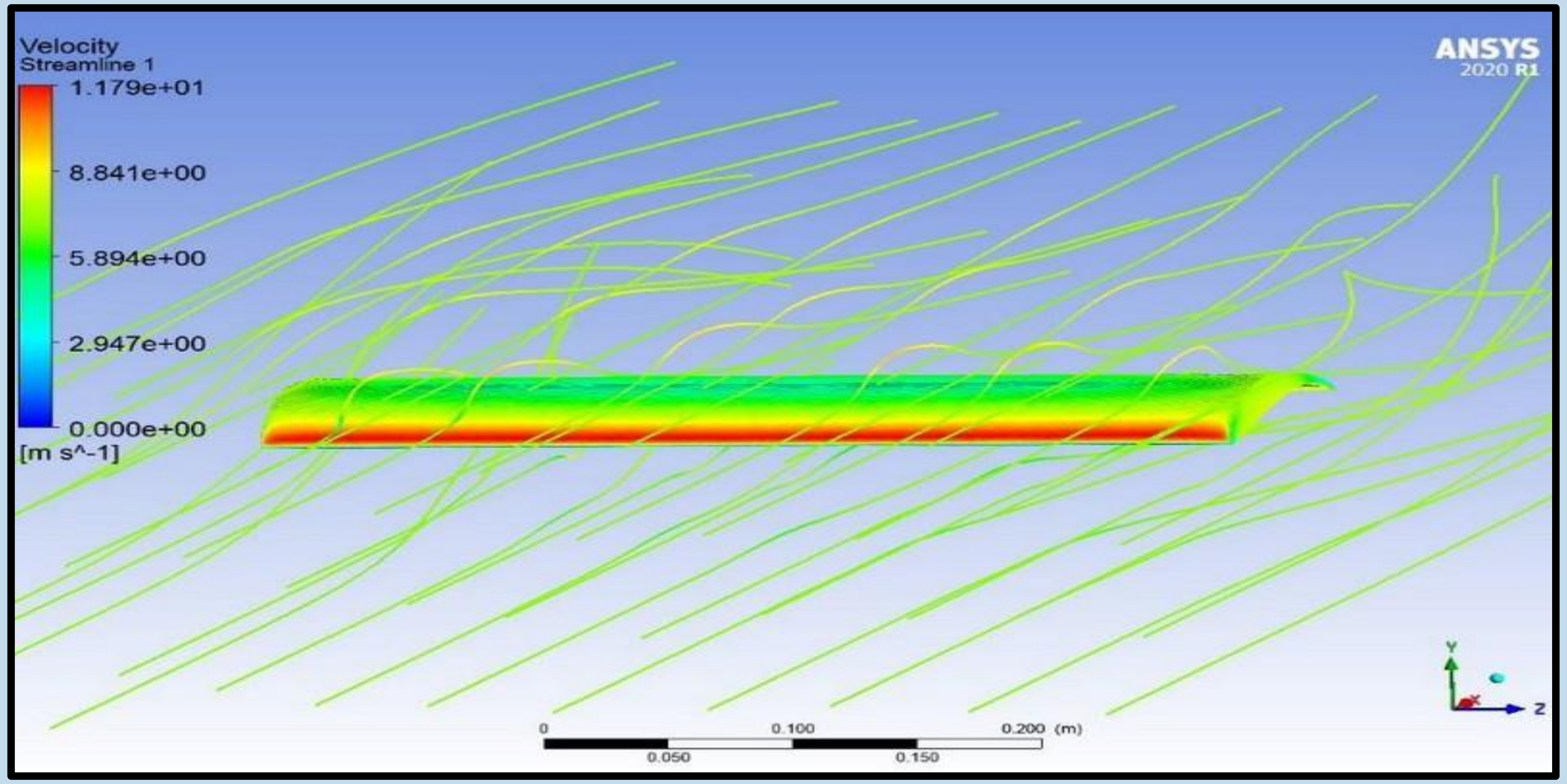
- S1223 airfoil section provides high lift and low drag profiles at low speed with a $Clmax$ of 2.1
- The pictures show the fluid flow analysis over the SELIG 1223 airfoil at the calculated stall velocity of 7 m/s.
- The viscous model used for the CFD analysis is the standard k-epsilon (2 eqn.) with enhanced wall treatment which is the most suitable for low speed analysis.

