# AERO DESIGN CHALLENGE 2021

## DESIGN REPORT

**ADC20210128 - OSPREY**

**TEAM MEMBERS**


1. KRISHNADAS M D
2. HARRY ANTONY CLEMENT
3. SYED AHAMED
4. JIBIN C
5. ROJA RAJAN
6. DILSHA AR
7. SIDHARTH P

**TKM COLLEGE OF ENGINEERING**

**TKM COLLEGE OF ENGINEERING, KARICODE, KOLLAM-691005, KERALA, INDIA**

**MENTOR: AHAMMAD VAZIM**


**30 MAY 2021**

SAEINDIA
SOUTHERN SECTION

ANNEXURE B

**2021 SAEISS AERO DESIGN CHALLENGE**

## STATEMENT OF COMPILANCE

CERTIFICATION OF QUALIFICATION

| | |
|---|---|
| Team Name | OSPREY |
| Team ID | ADC20210128 |
| College/University | TKM College of Engineering |
| Faculty Advisor | AHAMMAD VAZIM |
| Faculty Advisor Email | vazimka2@gmail.com |

As Faculty Advisor, I certify that the registered team members are enrolled in collegiate courses. This team has designed, constructed and/or modified the radio controlled airplane they will use for the SAE Aero Design Challenge 2020 competition, without direct assistance from professional engineers, R/C model experts or pilots, or related professionals.

Signature of Faculty Advisor

| Team Captain Information | |
|---|---|
| Team Captain Name | KRISHNADAS M D |
| Team Captain Mail | krishnadasmuraleedharan007das@gmail.com |
| Team Captain Mobile: | 9745471102 |

Note: A signed scanned copy of the statement should be included in your Design Report Page 2

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# 1. INTRODUCTION

## 1.1 SAE AERO DESIGN COMPETITION 2021

The SAE Aero Design 2021 competition is a national level competition intended to provide undergraduate and graduate engineering students with a real-world engineering experience through aircraft design challenges. Due to the global COVID-19 pandemic the larger SAE student competition aims to develop an operational plan that will maintain the mission while accounting for participant's health and complying with local laws and best practices. This year's competition is a virtual static event. By doing reports and presentations, and later dynamic events for the fly off this competition enhance the efficiency and knowledge on aerodynamic structure and their behavior under several predictable conditions thereby providing a much wider scope of understanding to students/aspirants regarding this field of work. Participants are also provided with the opportunity of trying out their own innovative ideas within the guidelines of the competition.

## 1.2 OBJECTIVE

To develop a network of Unmanned Aerial Vehicles (Fixed Wing)that can function for the surveillance and safety of women on the streets and roads. Attacks against women can be easily found out and to some extent can be prevented.

## 1.3 COMPETITIVE PROJECTION

Our team formed as a result of this competition consists of seven members- each one of us having a common interest and enthusiasm towards the field of aero-design. Appropriate airfoils were selected for our design. The design of the wing has done with the help of Autodesk Fusion360 and XFLR5.Requirement for a much stable condition prompted us to select a conventional fuselage. Each selection process of wing fuselage empennage winglets and electronic components were a result of the many brainstorming sessions conducted in the team and also by the numerous information obtained from various journals helped us to arrive at a conclusion. The main area of application of our aircraft is the safety of women whenever they feel insecure and thereby prevent attack against them. Our fixed wing UAV can move in a circle above the incident region and follow the attacker by ensuring safety to women.

# 2. LITERATURE REVIEW

Nowadays, the life of an aircraft fleet is no longer governed by its original design life. To a great extent, it is determined by the capability, the maintenance cost and the economic considerations required for the fleet to continue its operational requirements. With the need to maintain aircraft flying longer in an environment of continuous reducing funding levels, aircraft operators have recognized that the current methods of aircraft structural integrity cannot provide adequate information for assisting airframe and component management decisions. An additional tool or a more advanced approach is required.

Rong Ma and Peiqing Liu in 2009 were able to prove that the numerical simulation of lowReynold – number and high lift airfoil S1223 is reasonable. It was done using the Spalart Allmaras turbulence model and considering the treatment method of low free stream velocity through the transformation of three pneumatic parameters that includes Reynolds number, angle of attack and airfoil relative thickness which is being verified with the experimental data which proved the simulation.

Robert V Doggett, Jr., and Moses G Farmer in 1976 conducted a study on effects of winglets on wing flutter over a Mach number range from about 0.70 to 0.95 for a simple, swept, tapered, flat plate wing model and also equipped with two different upper surface winglets. It was found that the addition of a lighter winglet reduced the wing flutter dynamic pressure by about 3%; the heavier winglet reduced the wing flutter dynamic 14 pressure by 12%. In 2011 Shun C Yen and Yu F Fei investigated the winglet dihedral effect on flow behavior and aerodynamic performance of NACA0012 wings by using smoke-wire technique and surface-oil flow visualization schemes. The aerodynamic performance was measured using a force- moment balance and the experimental data indicated that the lift-drag ratio at stalling and maximum lift-drag ratio occurs at the winglet dihedral angle 90 degree.

Sheikh Nauehal Ahamed, Jadav Vijaya Kumar and ParimiSravani in 2014 optimized the empennage of a light weight aircraft such as Zenith aircraft. The anticipated load associated with the empennage structure are applied on the model to analyze the structural behavior and the results obtained from structural analysis and modeling are attempted to validate by hand calculations using various weight estimation methods.

