GROUP - 1

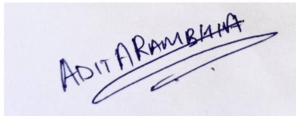
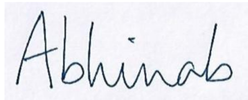
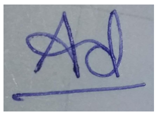
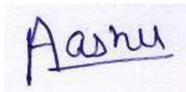
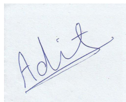
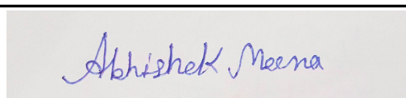
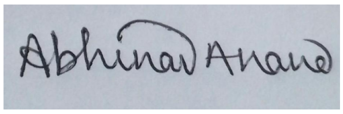
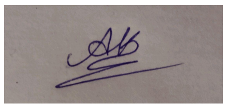
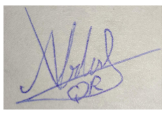
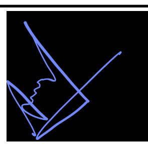
COMMERCIAL AIRCRAFT

Commercial Aircraft

Term: Spring 2022

Group 1

Submission date: 20/02/2022

Si. No.	Student name	Signature
1	Adit Atul Rambhia	
2	Abhinab Mondal	
3	Aaryan Darad	
4	Aashu Singhal	
5	Adit Kaushik	
6	Abhishek Meena	
7	Abhinav Anand	
8	Abhinav Kumar	
9	Abdul Qadir Ronak	
10	Abhay Upparwal	

Minutes

Sr No.-	Date	Time	Discussion
1	13/01/22	4 - 5:30 PM	Selection of captain and discussion of various objects for our model.
2	14/01/22	7 - 7:45 PM	The final discussion of topics and their various aspects and final selection of topic.
3	16/01/22	5 - 6 PM	Distribution of parts amongst the team members.
4	29/01/22	10 - 11 AM	Discussion for final changes in the updated proposal document.
5	07/02/22	10 - 11:30 AM	Discussion and research for the dimensions of the aircraft.
6	16/02/22	3 - 4 PM	Discussion of the final technicalities, write up, and format of the sketch proposal report

Modification

In the revised edition we decided to eliminate the windows from the fuselage and the doors from the cockpit. We have added a wing ferring in the fuselage to accommodate the wing.

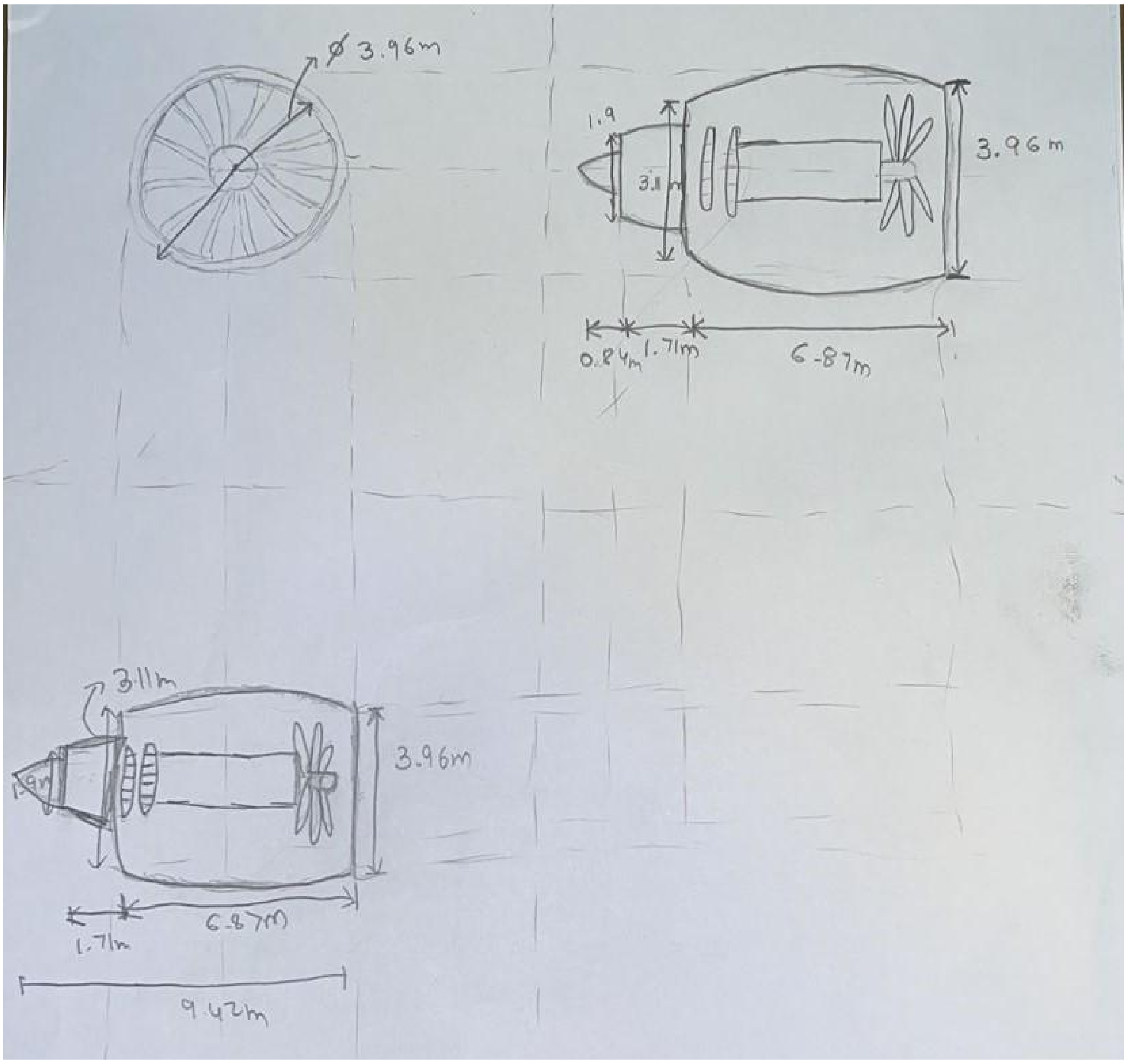
Division of work

1) **Tail**
Aashu Singhal - Stabilizers
Abhay Kumar Upparwal - Elevator
Abhinav Anand - Rudder