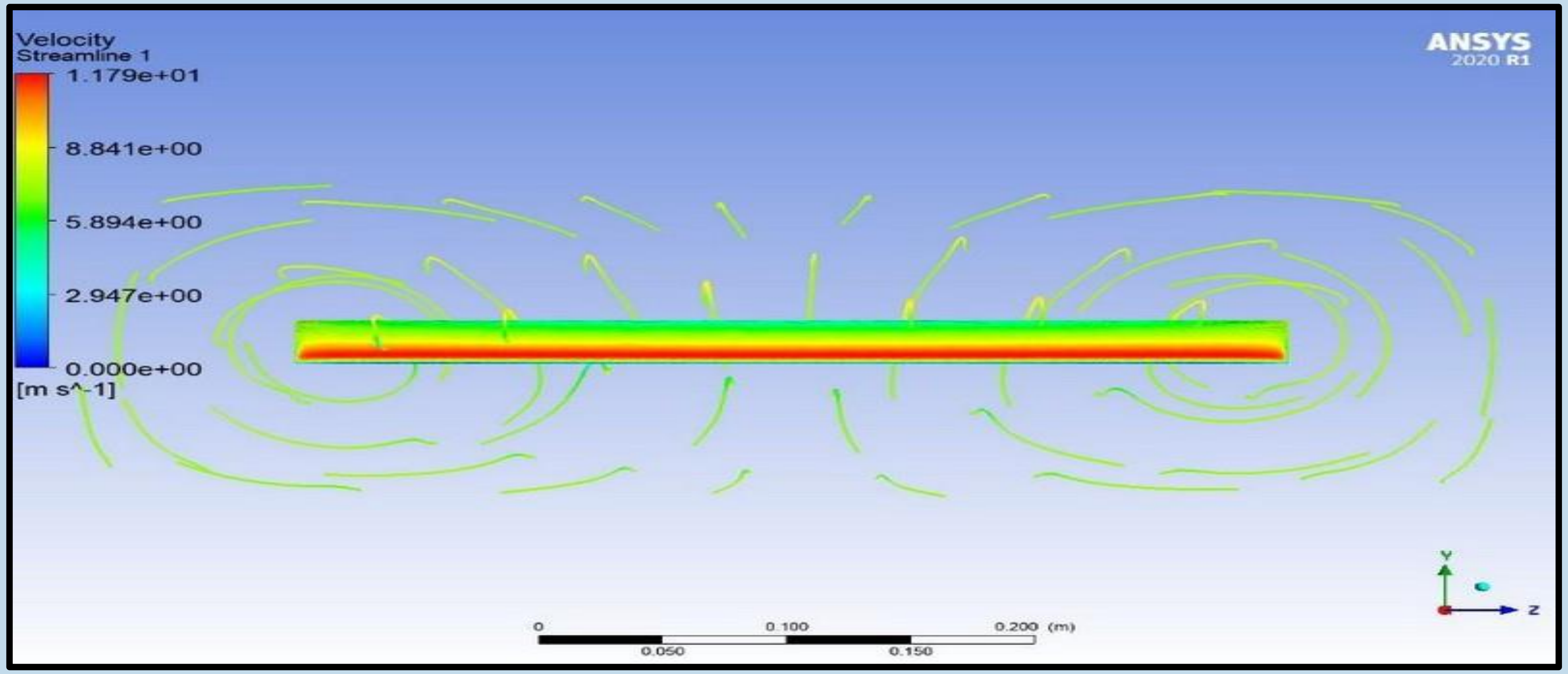


Visualization of pressure contour at 13 degree AOA

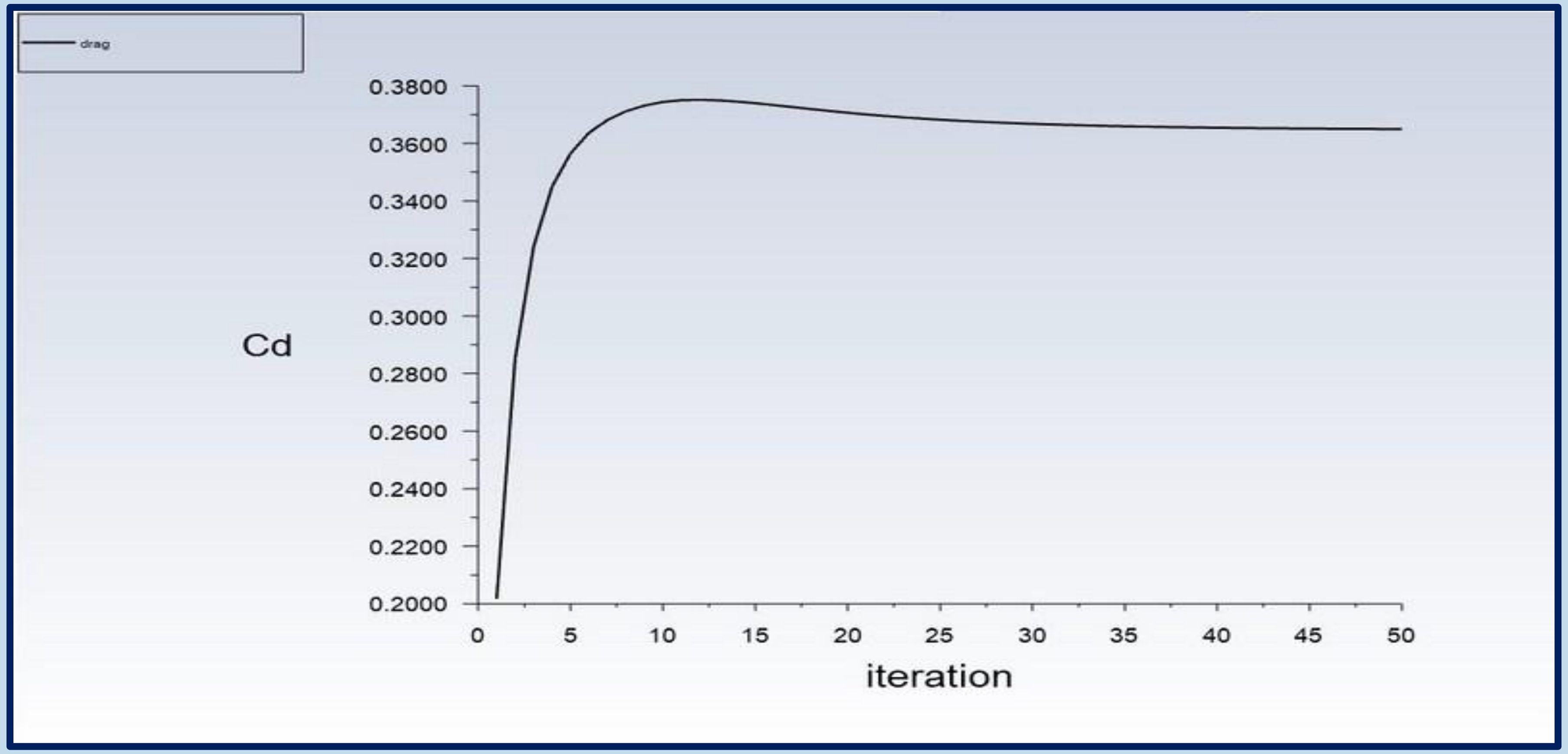


Visualization of velocity contour at 13 degree





Visualisation of flow over wing from different views



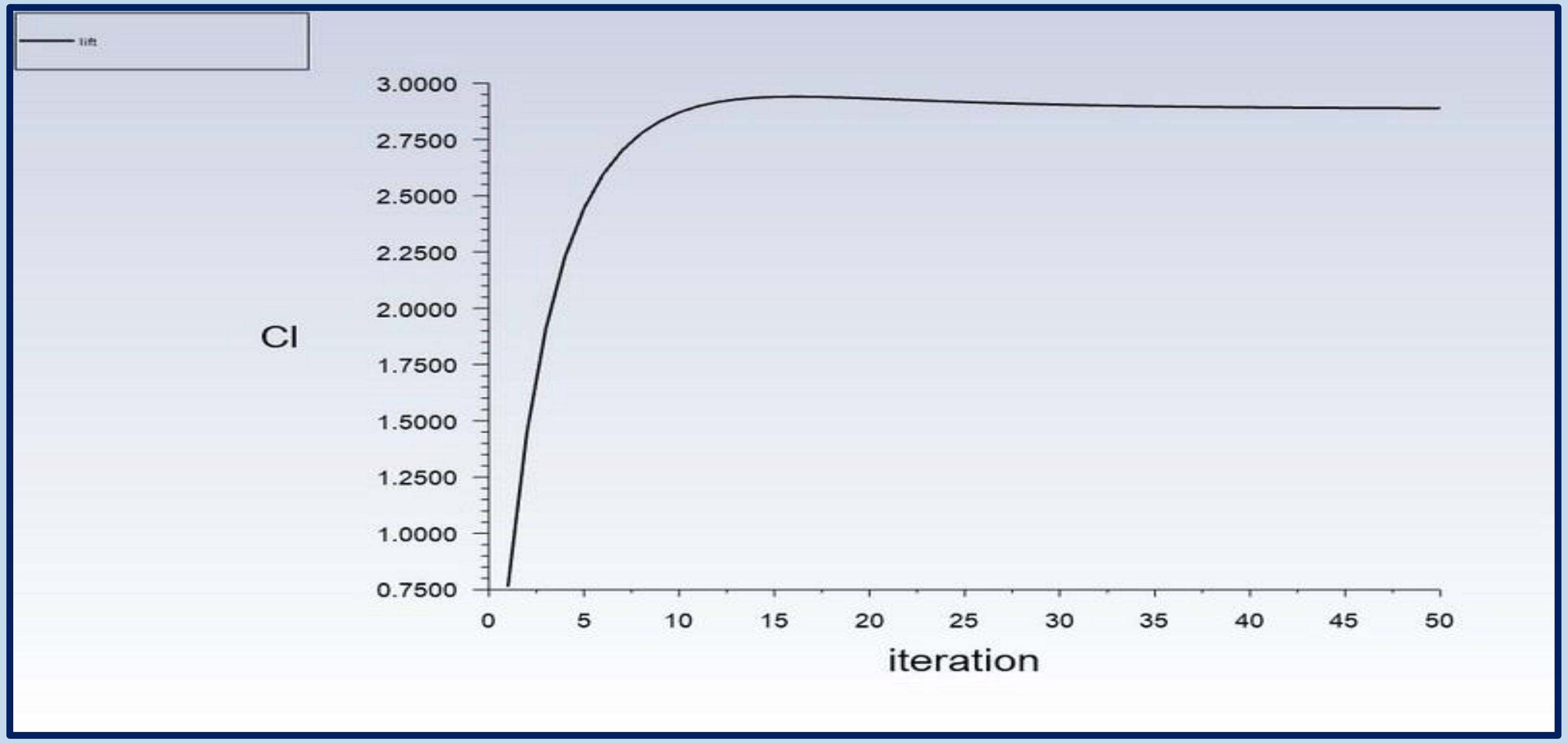
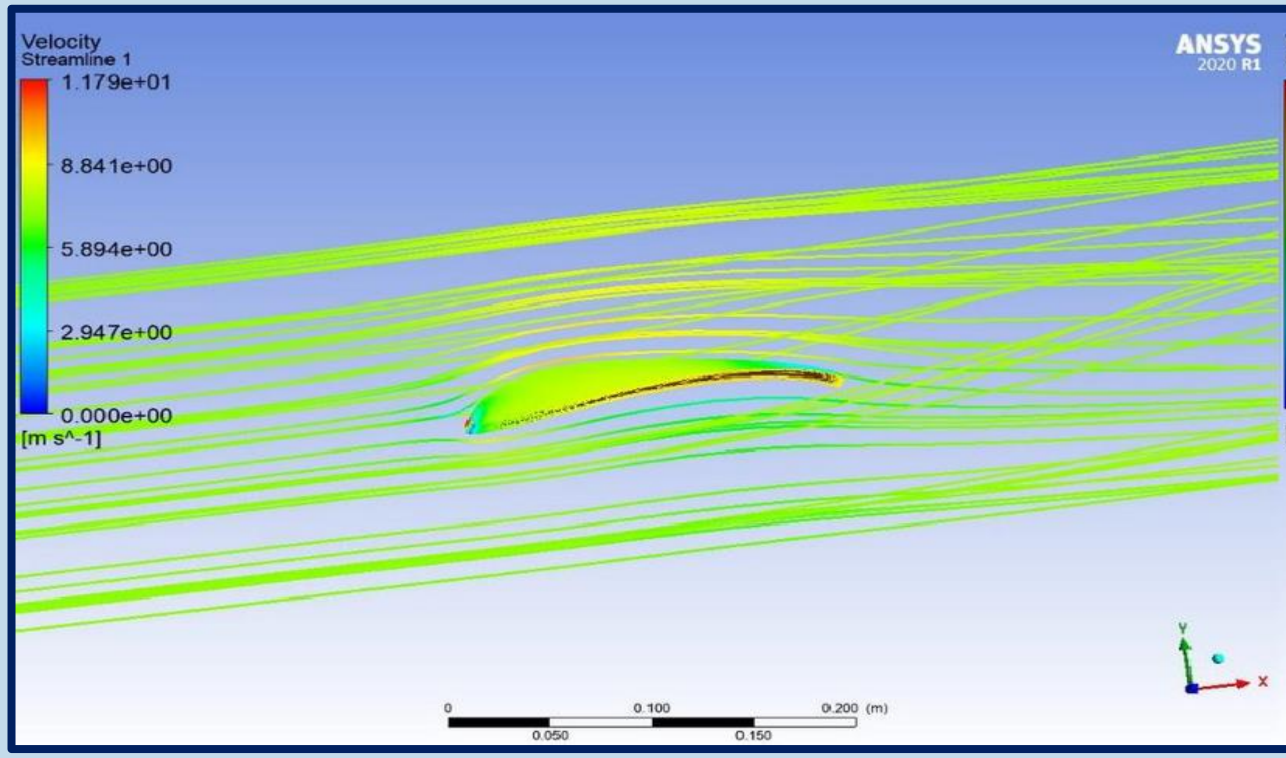


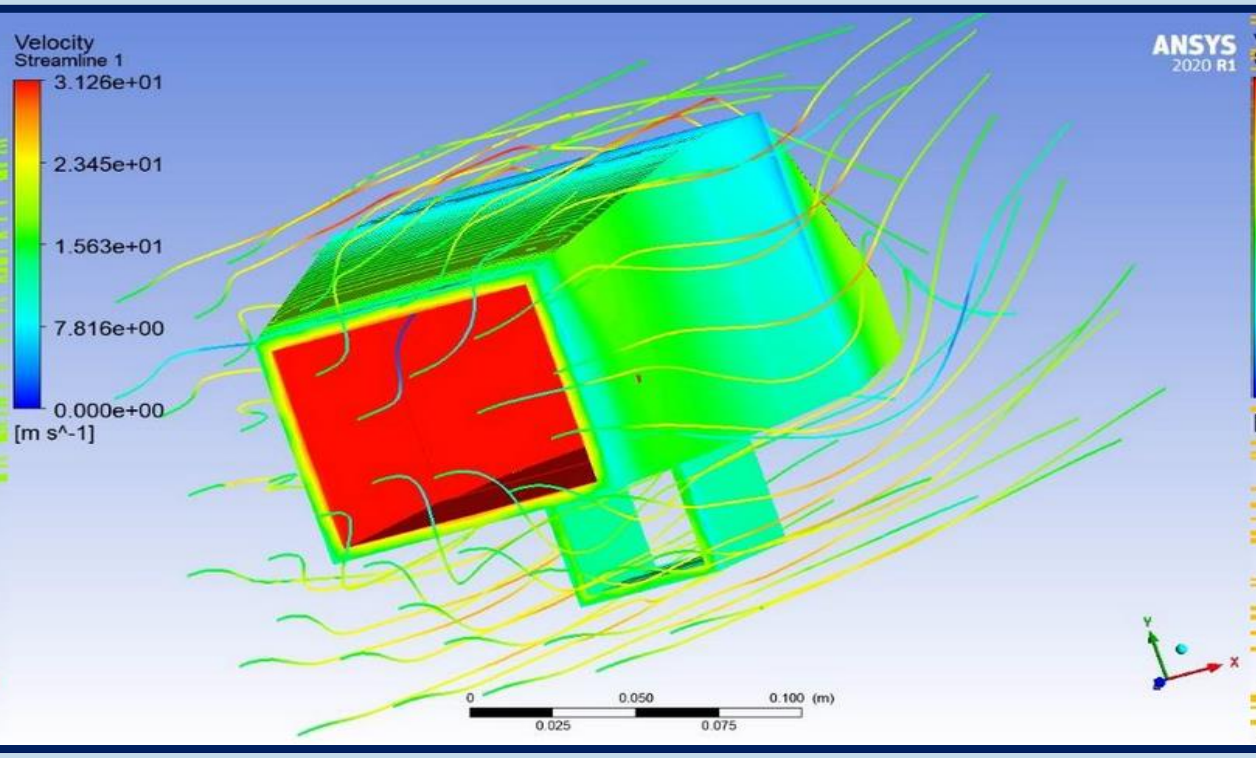
Fig 4.1 (e) - Cd vs iterations for wing analysis