The role played by the aircraft's central fuselage was being analyzed and studied by R Abhishek, B Ravi Kumar and H Sanakara Subramamian. They also focused on fatigue analysis on the central fuselage and were able to optimize the central fuselage design. Jan Roskam and Greg Fillmant worked on a design for minimum fuselage drag and they focused on sizing the fuselage such that zero-lift drag is minimized under constraints of cabin volume and stability. Mechanicsof Flight by A.C Kermode is an exemplary introduction to the major concepts of aeronautics. The book commences with a summary of the relevant aspects of mechanics, and goes on to cover topics such as air and airflow, airfoils, level flight, gliding, landing, performance, maneuvers and stability control. The fourth edition of the text Fundamentals of Aerodynamics by John David Anderson is a complement discussion of the fundamental principle in the aeronautical field and also conceptualizes the various theories in it using numerous illustrations and through a wide number of problems.

# 3. EXECUTIVE SUMMARY

RC planes are controlled remotely using a transmitter with joysticks that can be used to fly the plane and execute various maneuvers. The transmitter also comes with a receiver that is mounted within the Model RC Airplanes and receives and controls the commands sent by the transmitter. The servos are small motors that are physically connected to the control surfaces, such as the steering wheel. The type of material we choose impacts the strength and stability of RC aircraft, and it is also preferable to select a material with a high specific Young's modulus. A plane's channel count is defined by the number of mechanical servos it requires. It is sometimes necessary to put servos as near the centre of gravity as possible to balance the model correctly.

Aileron on the wings controlling roll. Elevator on the horizontal tail controlling pitch (up and down). Rudder on the vertical tail controlling yaw (left and right). Flaps on the wing, but change the wing camber to increase lift (and drag) for landing. Canard is a horizontal surface at the front of the plane that controls pitch. Much less common than elevators, but does the same thing.

Rolling the plane left or right will cause turning of plane and it depends on Dihedral effect. Dihedral effect of an aircraft is a rolling moment resulting from the vehicle having a non-zero angle of sideslip. Increasing the dihedral angle of an aircraft increases the dihedral effect on it. Our event's pioneers were unable to take part in the challenge. We've learned from our past blunders and the different misunderstandings we encountered while creating our previous aircrafts, and we've put our knowledge to good use.

# 4. DESIGN RESEARCH

## 4.1 WING DESIGN

### 4.1.1 AIRFOIL SELECTION

During cruise, lift developed by the wing was assumed to be equal to the weight of the aircraft. From this condition, the Cl value was obtained. Lift does not contribute to thrust force required while climbing. The cruise speed of the aircraft was fixed as 15m/s so as to satisfy our requirements based on the application selected. Lift increases and drag decreases with increasing Reynold's number. The flow on the wing is mostly laminar over a range of 50,000 to 500,000 and becomes turbulent towards the trailing edge. Whereas laminar flow seems promising and desirable as it reduces skin friction drag, turbulent flow too provides an advantage by preventing flow separation. Generally, for RC aircrafts a low Reynold's number is chosen and consequently Re was taken as 125,000.

| S.No | Airfoil | Specifications |
|---|---|---|
| 1 | S1223 | Max thickness 12.1% at 19.8% chord.<br>Max camber 8.1% at 49% chord |
| 2 | Clark Y | Max thickness 11.7% at 28% chord.<br>Max camber 3.4% at 42% chord |
| 3 | NACA 0009 (smoothed) | Max thickness 9% at 30.9% chord.<br>Max camber 0% at 0% chord<br>9.0% smoothed |
| 4 | NACA 4415 | Max thickness 15% at 30.9% chord.<br>Max camber 4% at 40.2% chord |

Table 4.1 List of initially considered highly cambered airfoils

Corresponding to the cruise flight condition.

Assuming,

$$l = W = \frac{1}{2}\rho v^2 s\, c_l$$

$$\text{Cl design } c_l = \frac{w}{\frac{1}{2}\rho v^2 s};$$

ρ and v correspond to mission of the airplane e.g. cruise

Taking w= 1.1kg, ρ=1.225kg/m3, v=15m/s, s=0.1100m3

We obtained the value of Cl design as 0.738.

(NOTE: the weight of the aircraft was overestimated for the increase in weight while construction)

Airfoil was selected such that it has this value of coefficient of lift is obtained at a fixed angle of attack. Generally, an airfoil profile is differentiated based on its camber. It can be highly cambered, moderately 4 cambered, or symmetrical. The down pitch moment of an airfoil increases with the increasing camber. High camber provides greater Cl and Cm, and zero camber/symmetry generates zero pitching moment; a moderate camber is the most preferred, for it gives enough lift with not much drag and has a gentle stall pattern in contrast to a sharp stall pattern for others. Keeping the requirements in mind, NACA 4415, Clark Y, S1223 airfoils were selected for comparison. Foil analysis was done in XFLR5 for these airfoils at 125,000 Reynold’s number.