2) **Body**
Cockpit - Abhinab Mondal
Lower Fuselage - Adit Rambhia
Upper Fuselage - Abhinav Anand

3)**Wings**
Main Chassis - Aryan Darad
Aileron - Adit Kaushik
Winglet - Abhishek Meena
Engine - Abdul Qadir Ronak

Engine



The engine is designed to provide maximum acceleration to the air and hence to the aeroplane. The front portion of the fan cowl is approximately 4 meters in diameter, in which the fan is around 3.4 metres in diameter and the rest is the thickness of the fan cowl. The thickness of the cowl is curved for smooth airflow. The posterior portion of the fan cowl has a small diameter than the front, because of the smooth-conical shape of the fan cowl. The exhaust nozzle is of diameter 2 meter and exhaust cone is of 1-meter base diameter and height 1.6 meter. In the posterior part, the area between the fan cowl and the exhaust nozzle is for the bypass exhaust and the area between the cone and exhaust nozzle is for the heated air. The core engine block is also of the same size as the exhaust nozzle but rectangular. The length of the fan cowl is 6.2 meters in length and it comprises the intake fan, core engine and turbine fan.[1]

"*Strong, lightweight, corrosion-resistant, th ermally stable components are essential to the viability of any aircraft design, and certain materials have been developed to provide these and other desirable* *traits* "[2]. Based on the function, each part needs a different type of material. The most important property every part of the engine needs is high heat resistant property because of very high temperature in the engine. The fan cowl needs to maintain the flow of air into the engine The material used for the fan cowl should be high load-bearing and strong to withstand the pressure of high-speed air but lightweight also, and it should be smooth(i.e., have a low friction coefficient) as well for smooth flow of air. Therefore, composite aluminium alloys are used for making the fan cowl[4]. These composite alloys are also heat resistant. The same type of material is used to make wings. The fan blades should be made of very strong material so that it does not break due to the high wind pressure. Traditionally, fan blades are made of titanium alloy but nowadays fan blades are made from carbon fiber, that are stronger as well as lighter than titanium blades[3]. The core engine is made of nickel and titanium alloy. The core engine is also coated with ceramic coatings to make it even more resistant to heat. The turbine blades are also made of nickel-titanium-aluminium alloy. These parts endure the most intense heat of the engine. The exhaust cone is also made of the same material as the core engine and turbine blades i.e, nickel-titanium-aluminium alloy[2].

References:

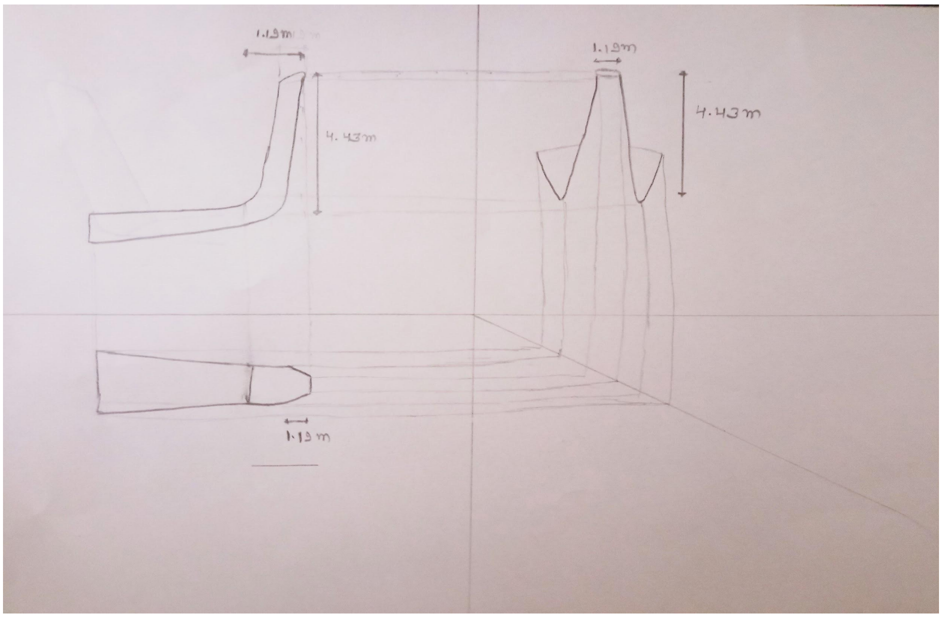
[1]
https://www.geaviation.com/commercial/engines/ge90-engine#:~:text=The%20GE90%3A%20A%20technology%20pioneer&text=The%20GE90%20engine%20family%20powers,million%20cycles%20since%20entering%20service.

[2]
http://www.madehow.com/Volume-1/Jet-Engine.html#:~:text=The%20combustion%20chamber%20is%20also,enable%20them%20to%20resist%20heat.

[3] https://www.pcmi-mfg.com/blog/carbon-fiber-in-aerospace-applications

[4]
http://faculty.up.edu/lulay/egr221/aircraft.html#:~:text=The%20Boeing%20777%20consists%20of,empenage)%20is%20graphite%20epoxy%20composite.