Fig 4.1 (f) - Cl vs iterations for wing analysis

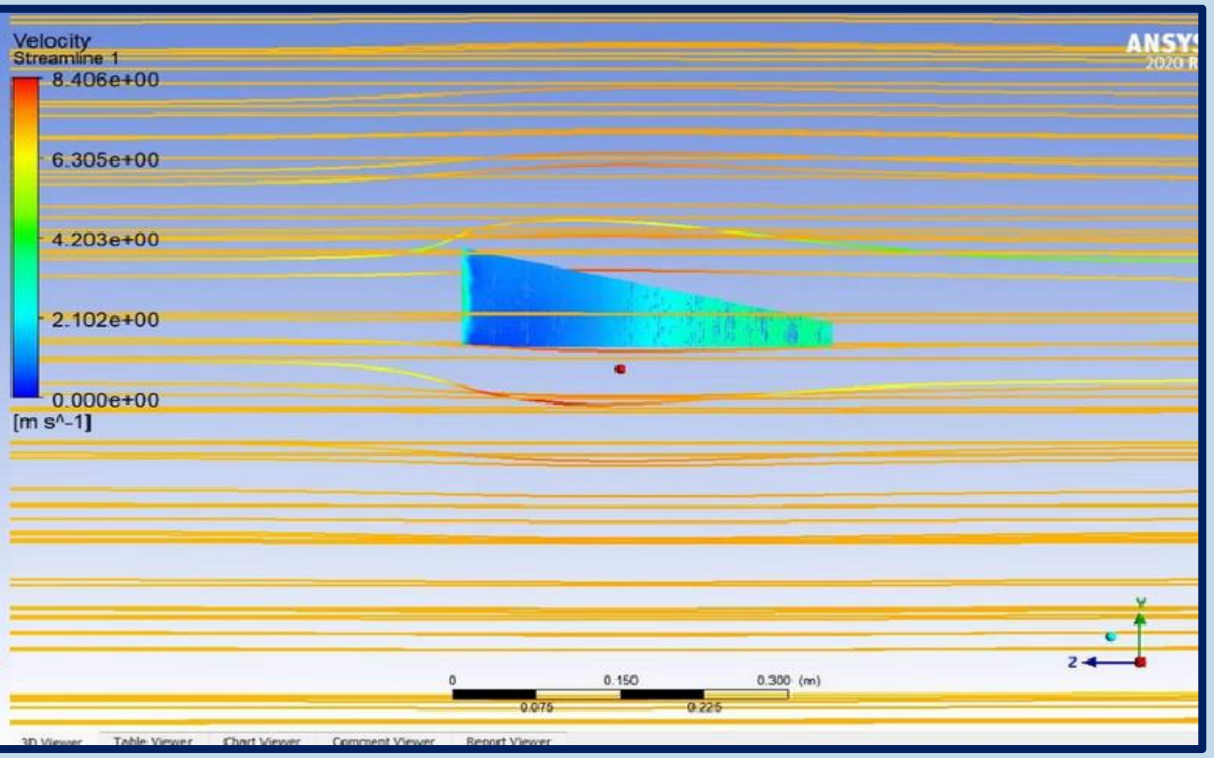
- The above graphs of the wing analysis gives the desired value of Cl of 2.8 as estimated and a minimal drag coefficient (Cd) of 0.36.