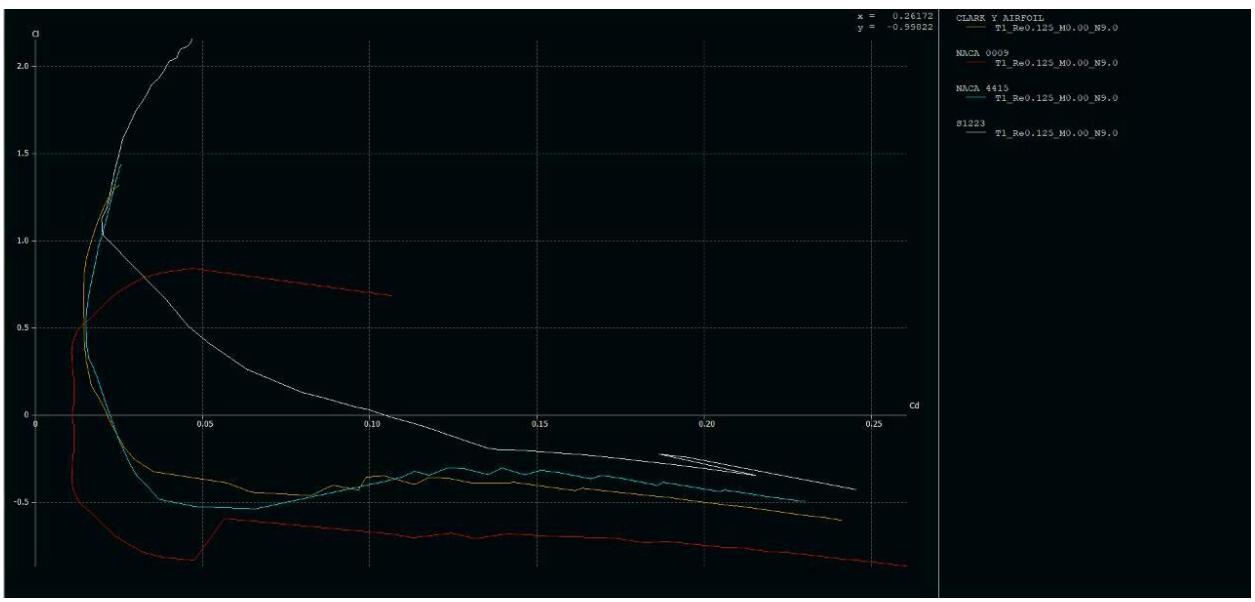


Fig 4.1. Cl vs Cd plot comparison of airfoils

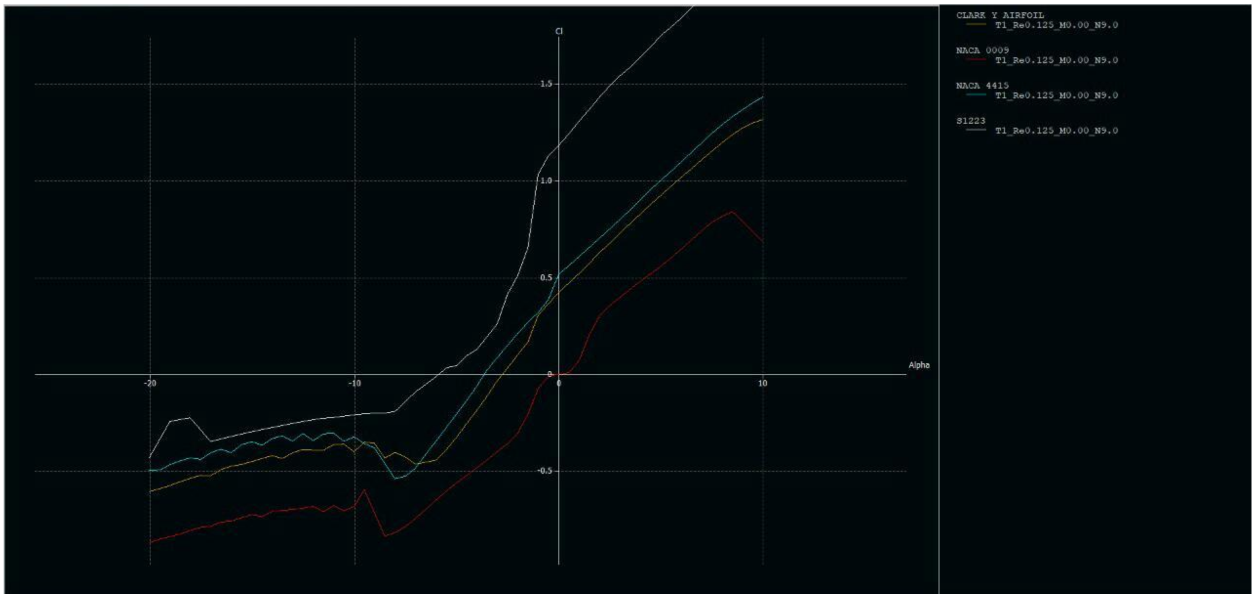


Fig 4.2. Cl vs alpha plot comparison of airfoils

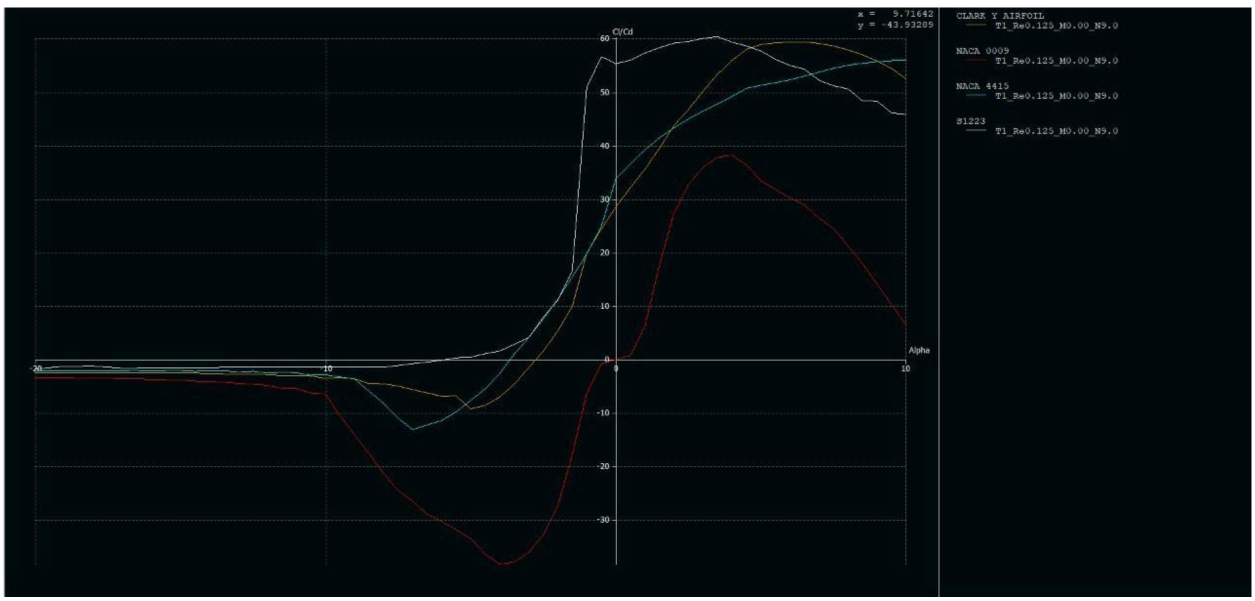


Fig 4.3 Cl/Cd vs alpha plot comparison of airfoils

From the above plots we observed that Clark Y has a lower Cl value compared to S1223 but higher compared to NACA 4415 and NACA 0009. Due to higher camber of S1223, value of Cd is high and hence lowering Cl/Cd ratio. Clark Y also had a lower Cm value. The construction of wing with S1223 airfoil will be difficult because of its large camber and very thin trailing end section. Consequently, ailerons were not used in the design. We also faced difficulty in mounting the wing on the fuselage.

CLARK Y is widely used in RC aircraft design due its predictable and gentle stall characteristics and flat bottom outline, it is an ideal choice for RC model aircraft. Flat bottom shape makes for simplified airplane construction. The CLARK Y has high camber, which allows for an efficient lift to drag ratio on a typical lightweight RC aircraft. It also has a deep mid-section that allows us to add any structure and wing span arrangement that is needed for a particular wing layout. In addition, the generous volume within the CLARK Y wing shape allows the placement of other functional equipment such as aileron and controlling servos within the wing structure.

### 4.1.2 WING LOADING

It is very helpful to know the approximate wing loading when predicting stall speeds. Aircraft with large wing areas relative to their weight (low wing loading) will have lower stalling speeds. For a fixed wing area, wing loading increases as the weight of the aircraft increases. It was essential to have a suitable value of wing loading to prevent stalling. Mass of the aircraft was estimated as 990g initially. Wing loading was obtained as 0.956/cm2.

### 4.1.3 BASIC WING DIMENSIONS

The aspect ratio decides the RC aircraft's wing span,

$$Aspectratio = \frac{\text{wing span}}{\text{chord length}}$$