Winglet



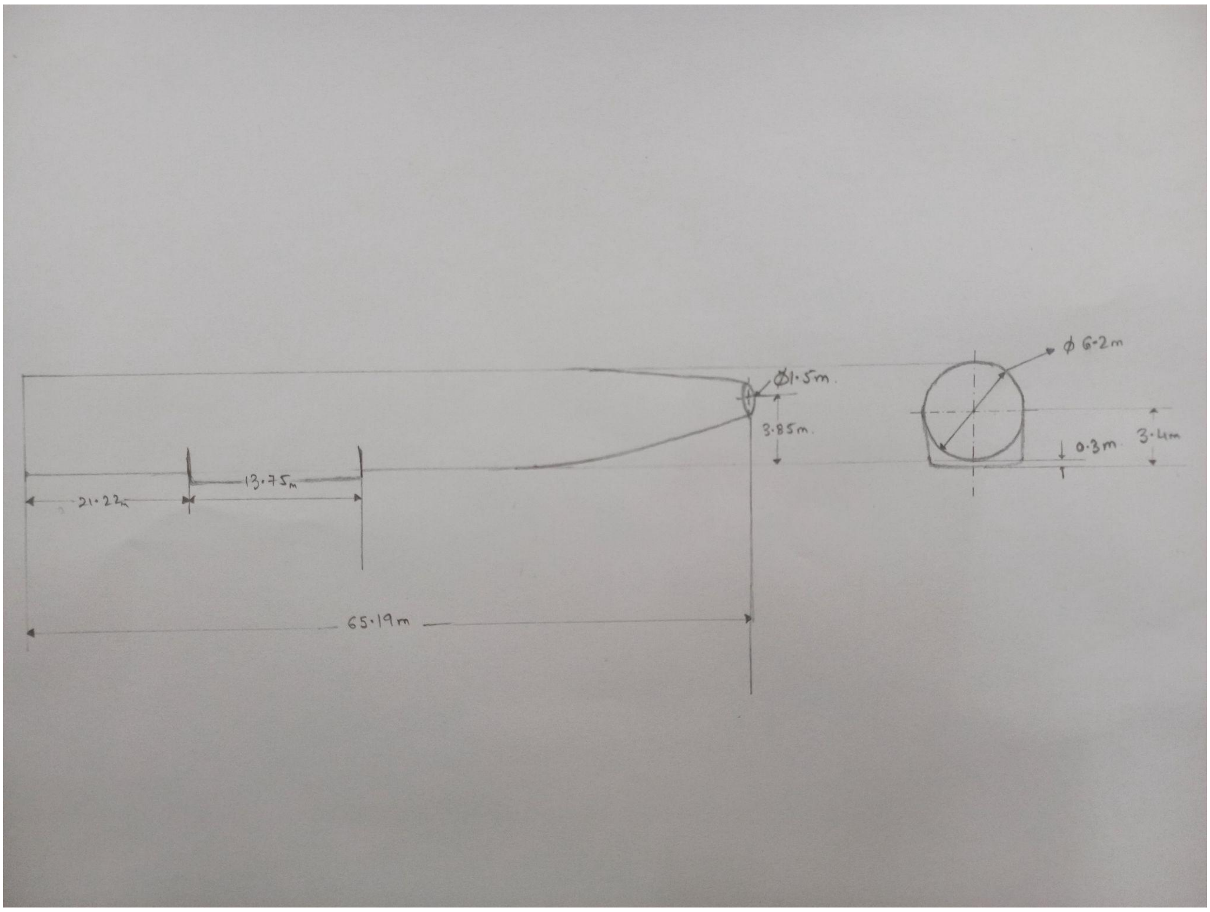
The winglet is a very complicated and essential part of aircraft. The fundamental principles of aerodynamics are used for the functioning of the winglet. In the case of the aircraft design process, reducing the overall drag at a compromising level would be one of the challenging processes. The size of the winglet also depends on the airplane's size. The height of the winglet is 4.43m. I take these dimensions, so they work perfectly when the aircraft fly. The winglet vortex, which rotates from beneath the wing, strikes the joint surface of the wing, producing a force that rotates inward and forward slightly as a sailboat towed nearby. "The idea behind the winglet is to reduce the strength of the tip vortex and therefore cause the flow across the wing to be more two-dimensional. "Winglets are vertical extensions of wingtips that improve an aircraft's fuel efficiency and cruising range.[1]

As for most aeronautic structures, also the winglet has to be lightweight and strong at the same time so that it can work in all conditions. We made its shape like elliptical so that it can follow aerodynamics principles. The winglet was built as two single-part shells (top and bottom), and we used the material as a composite material. Composite material is a combination of two substances with different physical and chemical properties. When combined, they form a special material to perform a specific function. For the winglet, we keep in mind certain properties of materials, for example, to be strong, light, extremely high tensile strength or electric resistant. It also increases the efficiency of aircraft.[2]

Reference

1. https://nasa.fandom.com/wiki/Wingtip_device
2. *ttps://www.sciencedirect.com/science/article/pii/S0263822316313800*

Fuselage



The fuselage is the central body of the airplane hence it must be long enough to hold all the parts of the aircraft. Also, depending on the utility of the aircraft (long-range, short-range, etc.), the plane has different lengths of fuselages. For a long-range aircraft, it would be more economical to accommodate more passengers/ cargo, and to manage the payload, we would require an equal distribution of the weight. The aircraft is designed to be so long so as to make the shape more aerodynamic and reduce the drag that a plane faces.

The cross section of the airplane is a regular cylinder of a diameter of 6.2m, and the cross section is a regular cylinder to reduce the complexity and cost of manufacturing. The total length of the aircraft from the end of the cockpit to the tail is 65.19m long. The length of the wing ferrings is 13.75m long as it is specifically designed to fit the wing to the fuselage and hence it is equal to the width of the wing part that it will connect.

The length of the fuselage till the tailcone is nearly equal to the length of the wingspan of the aircraft and hence we have chosen the dimensions in such a way. The diameter of the cross section of the fuselage is nearly one - tenth of the length of the fuselage.

The materials used here play a critical role in the safety, lifespan, and efficiency of the aircraft. There has been tremendous research and development in the field of aerospace materials. This industry uses a lot of alloys and composites to make the aircraft more durable.