Streamlines over an airfoil

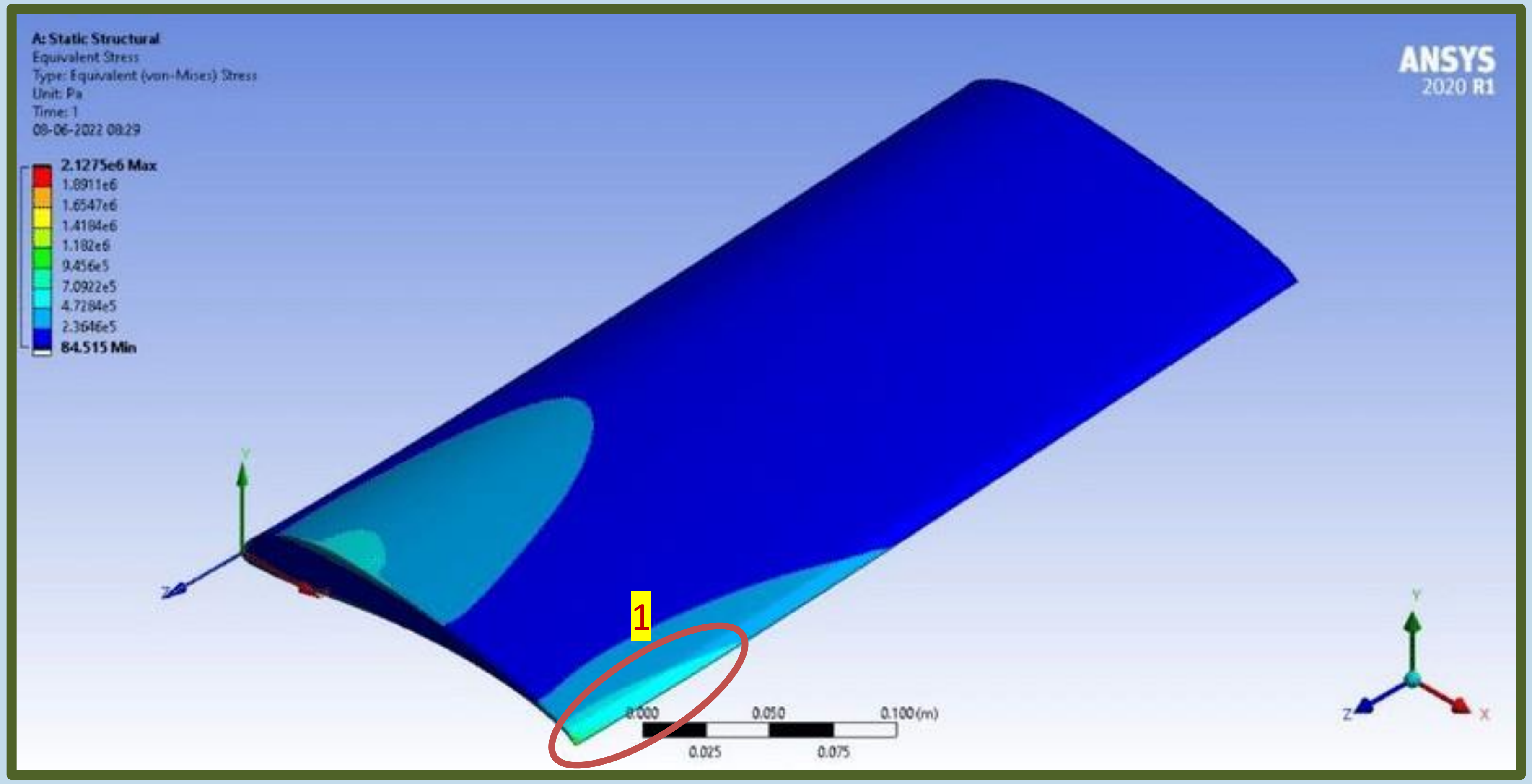


Visualization of flow over fuselage from front view

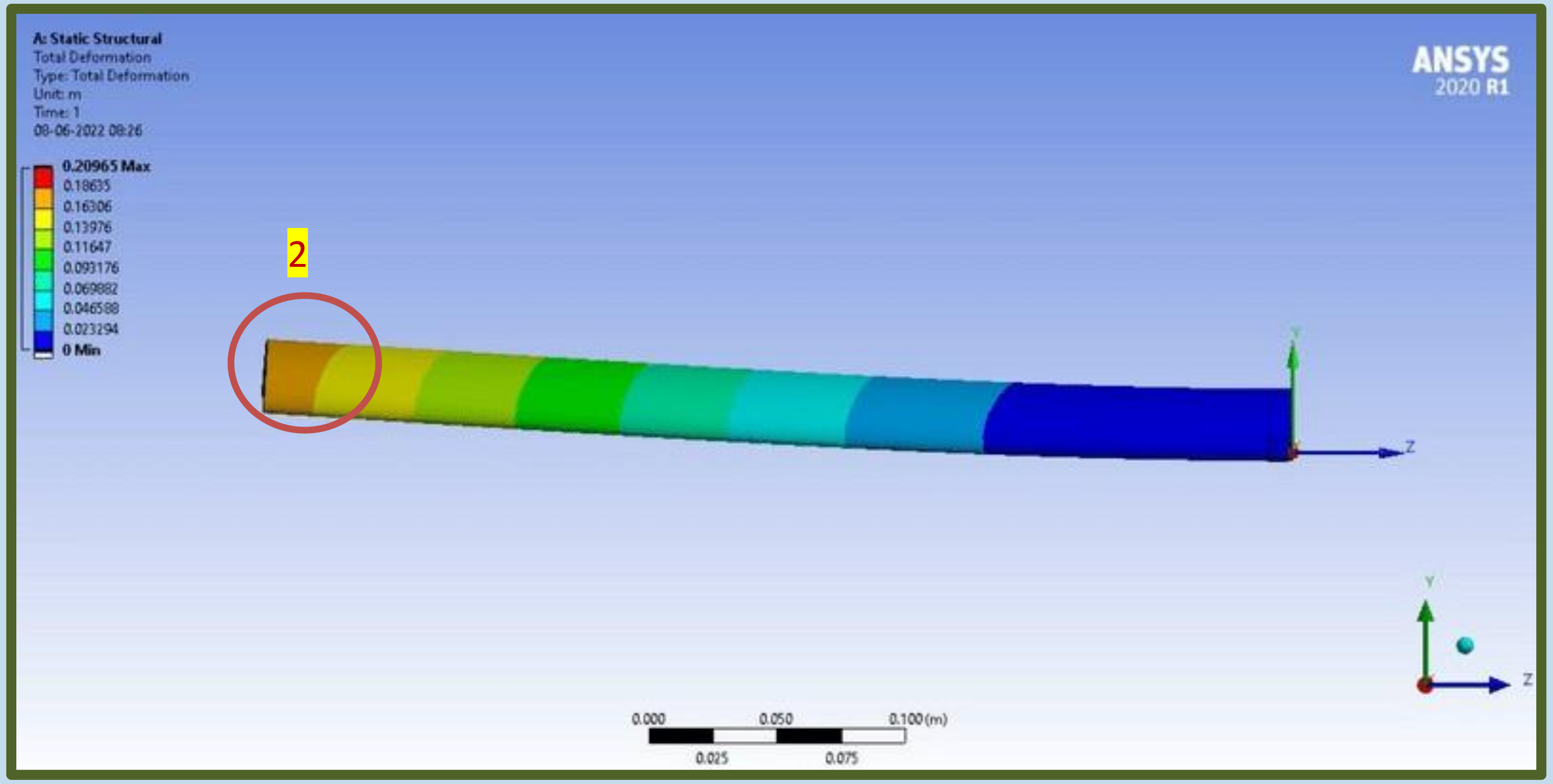


Simulation of streamlines over aft portion of fuselage

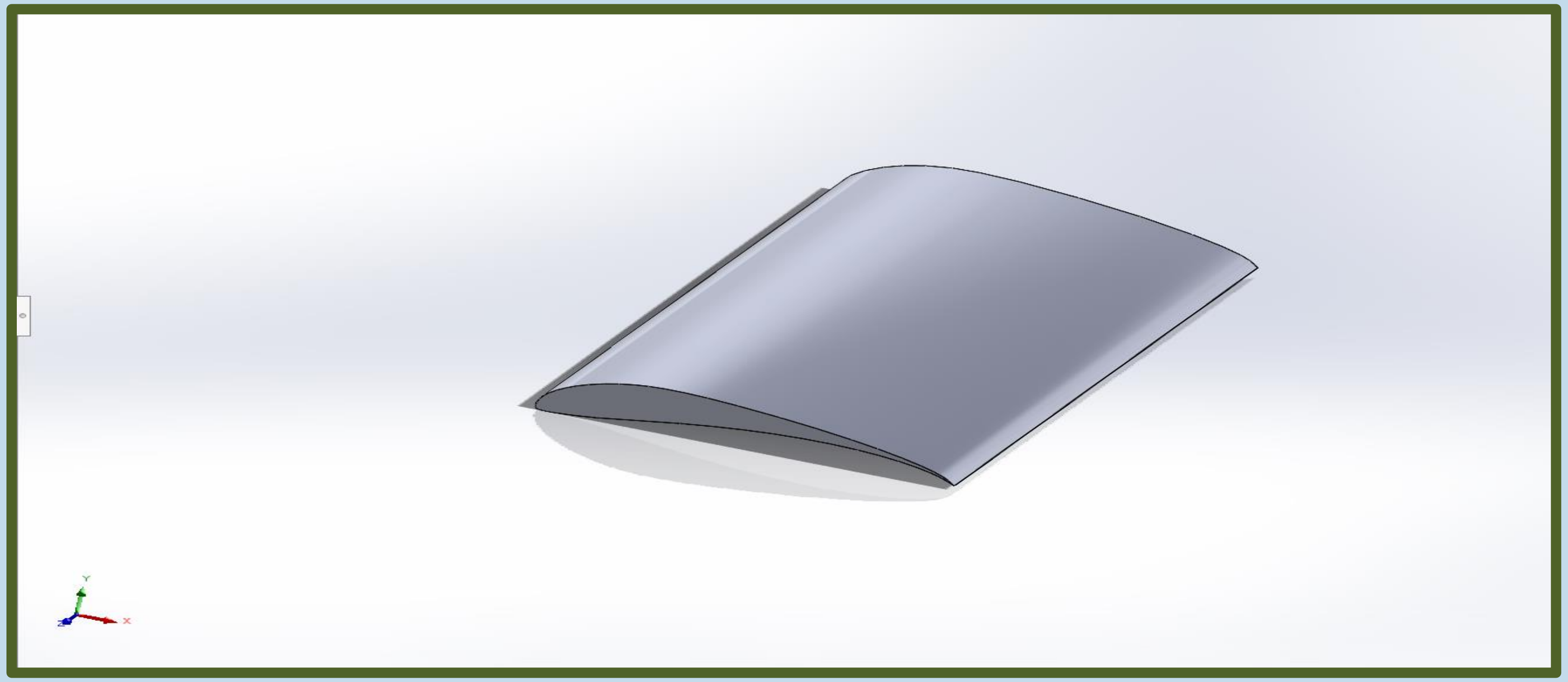
Structural Analysis



Visualisation of stress due to load on wing



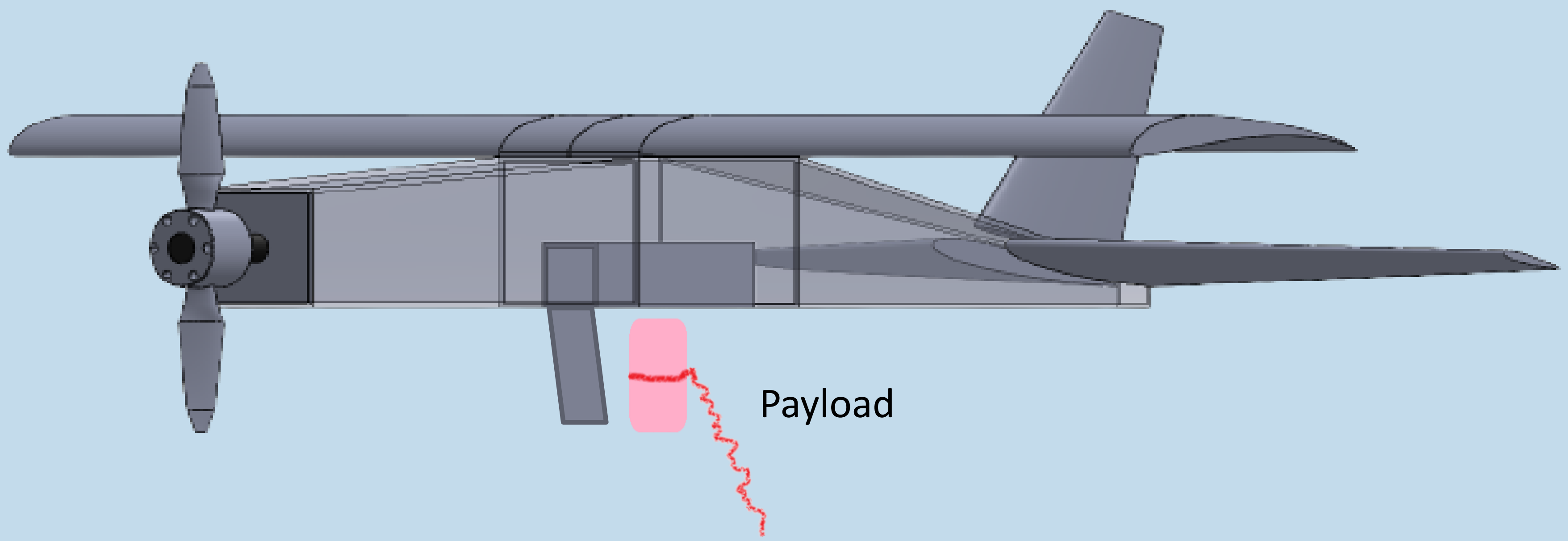
Visualization of deformation of wing due to lift produced at load factor 2g



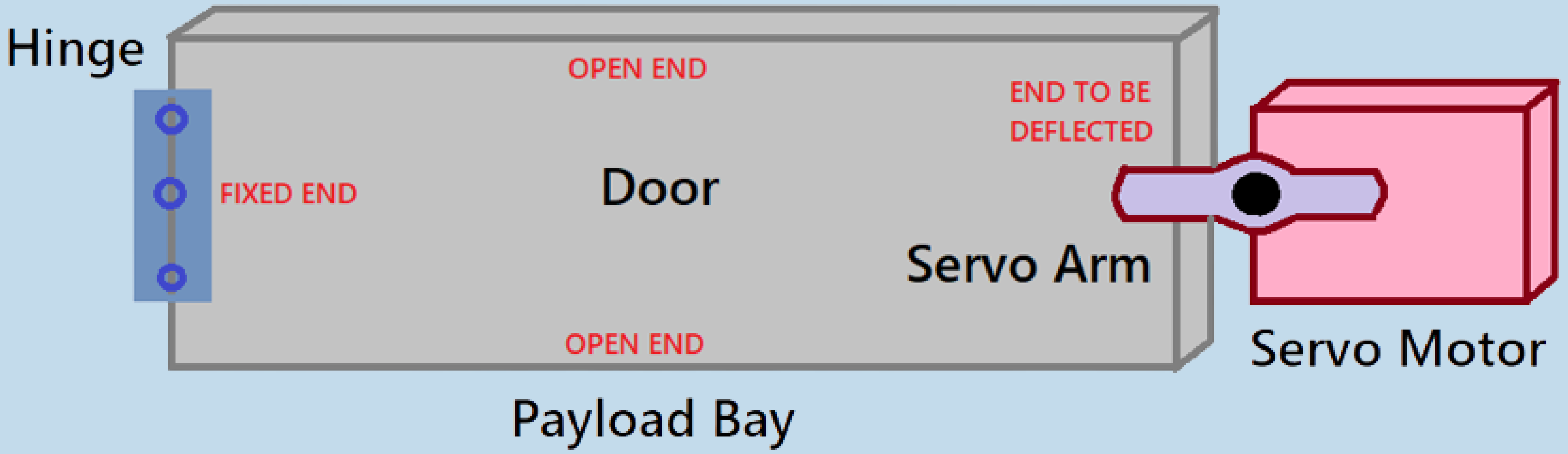
- The wing structure was designed with the help of CAD software. It is designed to be structurally light and sturdy
- The wing is a cantilever beam and is subjected to a uniform bending load of 16.677 N on each wing at the bottom surface assuming the load factor of 2g.

Sr No	Parameter	Max Value	Unit	Location
1	Equivalent Stress	7.1 * 10^5 Pa	Pa	Wing Tip @ Leading Edge
2	Max Deformation	0.17-0.18	meter	Wing Tip