From the eq.

$$Re = \frac{\rho \vartheta d}{\mu}$$

we get value of chord length as 12.3cm. As the AR was fixed as 7, we obtained wingspan as 86.17cm. We arrived at these values after many iterations by taking different values of AR, cruise speeds as shown above. The induced drag coefficient (Cdi) of a subsonic airplane is inversely proportional to the AR of wing. Therefore, a higher value of AR reduces the induced drag.

For a chosen wing area, the aspect ratio decides the span of the wing. Hence, airplanes which fly in proximity of ground, are subjected to air turbulence and have moderate aspect ratio of 6 to 7. We observed these effects of AR on the different parameters of the plane. It was decided to take AR as 7. After the final construction of the wing, there may deviations from this value due to different error that can accumulate during the process.

The dihedral angle is defined to be the degree or extent to which the wing is angled from a perpendicular orientation with the fuselage. The main benefit of addition of dihedral angle is to lower the center of gravity. Roll stability is also expected to have a positive effect due to this. XFLR analysis with dihedral angle had not shown much improvement in stability, possibly due to inaccuracy of model in the software. Dihedral angle was taken as zero as we could not obtain satisfactory results.

#### 4.1.4 WING PLANFORM

Wing planform is the shape of the wing as viewed from directly above it deals with airflow in three dimensions, and is very important to understanding wing performance and airplane flight characteristics. Aspect ratio, taper ratio, and sweepback are factors in planform design that are very important to the overall aerodynamic characteristic of a wing. Aspect ratio is the ratio of wing span to wing chord. Taper ratio can be either in planform or thickness, or both. In its simplest terms, it is a decrease from wing root to wingtip in wing chord or wing thickness. Sweepback is the rearward slant of a wing, horizontal tail, or other airfoil surface.