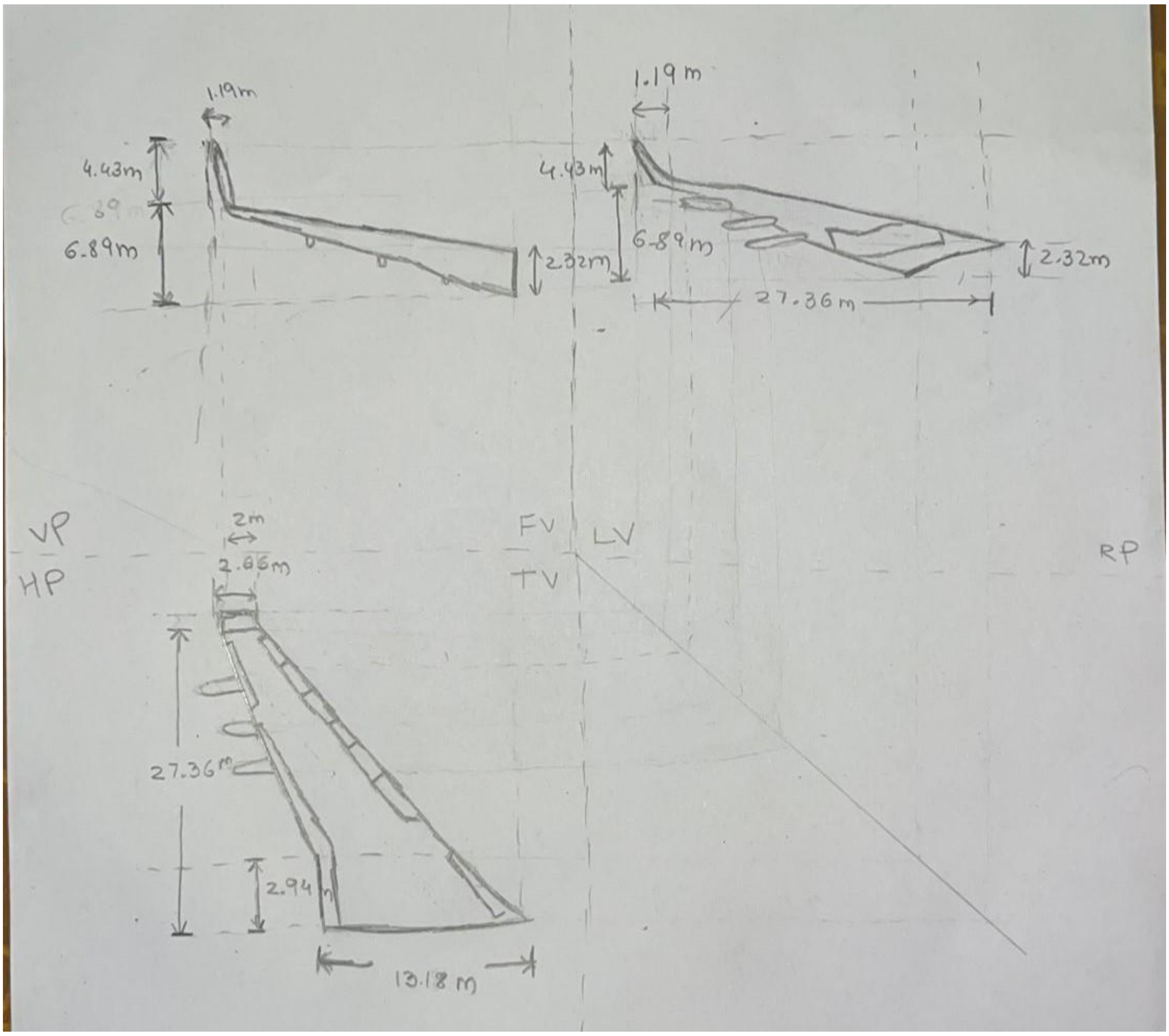
Aluminum is used due to its low density (2.7 g/cm3), high strength properties, good thermal and electric conductivity, technological effectiveness, and high corrosion resistance. But because aluminum loses its strength at high temperatures, it is not used to the skin surface of an aircraft[1].

The walls of the fuselage also have a mixture of duralumin. Duralumin alloys are relatively soft, ductile, and workable in the normal state; they may be rolled, forged, extruded, or drawn into a variety of shapes and products. Their lightweight and consequent high strength per unit weight compared with steel suit them for aircraft construction. Because aluminum loses corrosion resistance when alloyed, a special laminated sheet form called alclad is used for aircraft construction; it has thin surface layers of pure aluminum covering the strong duralumin core[2].

Titanium and its alloys are commonly used in the construction of aircraft due to their high strength properties, high-temperature resistance, and high corrosion resistance compared to steel and aluminum. Despite being expensive, titanium is used in aircraft construction due to its excellent material properties[1].

[1] - https://indmetal.com/latest-materials-used-for-aircraft-manufacturing/
[2] - https://www.britannica.com/technology/duralumin