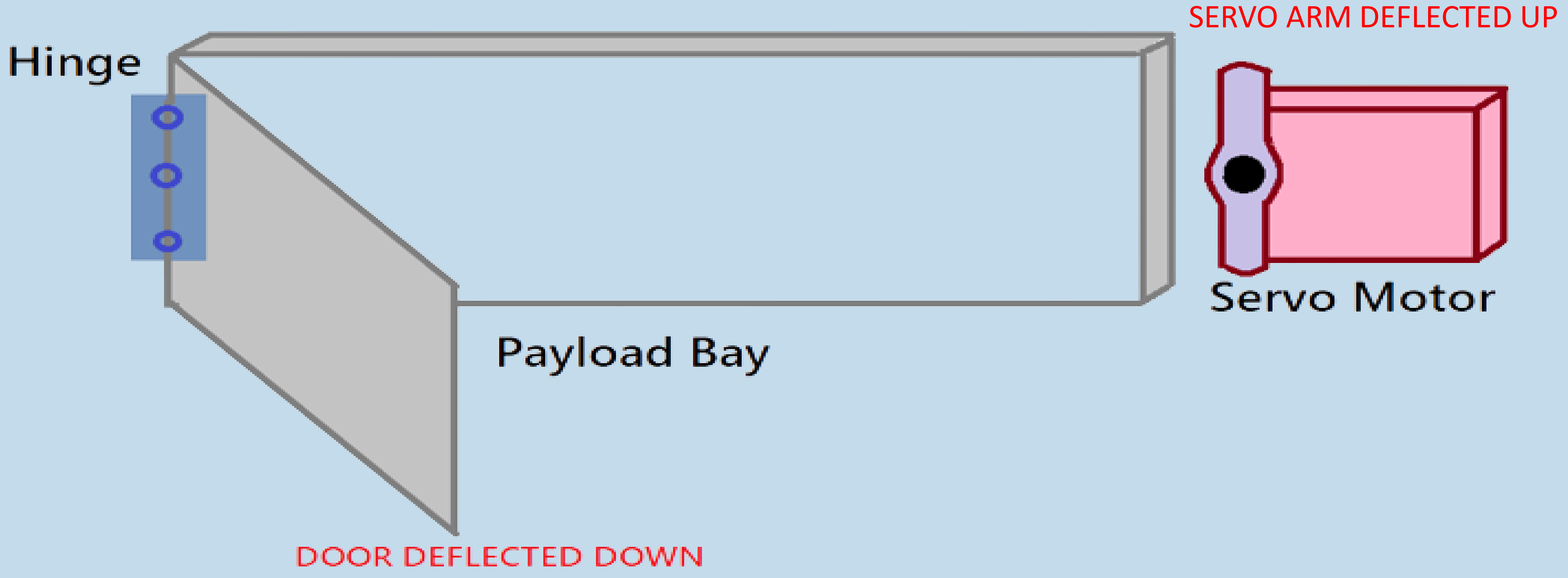
Payload Release Mechanism



CONDITION 0
Idealised through CAD Model

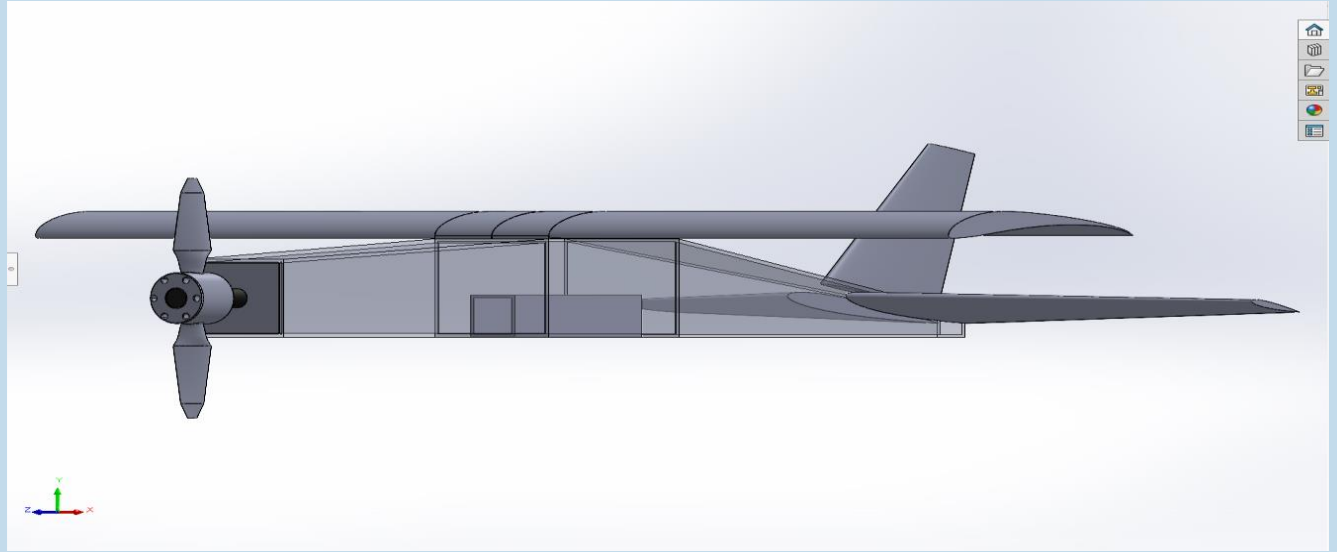


CONDITION 1
Servo Arm in Undeflected Position

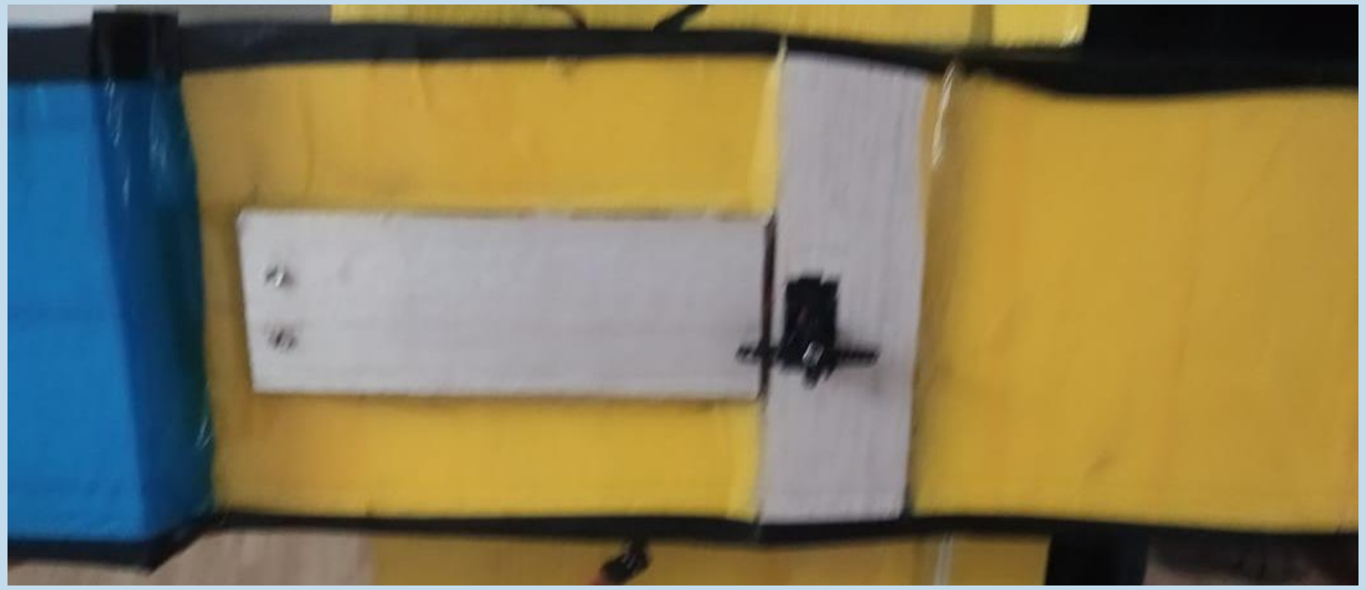


CONDITION 2
Servo Arm in Deflected Position

Payload Bay Integration



Fig(i) : Conceptualised CAD Model of Payload Bay



Fig(ii) : Payload Bay Integrated beneath the fuselage.

Fig(iii) : Fine Adjustments to accommodate payload inside payload bay

Tools Used

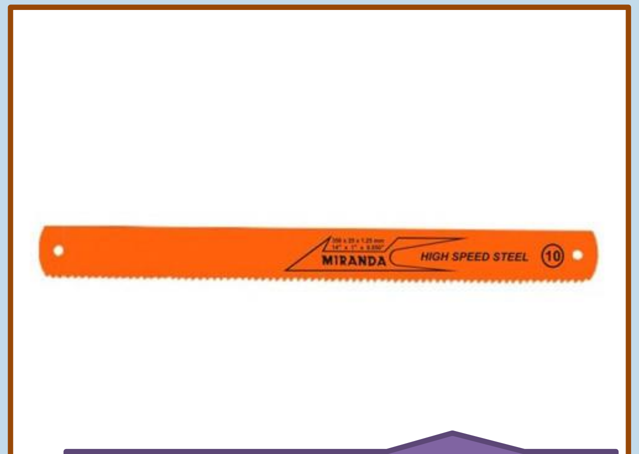
X-Acto Cutter
For Precise Cutting

Drilling Machine
For making ribs cutouts

Hacksaw
For cutting plywood

Cutter
For Secondary Cutting

Pliers
For handling pushrods & screws



Hacksaw Blade
For cutting balsa and plywood

Sandpaper
For smoothening the surfaces

Araldite
For permanent sticking

Fevibond
For stick the wood with other surfaces

Hot Glue + Glue Gun
For precise gluing of parts

Iron
For shaping the wing skin

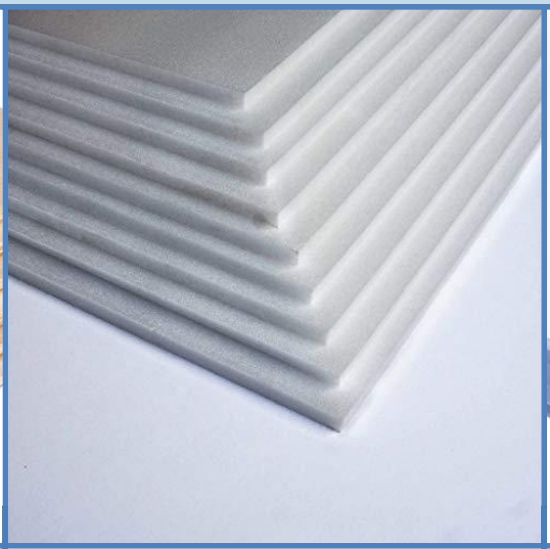
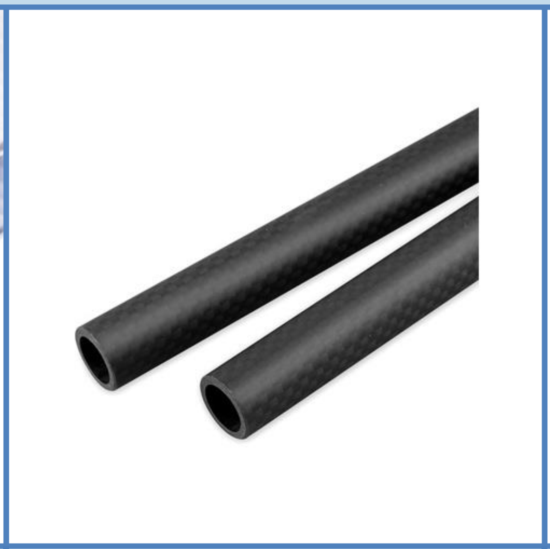
Wooden Scale
For accurate measurements