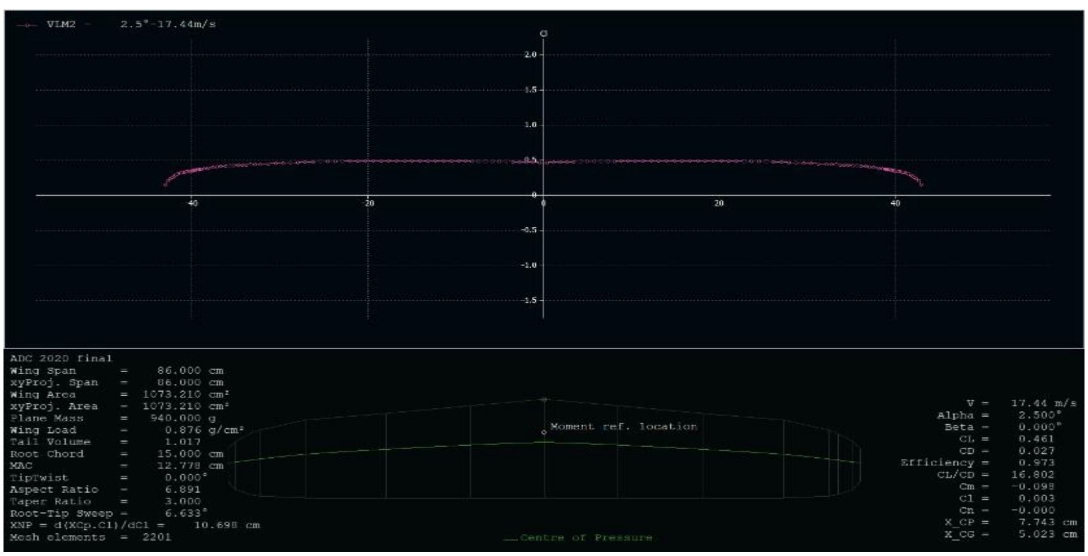


Fig 4.4 Lift distribution of modified wing planform.

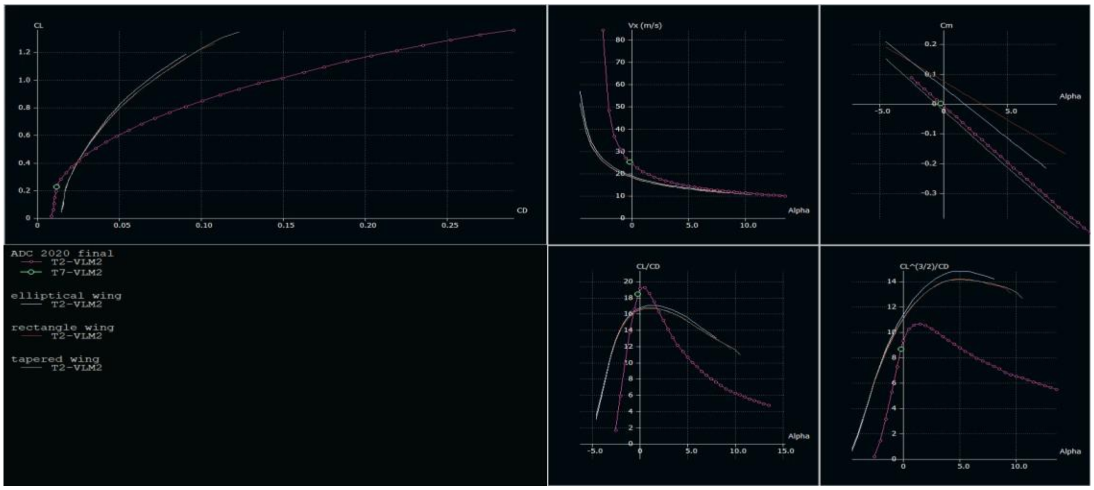


Fig 4.5. Plot showing characteristics of selected wings.

We observed the various plots and lift distribution of selected planforms. Keeping the objective of reducing drag and to obtain a uniform lift distribution, a wing planform was designed combining the features of tapered and elliptical wings, where the tapered wing was designed by modifying the rectangular wing. The chord of the wing is varied across the span for approximate elliptical lift distribution. While it isn't as efficient as the standard elliptical wing, it does offer a compromise between efficiency and manufacturabilityand the elliptical wing is aerodynamically most efficient because elliptical span wise lift distribution induces the lowest possible drag and. However, the manufacturability of this aircraft wing is poor.A slight taper was provided from root to tip of wing and an elliptical curve at the leading edge near the tips. This was analyzed on XFLR5.

The result showed that drag reduced and hence, Cl/Cd was increased. Cl3/2/Cd showed significant drop compared to the other planforms. This implied that lower value of required thrust was only necessary. Therefore 97% efficiency was indicated. These observations were made at alpha 2.5 degrees.

### 4.1.5 WING MOUNTING STYLE

Generally, three methods are primarily adopted for mounting the wing in regard to fuselage position;

(i) low mount (ii) mid mount and (iii) high mount wings. A mid mount wing configuration was chosen. Mid wing airplanes are very stable at slow speeds which implies they could right themselves if they encounter a turbulence. As our application requires more stability than maneuverability, mid mount wing was suitable.