Wings

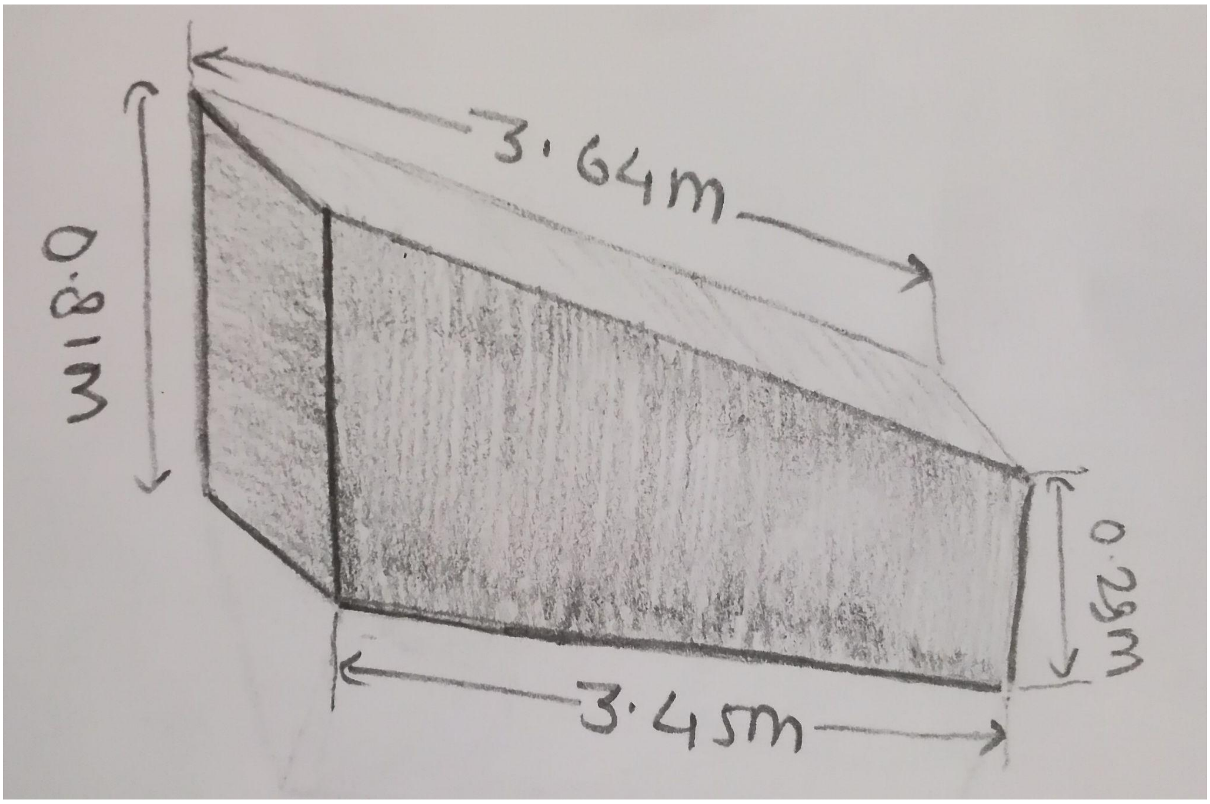


Wings are one of the most crucial parts of an aircraft. Wings are responsible for the lift that an airplane gets. In easy words, wings determine how high a plane would go. Therefore, the design of wings is critical. In large commercial aircrafts, the wings are smaller relative to the large mass of the plane to make it heavy wing loading(i.e., the total mass of an aircraft divided by the area of its wing). Most of the faster aircrafts have high wing loading. Aircrafts with high wing loading need to be faster as they cannot glide and float in the air. Wings generate lift by the flow of the air around it, and the larger the wing area more lift will be generated at a given speed since the flow of air will increase, so to generate the same lift with a small wing area, the speed of the aircraft should be more to cause the same airflow around it. One of the reasons for high wind loading is to counter wind turbulence since high wing surface area makes strong interaction with wind and the aircraft easily shakes by turbulence. The angle that the wing is making with the axis of the fuselage is considered for good aerodynamic flow. For the construction of the wing, the material used should be strong and high load-bearing but lightweight at the same time so as not to increase much weight of the plane. The surface of the material should have a low friction coefficient(i.e., smooth) to ensure a smooth flow of air over it. Properties of materials like damage tolerance, chemical stability, corrosion resistance are also considered. For these purposes, Carbon-Fiber Reinforced polymers and composite aluminium alloys are used to make wings. The upper and lower wings are made of two different types of composite aluminium alloys based on their weight and to suit accordingly to pressure variation. Aluminum is the material of choice due to its mechanical properties, low density, and low cost.

References:

[1]https://www.boeing.com/commercial/777/#/design-highlights/technology/light-durable/
[2]https://www.sciencelearn.org.nz/resources/301-wing-loading#:~:text=Wings%20generate%20lift%20due%20to,lift%20at%20any%20given%20speed.v
[3]http://faculty.up.edu/lulay/egr221/aircraft.html#:~:text=The%20Boeing%20777%20consists%20of,empenage)%20is%20graphite%20epoxy%20composite.

Elevators



Elevators are designed by keeping in mind certain requirements of aircraft. The elevator is a moveable part of the horizontal stabilizer, hinged to the back of the fixed part of
the horizontal tail. The elevators move up and down together. Lifting can also be defined in terms of air pressure, pressure is normal force per unit area. Wherever there is net force there is also a pressure difference, thus the twisting / turning curve indicates the presence of a net force and consequently a pressure difference. The net force direction suggests that the average pressure in the upper wing area is lower than the pressure level below.
Pfingsten focuses on varying the length of the slot and the size of the deviant flap. The rotation control simulation has a slot length, flap size and flap rotation (η) similar to the current study. In The simulation most directly comparable with the current study (h / c = 0.001, η = 40 °, Cμ = .03), the findings of Pfingsten predict an almost 100% increase in height above the base, CLmax≈4 comes to α = 5 °. Like Pfingsten, the Burnazzi is looking at the effects of the wind blowing on a deviant flap but with the addition of a curved nose.

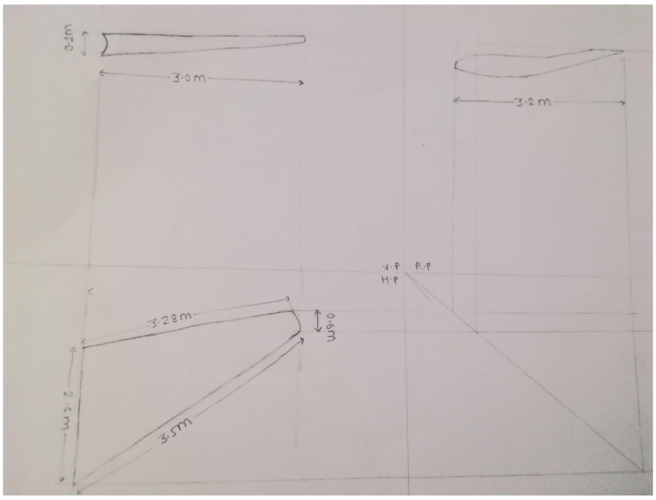
For the construction of Elevator we usually prefer materials which are light in weight and increase the efficiency of the aircraft. we consider two different airfoils from National Advisory
Committee for Aeronautics (NACA), NACA 0012 and NACA 2412 to make optimized elevators. The optimized elevator is attached with NACA 63206 wing to produce maximum lift coefficient and minimum drag coefficient at various altitudes.
NACA 0012 – Maximum thickness 12 %

at 30 % chord, maximum camber 0 % at
0 % chord.
NACA 2412 – Maximum thickness 12 %
at 30 % chord, maximum camber 2 % at
40 % chord.
NACA 63206 – Maximum thickness 6 %
at 35 % chord, maximum camber 1.1 %
at 50 % chord.

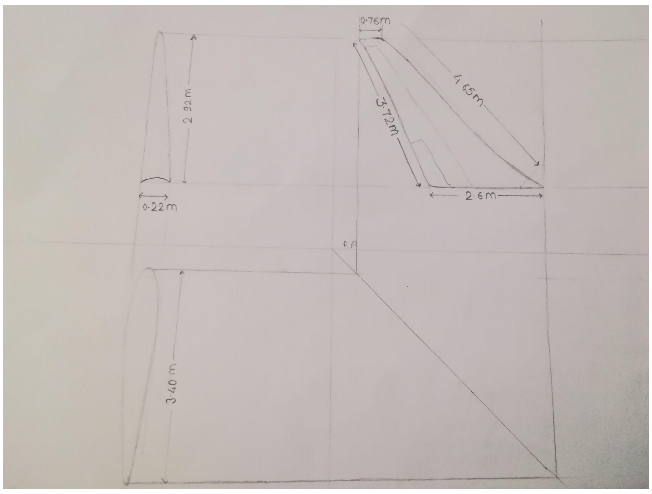
References:

[1]-P.Sethunathan,(2015),Cite right:Design and Analysis of Optimized Elevator to Improve Aerodynamic Effects, Namakkal; Paavaai Group of Institutions