Screw Driver
Fixing the Electronics

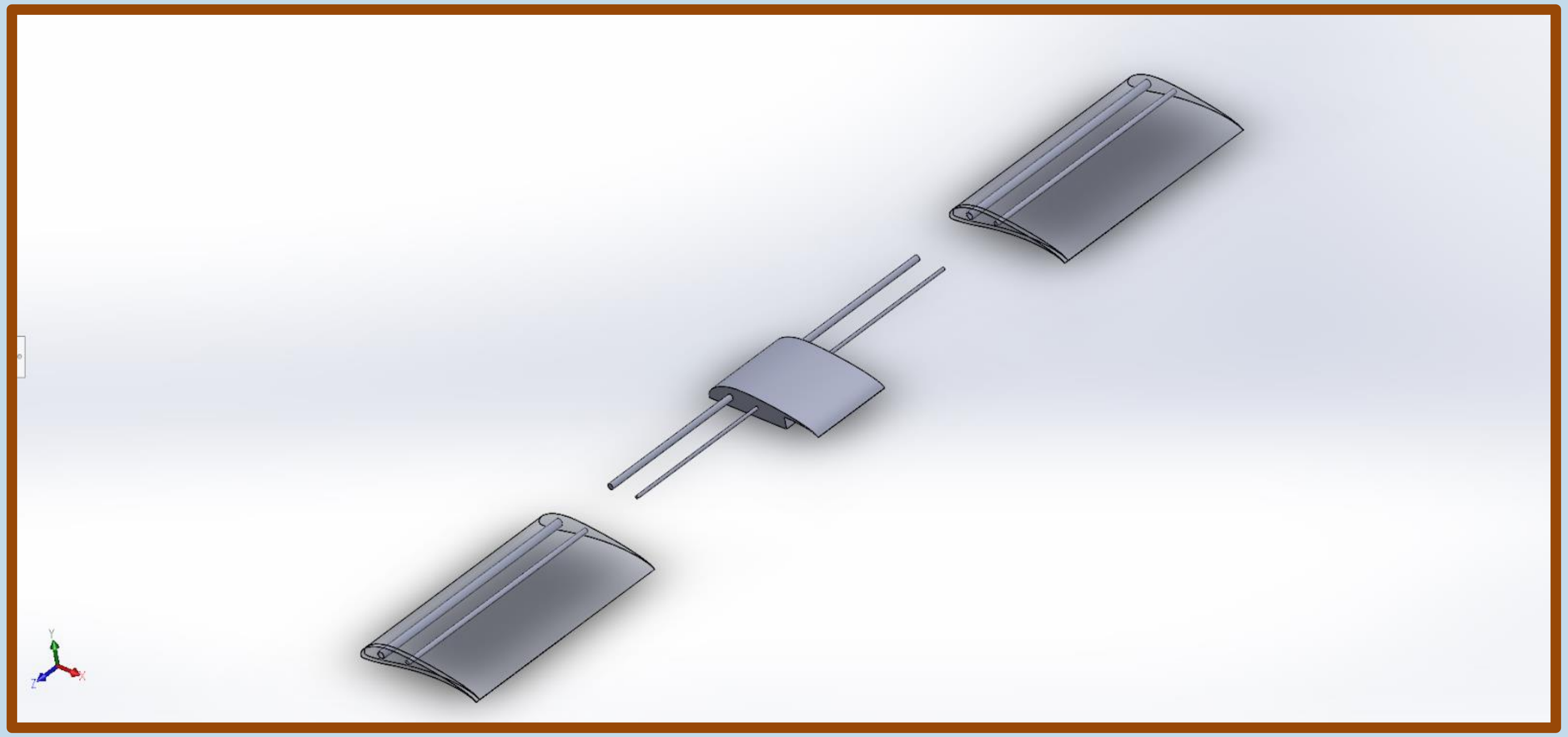
Transparent Tape
For covering the surfaces

Dremel
To cut the carbon rods & plywood

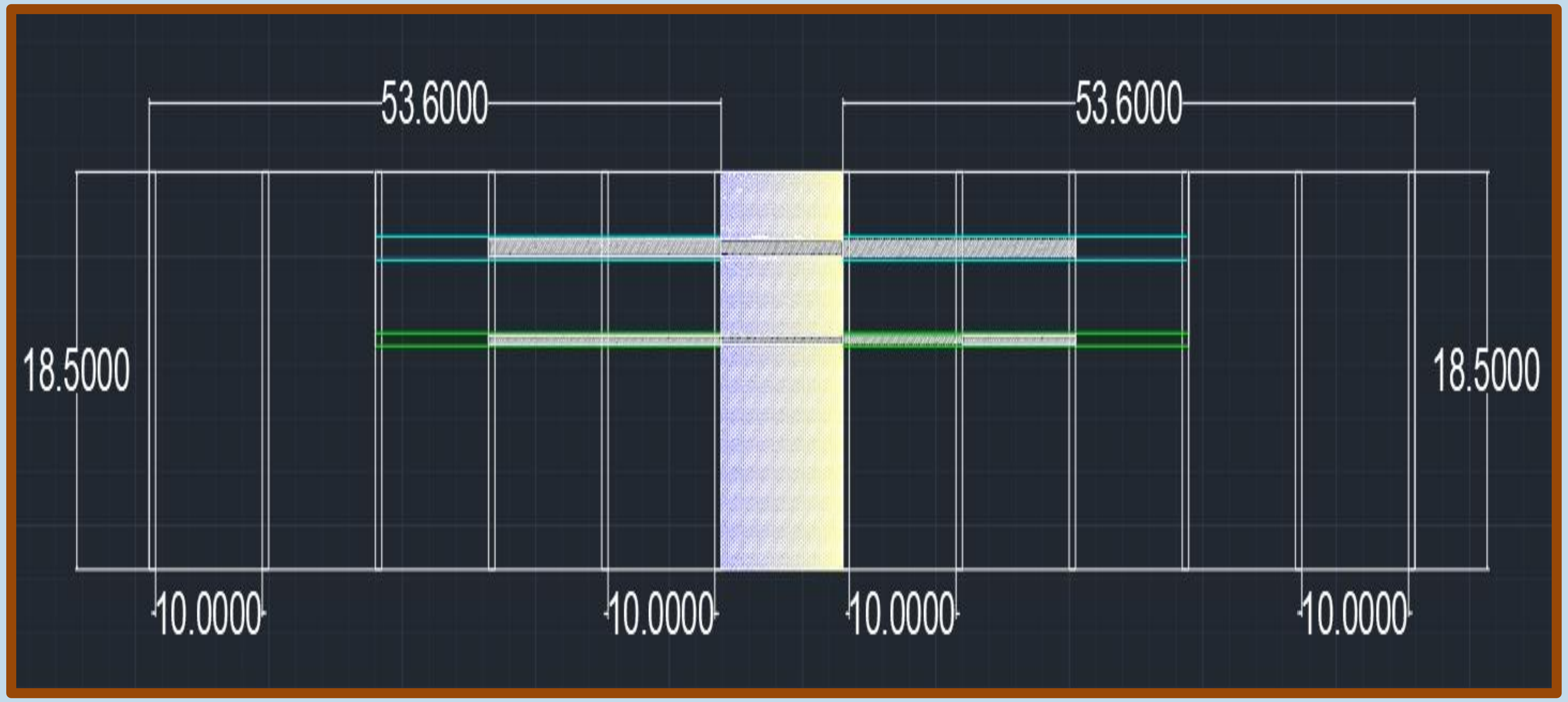
Materials Used

						
Balsa Wood	**Ply Wood**	**Depron Foam**	**Corrugated-Sheet**	**Carbon Fibre Tubes & Rods**	**Balsa Sticks**	**White Sponge**
o We have used two configurations of balsa wood : o 1. 6mm – For making ribs o 2. 3mm – For making Elevator o It is known for its higher strength to weight ratio.	o Thickness : mm o It has been used to make the ribs for wing tip and engine mount o It is known for its higher strength and impact resistance which is our philosophy behind choosing it.	o Thickness : 6mm o Our entire Fuselage have been made just by using depron foam board. o It is known for its high resilience and resistance to tension, o strong toughness, good shockproof o and cushioning performance.	o Thickness : mm o It is used for making skin for wings, vertical and horizontal stabilizer o It's the flexibility of the material which led us to choose it so that we can maintain the airfoil shape of skin using iron.	o Thickness : 10mm (Hollow) 6mm (Hollow) 3 mm (Hollow) 8 mm (Solid) 4 mm (Solid) o It is used for making spars for wings and emphanage. o We have chosen it because of its **high stiffness, high tensile strength, low weight**	o Thickness : 3mm o It was used to support the horizontal and vertical stabilizer with the fuselage along with the carbon rods. o It is very light in weight and can carry secondary loads.	o We used it to make the Landing Plates o Its property of high shock absorption impressed us to incorporate it in our fabrication