## 4.2 EMPENNAGE

### 4.2.1 TAIL DESIGN

In order to maximize lift, easy maneuverability and stability, selecting the optimum tail design was a crucial. The tail of an airplane is designed to provide both stability and control of the airplane in pitch and yaw. Horizontal and vertical tails were designed to achieve longitudinal and lateral stability. Movable surfaces on the tails namely, the elevator and rudder provide control about longitudinal and lateral axes. The team considered comparing both the conventional tail and T tail designs for the initial analysis.

We found out that conventional tail is having the lowest structural weight, not much prone to deep stall condition, less maintenance concern and is easier to fabricate. Most commonly used tail design is conventional as it is simple and easy to fabricate while being efficient at achieving stability.

T tails have the horizontal tail acting as an end plate on the vertical tail. Aircraft with T-tails are at risk of entering a “deep stall”. This occurs when the aircraft pitches to an angle of attack where the horizontal stabilizer is in the wake of the main wing. Sudden pitch to an angle of attack well above the stall angle of attack would lead to a potentially irrecoverable stall condition due to the turbulent airflow over the tail surfaces, reducing the effectiveness of the horizontal stabilizer and control surfaces. As the horizontal tail was mounted on the vertical tail, it had to withstand extra weight and better structural strength for vertical tail had to be provided. Hence we preferred conventional tail over T tail.

### 4.2.2 AIRFOIL SELECTION

Standard NACA009 is a symmetric airfoil which is best suited for the proposed design. They are most commonly used for airplane flying at low Mach numbers. Moreover, due to its good structural strength and less camberness it’s easy to fabricate. Symmetric airfoil helps to behave in a similar manner when at a positive or negative angle-of-attack.

### 4.2.3 HORIZONTAL TAIL

The main purpose of a horizontal tail is pitch stability. Various parameters were analyzed and decisions were taken regarding these factors:

a. Tail sizing

The horizontal tail aerodynamic centre ($l_{ac}$) from the leading edge of wing(datum ) was taken as 53.15cm. According to our application which is related to agriculture, horizontal tail volume coefficient (VH) was chosen as 0.8.

*Position of Centre of gravity,* $x_{cg}=0.314c$

*Position of aerodynamic Centre,* $x_{ac}=0.25c$

*HorizontaltailArm,* $l_t=l_{ac}-x_{cg}$

$=49.2cm$

*Horizontaltailvolumecoefficient,* $VH = \frac{l_t \times S_t}{S \times c}$

*Thus, Horizontal Tail Plan form Area(St)=* $\frac{1035 \times 12.3 \times 0.8}{49.2}$

$=207cm^2$

*ElevatorArea* $=0.30 \times 207=62.1cm^2$

An aspect ratio within 3 to 5 was selected. While choosing aspect ratio of horizontal tail, the reduction of structural weight was given more importance than the reduction of drag. Hence, aspect ratio was selected as 3.3

b. Horizontal Tail Incidence

The horizontal tail incidence is chosen such that during the cruise, the lift required from the tail, to make the airplane pitching moment zero, is produced without elevator deflection. After analysis in XFLR5, the team decided to choose an angle of -2 degrees. At this angle of incidence, positive pitching moment coefficient was obtained at zero angle of attack of the aircraft. This shows the aircraft was longitudinally stable. Negative moment would act if angle of attack becomes positive and vice versa.

### 4.2.4 VERTICAL TAIL

Directional stability or yaw stability is given to the aircraft using a vertical tail. Various parameters were analyzed and decisions were taken regarding these factors:

A. Tailsizing

Vertical tail volume coefficient($V_V$)is chosenas0.04

During the preliminary design phase, the vertical tail arm $l_V$ was taken as 52.12cm.

Vertical tail plan form Area ($S_v$) = $\frac{Vv \times S \times b}{lv}$

$$= \frac{0.04 \times 1035 \times 86}{52.12}$$

$$= 68.31 cm^2$$

*RudderArea=0.5×68.3=34.15cm²*

An increase in the aspect rationales of increases the height of vertical tail and in turn the height of the airplane. Directional control improves as the moment arm increases. From the initial approximations, vertical tail was modeled in XFLR5 and aspect ratio was adjusted for lateral stability.

## 4.3 FUSELAGE DESIGN

The fuselage is an aircraft's main body section. It acts as the backbone of an aircraft and serves to position control and stabilization surfaces in specific relationships to lifting surfaces, which is required for aircraft stability and maneuverability. The main purpose of it is to lodge the engine, wing, empennage, electronics and payload housing. According to the aerodynamicconsiderations it is thus critical to design the fuselage in such a way that it facilitates airflow with minimum drag.

### 4.3.1 AREA OF CONTROL SURFACES

| Components | Area |
|---|---|
| Horizontalstabilizer | 20%ofwingarea= 207cm$^2$ |
| Elevator | 30%of horizontal stabilizer area=62.1cm$^2$ |
| Verticalstabilizer | 33%of horizontalstabilizer area=68.31cm$^2$ |
| Rudder | 50%ofvertical stabilizerarea=34.15cm$^2$ |
| Aileron | 12%of halfwinga1rea=66cm |

Table 4.2 Area of Components

### 4.4 STABILITY AND CONTROL

Based on the decided values, the wing was designed in XFLR5 and Autodesk Fusion360 using ClarkY airfoil and analyzed. Centre of gravity was adjusted such that the slope of Cmv salpha graph was negative and value of Cm was positive at alpha zero degrees. This was necessary for a stable aircraft. Negativeslope meant that if a gust of wind pitched up the nose, the aircraft automatically regains stable flight by having a counter acting moment about the centre of gravity and pitching down without any external inputs. In other words, we can say that it was dynamically stable in longitudinal axis.