Stabilizers



Horizontal Stabiliser



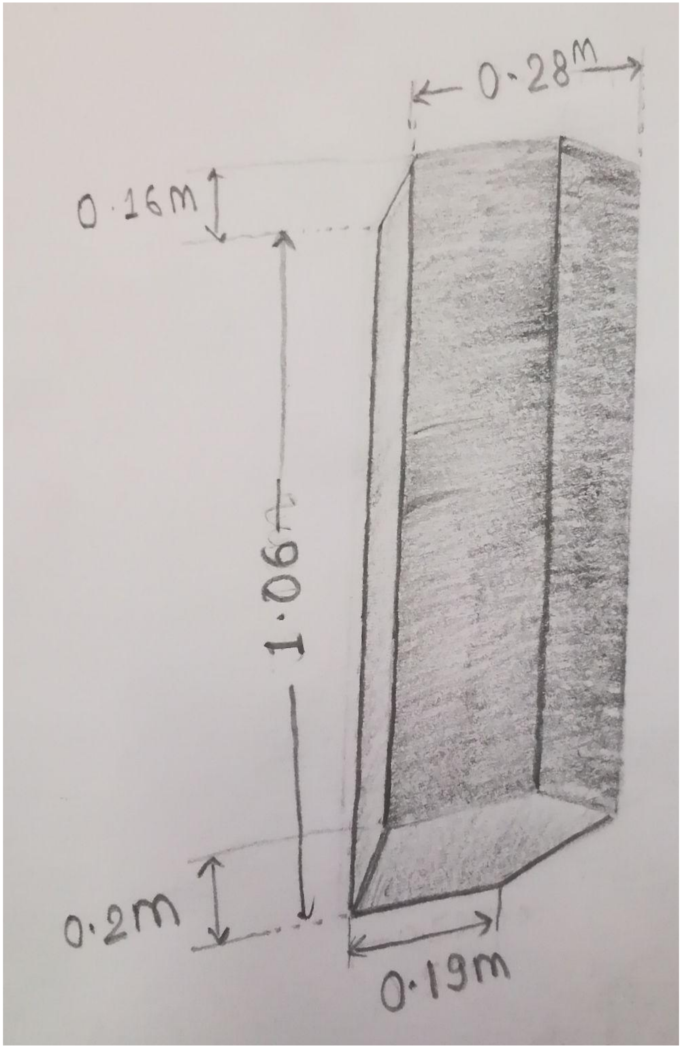
Vertical Stabiliser

Horizontal stabilizers are designed by keeping in mind certain requirements of aircraft controllability such as approach trim, takeoff rotation and are typically critical at the forward center of gravity(CG) limit. The size of the horizontal stabilizer also depends on the airplane loadability requirements and the resulting range of CG travel that must be required. This range is important to customers to ensure flexibility. By relaxing the stability requirements not only a small horizontal stabilizer results but the entire range of the CG moves[1]. Vertical stabilizers sizing requirements are based on static directional stability. Sideslip characteristics and the pilot's ability to control the effects of in-air engine failure are the prime reasons which have sized the vertical stabilizers. The rudder input due to the crosstie is responsible for the reduced area of vertical stabilizers[1].

For the construction of stabilizers we usually prefer composite materials which are light in weight and increase the efficiency of the aircraft. For the stabilizers we keep in mind certain properties of materials like elastic modulus, strength, fatigue resistance and fracture toughness, etc. Toughened-resin materials or additional gage are used to increase resistance to the service threats. Stabilizers are configured as a two-cell box, consisting of a main structural box and an auxiliary or forward torque box, leading edges, tip, and fixed trailing edges. The main torque boxes are made from CFRP composite material: solid-laminate front and rear spars, honeycomb sandwich ribs, and integrally stiffened laminated skin panels. The main box panels and spars feature a toughened-matrix CFRP material.The pre impregnated fiber/resin system provides improved resistance to impact damage over previous brittle materials. The auxiliary torque box and fixed trailing edges are glass or glass/CFRP sandwich panels with aluminum ribs. The leading edge, tip, and auxiliary spar are aluminum construction[2].

References:
[1]-https://www.icas.org/ICAS_ARCHIVE/ICAS1996/ICAS-96-0.4.pdf
[2]-https://msol.berkeley.edu/wp-content/uploads/2020/10/AVIAVIS-Short-Range-High-Capacity-Transport-Aircraft-Design.pdf

Rudder:



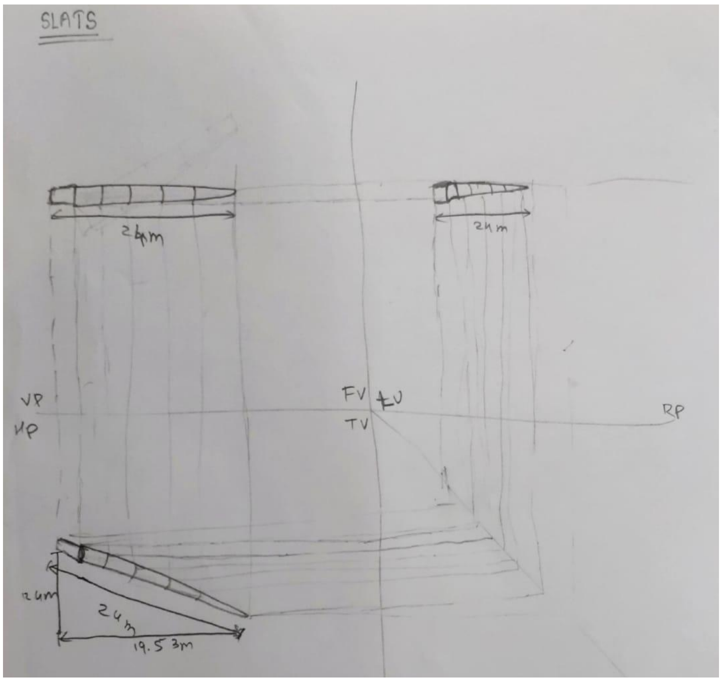
Rudder is one of the simplest parts of the aircraft. Though some important points are taken into consideration. It depends mainly on the gust load, aerodynamic load for its design and analysis purpose. It also depends on the type of plane whether it is a fighter jet or an aeroplane. Its size depends on how bigger the aircraft is. Some research has been done to explain the optimised rudder design, and it's structural analysis. MILF-8785-C standard is referred to for determining the load acting on the aircraft rudder, its distribution throughout, and for optimisation. Material selection in the construction of rudder is quite complex as it is more of a trade-off between low density, high strength, and ease of processing or fabrication. It depends on different criteria which depends on the operational requirements, and constraints of the aircraft and its structural members. Some of the important requirements are fabrication characteristics, fatigue strength, corrosion, brittleness, environmental stability, fracture toughness, compatibility with other materials, crack growth rate, availability, and cost. Rudder is made using a standard Al 2024-T3 alloy. But, some of the experiment has been done using Al-Sc alloy which has shown 1.5 Times more strength along with the highest increase in tensile strength than the standard Al