Wing Construction

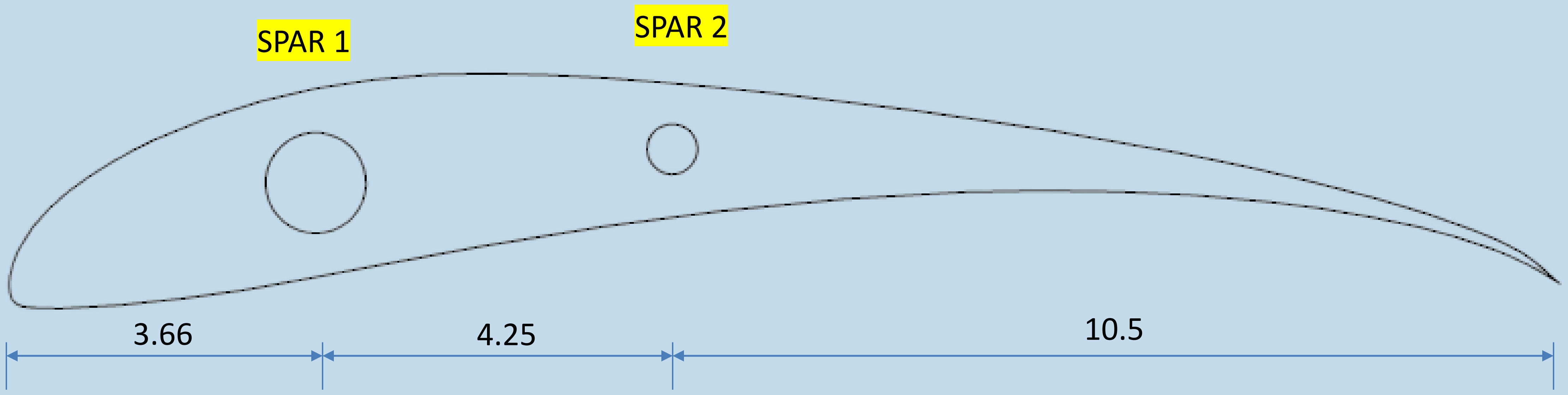


CAD MODEL- SOLIDWOKS

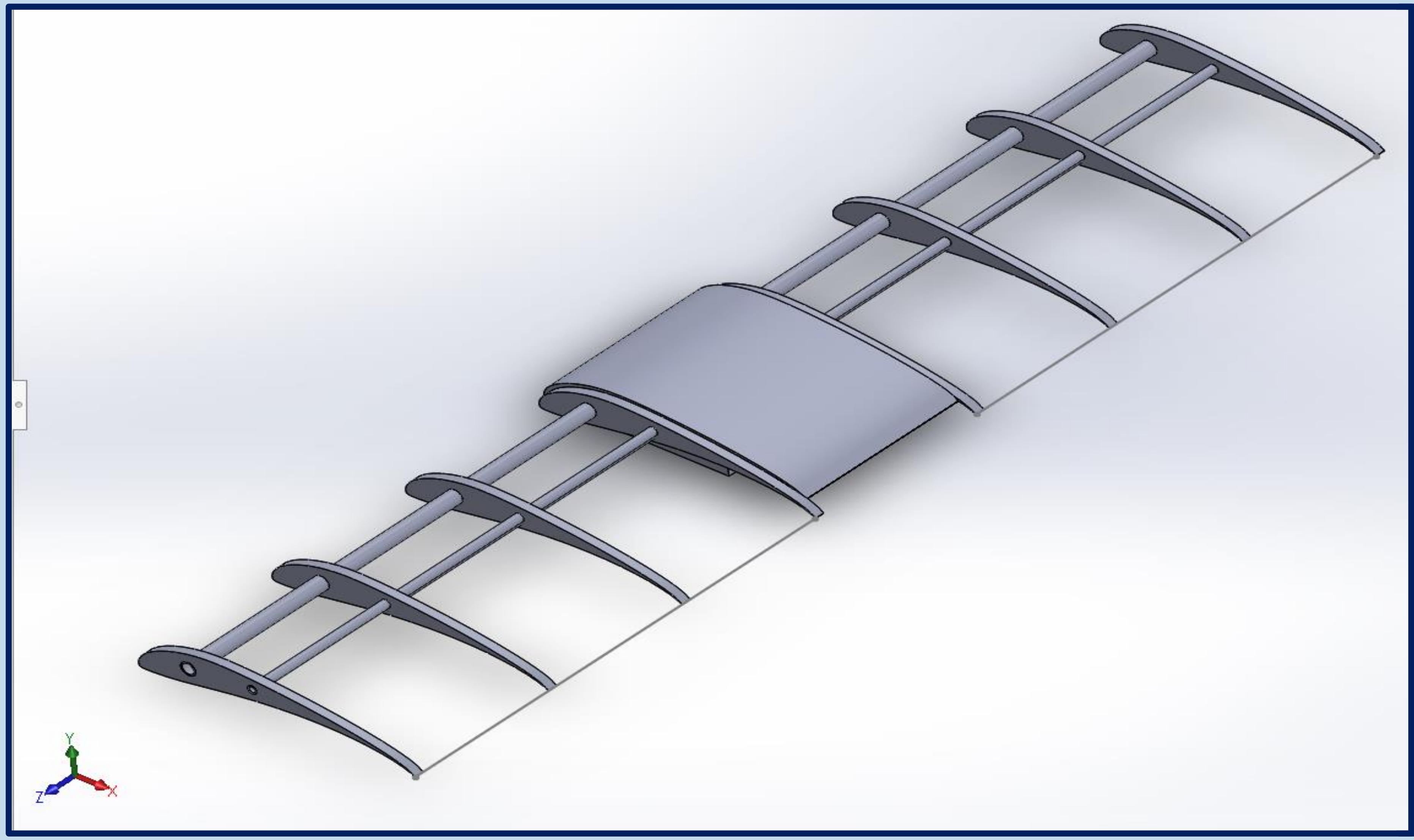


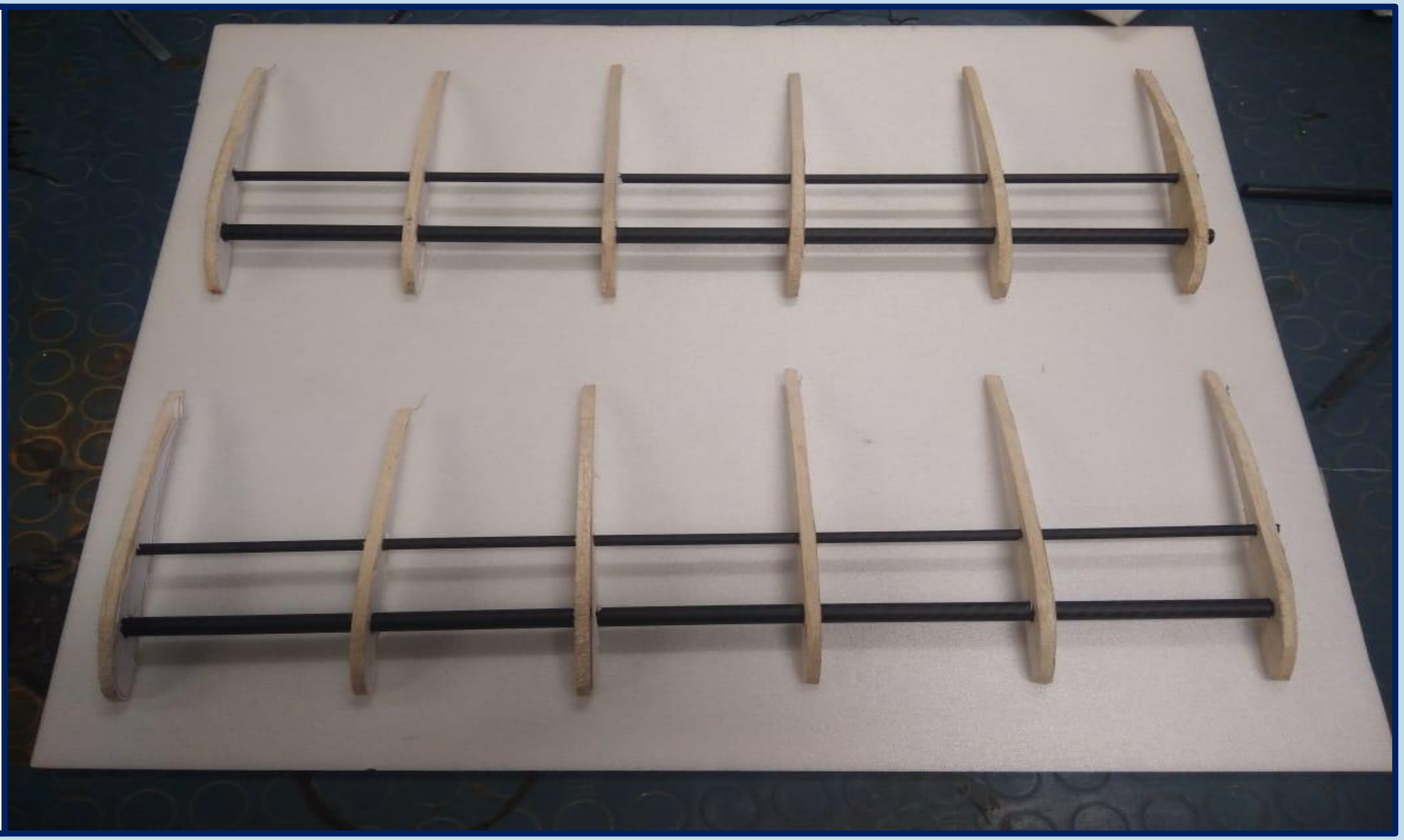
2D Top Schematic - AUTOCAD

- Each Wing contains around 6 ribs spaced at approximately 10 cm distance from each other.
- The distance from the leading edge is around 3.66 cm.
- A carbon rod of 8mm diameter is fixed in the center portion of the fuselage, extending around 20 cm from both the sides.
- While assembling, the carbon tube can be integrated inside the rod (rod extends at around 1/3 of the length of span.



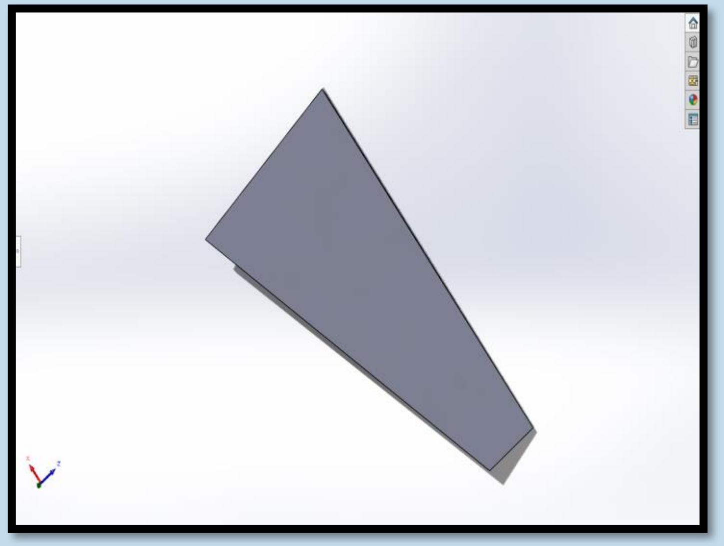
- In the similar way, the carbon-tube & carbon-rod integration is done at 7.91 cm from the leading edge.
- The carbon-tube is 6*4mm diameter, extending till 2/3 length of span from root
- The carbon rod has 4mm diameter extending to 1/3 the length of span from root.



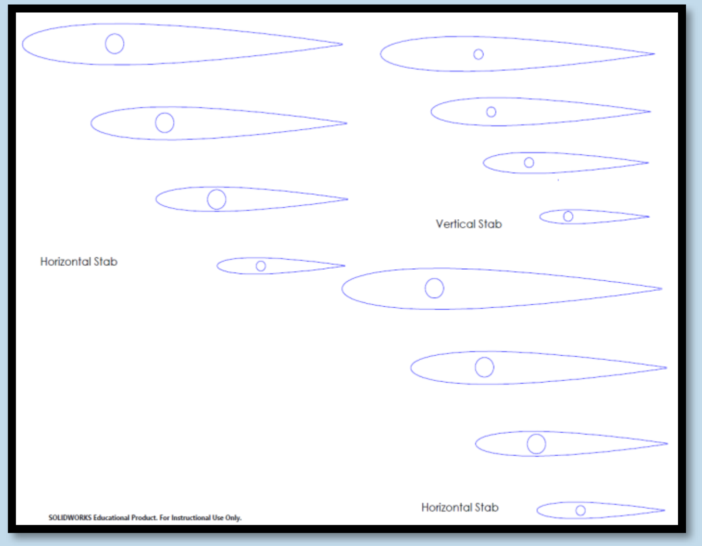


CAD MODEL BLUEPRINT CUTTING SANDING DRILLING SKIN WING INTEGRATION FINAL PRODUCT

Emphanage Construction

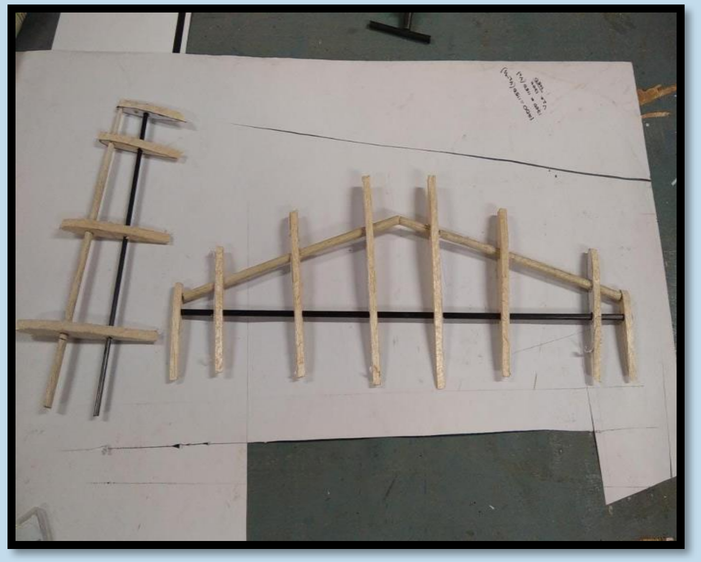


(i) Designing a CAD Model (Horizontal Stabilizer)