| Component | Mass(gram) | Location(cm) |
|---|---|---|
| Battery+ESC | 190 | -7 |
| Motorandpropeller | 90 | -12 |
| HorizontalStabilizer | 50 | 55.37 |
| Verticalstabilizer | 30 | 59.27 |
| Wing | 150 | 7.23 |
| Fuselage | 150 | -1 |
| Gyrostabilizer | 20 | 4 |
| Servo1 | 10 | 7 |
| Servo2 | 10 | 7 |
| Servo3 | 10 | 20 |
| Servo4 | 10 | 25 |

Table 4.3 Mass and location of components

Transverse axis of the wing was taken as the datum.

*Mean aerodynamic chord=12.31cm*

Position of centre of gravity (with payload) = 3.2cm

Position of aerodynamic centre = 3.07cm

*Position of neutralpoint=4.308cm*

*Static stability margin* $=\frac{NP-CG}{MAC}\times 100\%=\frac{4.308-3.2}{12.31}\times 100\% = 8.94$

The approximate centre of gravity was obtained from XFLR5

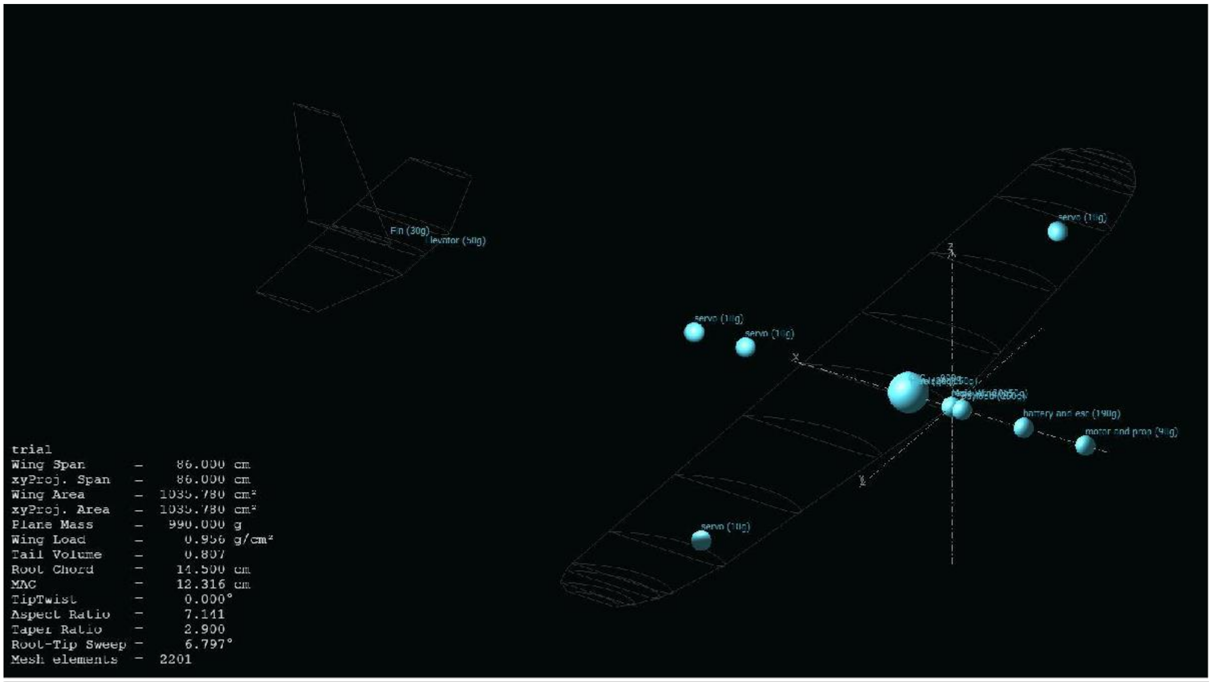


Fig 4.6 Mass distribution

## 4.5 THRUST ANALYSIS

With respect to the nature of power output of propeller motors and the inherent relationship between a motor and a propeller, it was necessary to consider motor choice and propellersizing in tandem. As such, the first general relation to consider was thrust versus RPM. Next to be considered was propeller pitch versus thrust. Consequently, lower pitches meant higher thrust values, but also lower RPM. Therefore, a higher power motor was required to spin a Propeller with less pitch at the same RPM as one with more pitch.

Finally, the relationship that brought the voltage of the battery and RPM of the motor together was the KV parameter of the motor. KV is a measure of the RPM per Volt a motor can output. and in doing so, how much torque a motor output. Lower K meant lower RPM with more thrust which was typical of slow flying planes, much Ike the very aircraft our team was designing. Using these general guidelines as well as the parameters of the battery. The motor Kv value was selected to be 1400Kv. To determine prop size. it was necessary to relate thrust and power to pitch speed, Vpitch. Pitch speed can be calculated using equations:

$$RPM = K_v V_{battery}$$

$$V_{pitch} = RPM\ pitch \eta_{prop}$$

$$T = \frac{P}{v_{pitch}}$$

$$A_{prop} = \frac{T}{0.5 \times p \times V_c^2}$$

$$D_{prop} = 2 \times \left(\frac{A_{prop}}{\pi}\right)^{0.5}$$

Dynamic thrust had to be greater than static thrust. It is given by

$$T = T_c\, \rho\, V^2\, D^2$$

Since static thrust is dependent on the diameter of the propeller disk and the outgoing airspeed, we determined that a nine-inch diameter, 4.5-inch pitch propeller was needed for our application.