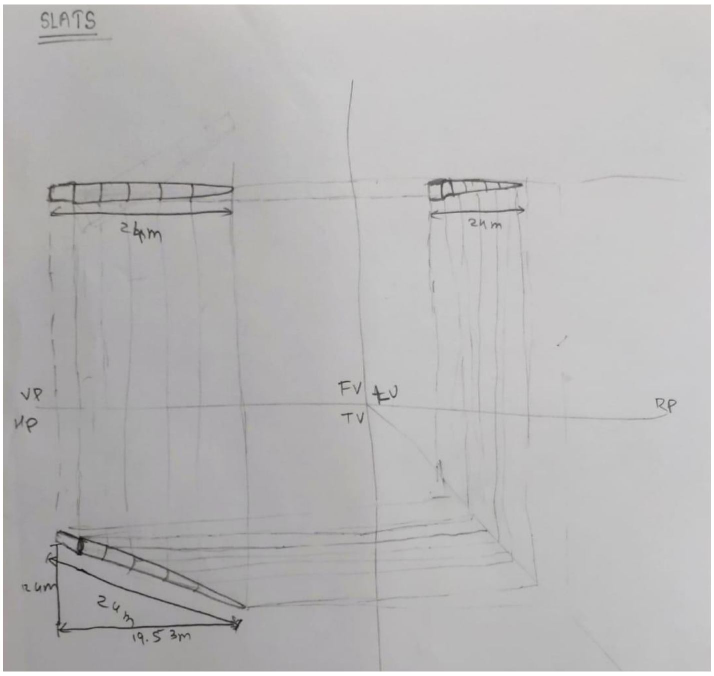
2024-T3. For the calculation of load and skin thickness, MIL-F-8785C is taken as standard, which is analysed in the later stages. SOLIDWORKS® software is used for modelling rudder and vertical stabilizer. Depending on the nature of load acting, a high strength to weight ratio material is chosen for design and fabrication of the optimized aircraft rudder. For the structural analysis ANSYS WORKBENCH® software is used.

Reference:

https://www.researchgate.net/publication/326357654_Structural_Analysis_and_Optimization_of_Aircraft_Rudder

Flaps And Slats





Our E.G. The group had decided to design an aircraft and my parts are wing's Flaps and Slats. Slats are situated at the leading edge of each wing of the airplane while flaps are trailing edges. Their size depends on the size of aircraft; actually their work is to provide more air drag to airplanes during landing and takeoff at low speed as they increase the surface area of wings by expanding together, so their size depends on the size of the airplanes as when airplane is big then more drag is required during takeoff also during mid flight sometimes there is requirement of speed reduction at that time flaps and slats are useful. We decided to make an airplane with wings dimensions as shown in the rough sketch and proportionally I decided the dimensions of flaps and slats.

Flaps and slats are used together to increase the surface area of wings to increase the air drag during takeoff and landing so too much load is applied to these and also these have to be lightweight to increase efficiency of aircraft so these are made up of aluminium and some combination of other materials to provide strength.

Aileron

Aileron

Aileron is an essential part, but it is structurally simple. The following points are kept in mind while designing the Ailerons —

SIZE

The first design decision is how big to make them. They help the aeroplane in rolling. Hence, the more rapid the roll response needed, the larger and stronger the ailerons need to be. Depending on the mission of the aeroplane, it needs different roll responses. For example, a cruise aircraft requires very low roll responses, but some military and aerobatic aircraft require roll responses as high as 400 degrees per second.

HINGE MOMENT

The second aileron design decision is the force or moment required to deflect them. As we can imagine, the larger the aileron and the faster the aeroplane flies, the more force is needed to move the aileron. Ailerons are controlled by the pilot’s muscle power alone. Fighter and bomber aeroplanes have large ailerons and fly at very high speeds. Hence, keeping the aileron hinge moments down to a level where the pilot’s strength could still command a large aileron deflection is vital. The primary factor is the chord of the aileron. An aileron can have a range of span and chords for a given area. The longer the span, the shorter the chord. Hinge moment is directly proportional to the chord size. Hence, a short-span, long-chord aileron will require more force to actuate than a long-span short-chord aileron.