(ii) Using the blueprints to sketch appropriate shape on balsa wood & cut it out firmly

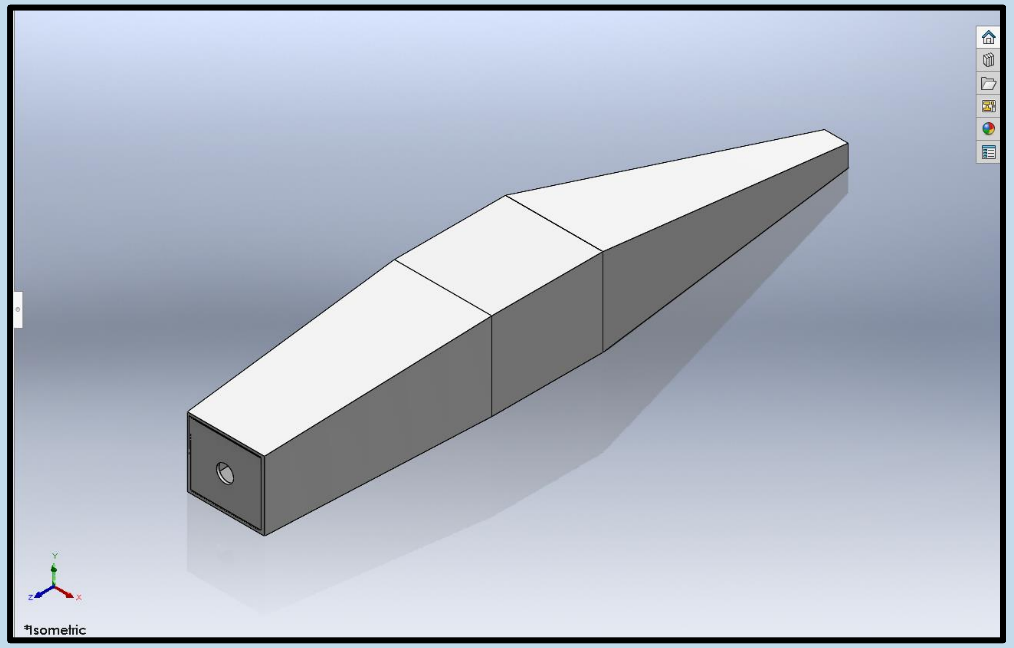
(iii) Drilling of holes to insert carbon rods & balsa sticks at appropriate location.



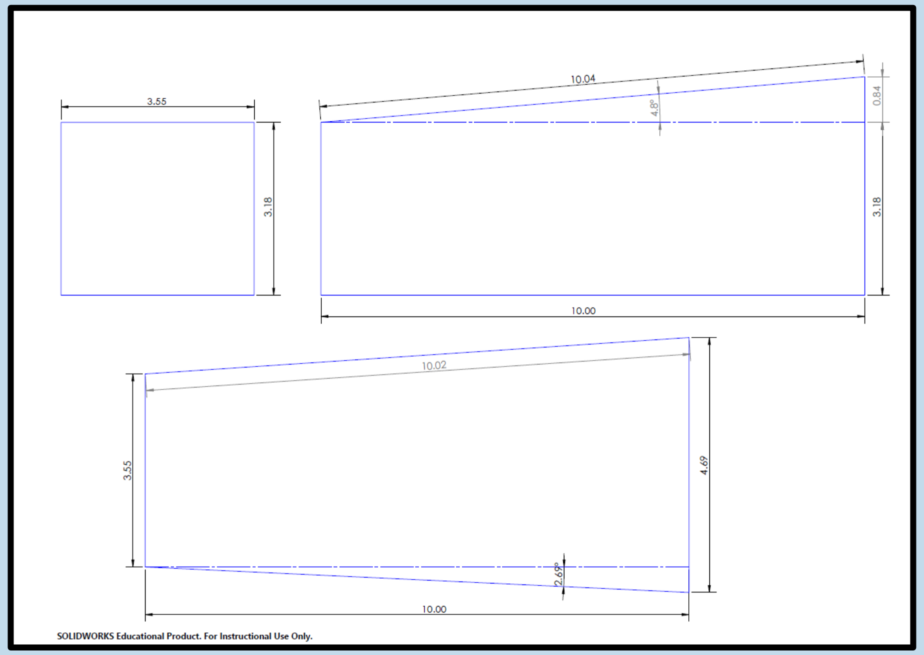
(iv) Skeleton of the structure

(v) Final Model

Fuselage Construction



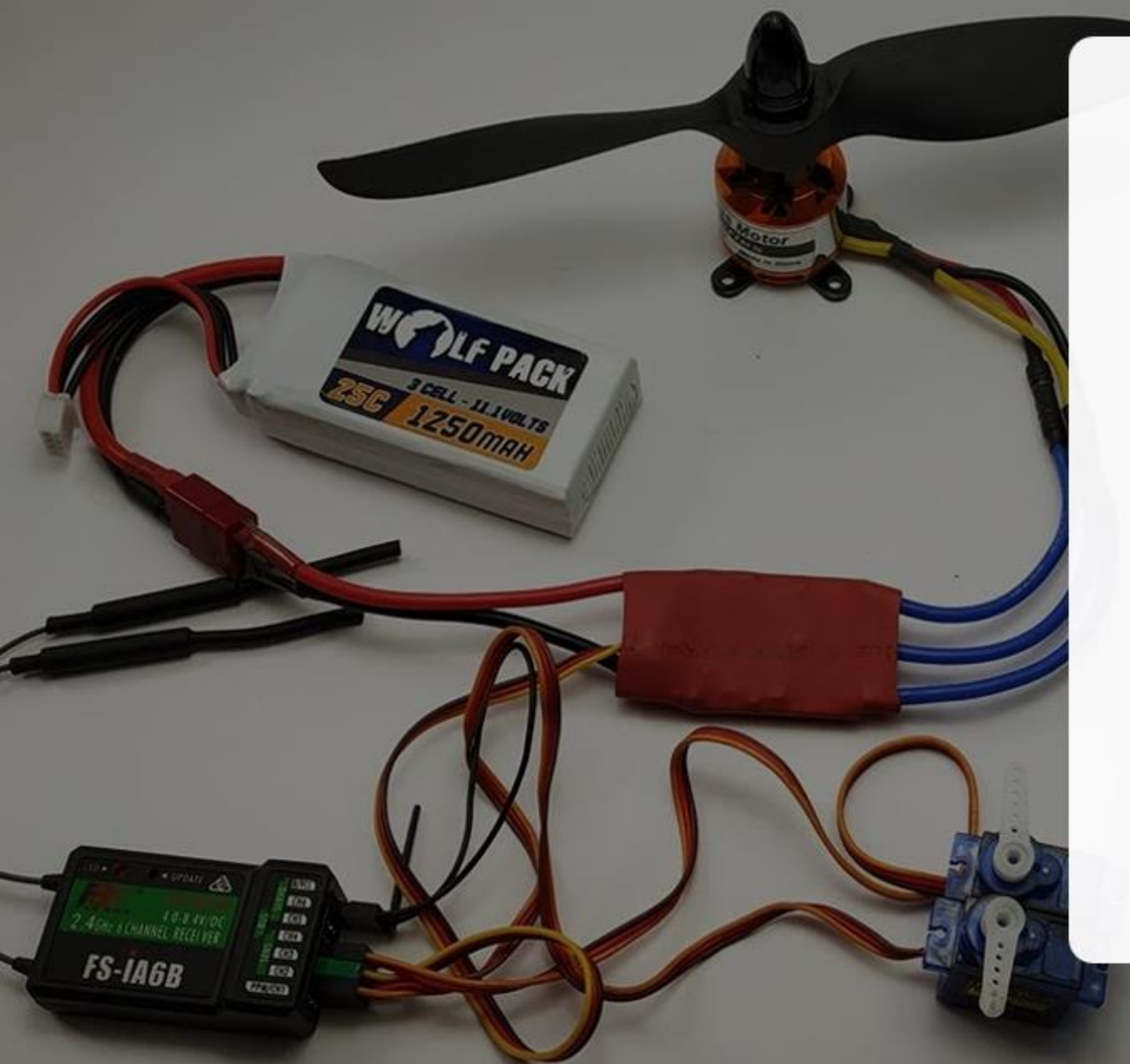
(i) Designing a CAD Model (Solidworks)



(ii) Using the blueprints to sketch appropriate shape on depron foam board.

(iii) Fabricating the structure solely using depron foam board.

(iv) Final Model



Why Electronics ?

- A wide variety of electronic components and subsystems are used in the manufacture of unmanned aerial vehicles (UAVs).

- Unlike heart in human's electronics is also the heart of UAV which means without electronics a UAV won't be able to perform tasks assigned to it.

Major Components !

Transmitter

Motor

Receivers

Servos

ESC

Battery

Propeller

Battery Selection !

- ✓ LiPo battery packs are ideal for use with brush-less motors in radio-controlled airplanes and copters due to their small profile, low weight and high capacity.
- ✓ **We have taken 2200 mAh 3 Cell battery of 30 C "C" rating I.e. (2.2 * 30 ~ 66 A) of output current.**
- ✓ **Weight - 175 gms**

Motor Selection !

- ✓ You motor is the power plant of your plane. The motor will turn your propeller at a high speed to propel it through the air!
- ✓ **We have taken a 750 kV motor high torque motor which has rpm approximately 8325.**
- ✓ **Weight - 115 gms.**

ESC Selection !

- ✓ We have chosen 40 amps ESC.
- ✓ Weight – 35 gms

Tx & Rx Selection !

- ✓ The transmitter is what you use to control your plane with.
- ✓ The receiver is what goes into your aircraft and controls the servos and motor(s). You can see from this receiver that it is a 6-channel receiver.

Transmitter	Receiver
Range(GHz) - 2.4~2.48 Bandwidth(KHz) - 500	Ch - 6

Servo Selection !

- ✓ Servos are what move your control surfaces. The servos plug into the receiver.
- ✓ Weight per servo - 13 gms.

Channel No.	Control Surface Servo
Ch 1	Aileron1
Ch 2	Elevator
Ch 3	ESC/Motor
Ch 4	Rudder
Ch 5	Aileron 2
Ch 6	Payload Bay

Propeller Selection !

- ✓ We have chosen The Orange HD Propellers 1447(14X4.7) Carbon Nylon Black.
- ✓ Length - 14"
- ✓ Pitch - 4.7"
- ✓ Shaft Diameter - 7.86 mm
- ✓ Weight - 57 gms

Thrust Produced !

- The thrust produced from the above combination of electronic components and our structure is around 1.2 ~ 1.5 kgs.


Microsoft Hyperlapse Pro

Thank You...