AERODYNAMIC DRAG AND GAP FLOW

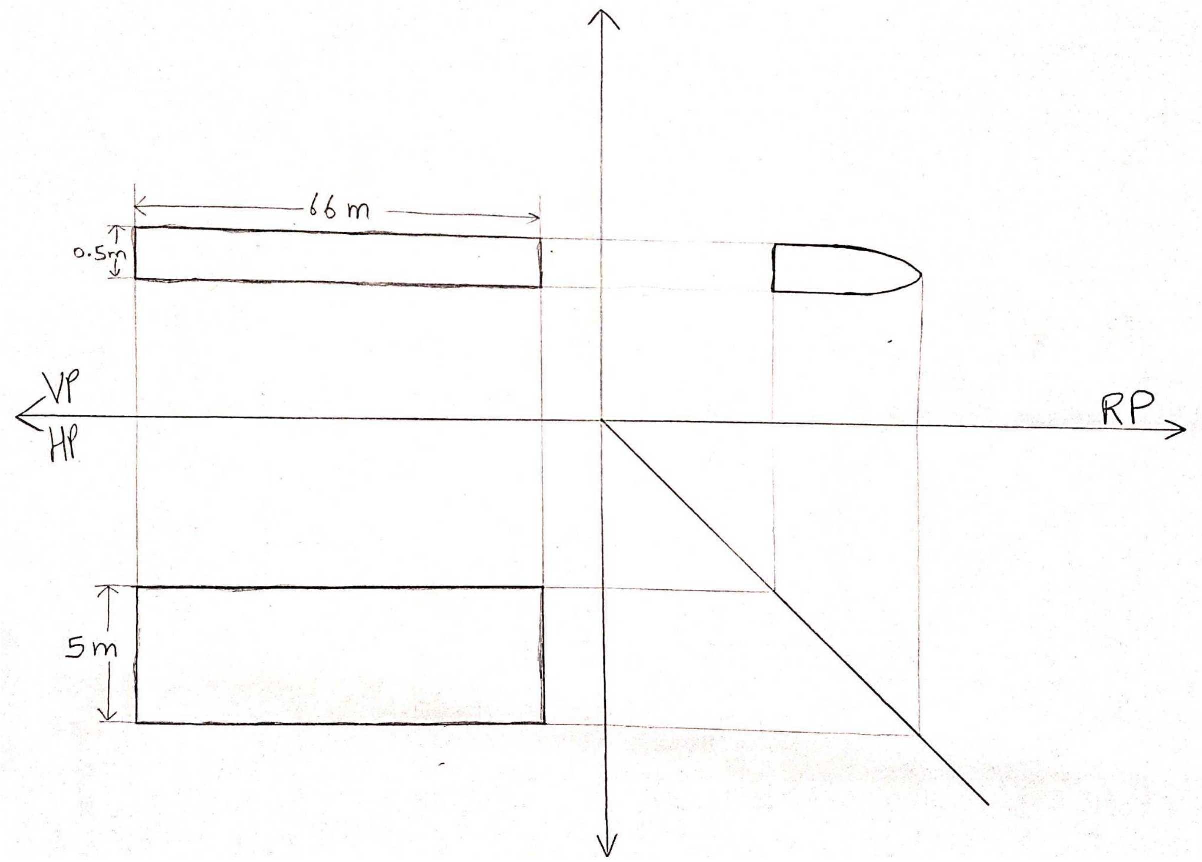
Another problem is the aerodynamic effects of the aileron when they are in a neutral position. With undeflected ailerons, the main problem is airflow around and through the gaps. This can reduce the lift of the wing. Ideally, the ailerons should not be visible aerodynamically when not open. To reach as close as possible to ideality, gaps should be small and well-sealed. There should not be any exposed hinges, control arms or linkages.

Keeping all the above points in mind, the aeroplane dimensions are calculated, and the aeroplane is fabricated accordingly.

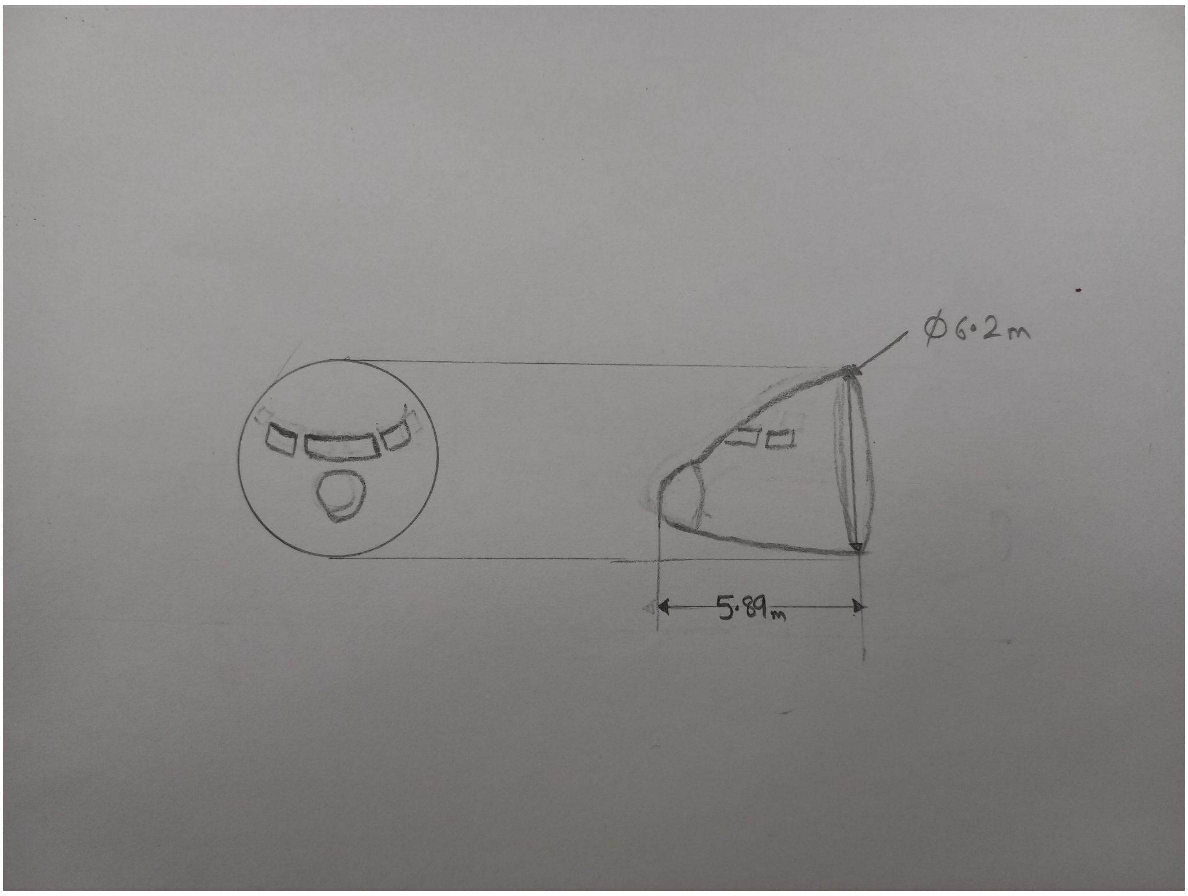
MATERIALS REQUIRED

Ailerons are the outer body of the aeroplane. Hence, it is made from the same materials, i.e. high-quality aluminium alloy.

References–
https://www.kitplanes.com/design-process-ailerons/



Cockpit



The dimensions of the cockpit are adjusted in a such a way so that it fits the fuselage. Hence the diameter of the part of the cockpit that joins touches the fuselage is 6.2m in length. The length of the cockpit from the tip to the start of the fuselage is nearly one - eleventh of the length of the fuselage. It is given a a narrow nose like structure on the front to give a more aerodynamic shape to the plane and to reduce the drag faced by it.

The cockpit body is made of composite of several high strength materials. Fibreglass and carbon composite is primary used for the construction of the nose. The main body is made out of high grade aluminium alloys and carbon fibre. The windows are made of toughened glass laminates and polycarbonate .

The material of the cockpit is similar to that of the fuselage as it too faces the same external pressure and drag.