| | |
|---|---|
| RPM/V | 1400 |
| Diameter× pitch | 10×4.5 |
| Thrust | 1000g |

Table 4.4 Thrust Analysis table

# 5. ELECTRONIC SYSTEMS

## 5.1 MOTOR SELECTION

Thrust is the force which moves an aircraft through the air. Thrust is used to overcome drag and weight of an airplane. Total thrust that is produced by the combination of engine and propeller should be greater than the sum of drag and weight component. We considered the basic equations of motion and considered thrust to weight ratio for different types of RC Plane as given in the table below. Choosing the thrust-weight ratio as 0.7 and assuming the plane weight as 1100gram. (NOTE: the weight of the aircraft was overestimated for the increase in weight while construction)

Thrust= 0.7x1100 = 770gram

RPM/volt of the motor is selected as 1000Kv, as we consider a plane of low air speed and

High thrust.

Power to thrust ratio (watts/gram), $W/g = \frac{0.17 \times kv}{1000} + 0.09$

$$= \frac{(0.17 \times 1000)}{1000} + 0.09$$

$$= 0.26 W/g$$

Power= Thrust x (power to thrust ratio) = 840 x 0.26= 218.4 W

Applying Factor of safety (50%)

Power= 218.4 x 1.5= 327.6 W

Since a motor of above specifications were not available, a commercially available motor of following specifications was selected.

A2212 - 1400KV BLDC Brushless Motor

Thrust with 1045 propeller: 1000gms approx.

Minimum ESC Specification: 18A (30A Suggested)

RPM: 1400KV/Volt

A 10x4.5 propeller is used with the motor based on recommendations of the manufacturer and costumers.

## 5.2 SERVO SELECTION

The maximum torque required for control surface depends on width, length of control surface, speed of Flight, maximum control surface deflection.The result is the max torque found for the control surface for the maximum servo deflection.

The torque is calculated as

$$T(Oz\text{-}in)= \frac{w^2 \text{ x } v^2 \text{ x A x L}}{430000}$$

W = Control surface width in inch, L = Control surface length in inch, V = Speed in mph,

A = Maximum Control surface deflection in degrees

Applying the above equation for a maximum deflection of 45°, the torque is found to be 0.6 kgfcm (0.96 kgfcm) for elevator, 0.25 kgfcm (0.4 kgfcm) for rudder and 0.568 kgfcm (0.9088kgfcm) for each Aileron. Increasing the resultant torque by 60% (provided in brackets) due to safety reasons and it may not work to its advertising capacities.

Glancing through numerous items accessibility in market, the servo which match the requirement was found to be three Tower Pro SG90 mini gear micro servo 1.2 kgfcm @ 4.8V servo motor for ailerons and rudder. Due to flap down condition of elevator offers more drag force,Towerpro SG92R 2.2kg micro servo motor was selected for elevator as it is of higher torque.

## 5.3 BATTERY AND ESC SELECTION

A 3S Li-Po Orange 2200 mAh with 30C continuous current rating battery is chosen. As the Electronic Speed Controller (ESC) should be able to deal with the peak current the motor-propeller combination, an ESC that can handle 18A is required. After considering a factor of safety Standard 30A BLDC ESC is used. It has BEC (battery eliminator circuit) of 5V 3A specification.

## 5.4 CIRCUIT DESIGN CONFIGURATION

The basis for selection of the servo motors for control surfaces and throttle has already been discussed in the previous section. Lithium polymer battery (11.1V) is connected to an electronic speed controller which is having internal BEC connection. This reduces the voltage to 5V with maximum current of 3A, which is then fed to the receiver of the corresponding paired transmitter. Servo motors are connected to the gyroscope which is then connected to the channels of the receiver.

# 6. TECH DATA SHEET: WEIGHT BUILDUP

| SI No. | COMPONENTS | WEIGHT (in Kg) | PRICE (in INR) |
|---|---|---|---|
| **UAV** | | | |
| 1 | 1400Kv BLDC Motor | 0.072 | 439 |
| 2 | 2200mAh Li-Po battery | 0.167 | 1549 |
| 3 | 30A BLDC ESC | 0.023 | 499 |
| 4 | Towerpro SG92Rservo × 4 | 0.036 | 262 |
| 5 | Orange 1045 Propeller | 0.030 | 249 |
| 6 | RC Receiver | 0.0064 | 1250 |
| 7 | Fuselage | 0.150 | 600 |
| 8 | Wing | 0.150 | 900 |
| 9 | Vertical Stabilizer | 0.030 | 200 |
| 10 | Horizontal Stabilizer | 0.050 | 290 |
| 11 | Gyro stabilizer | 0.020 | 800 |
| **Total Weight** | | **0.792 kg** | |
| **Payload** | | | |
| 1 | Pulse rate sensor | 0.010 | 120 |
| 2 | GSM module | 0.080 | 799 |
| 3 | GPS module | 0.085 | 320 |
| 4 | Camera | 0.010 | 1190 |
| 5 | Buzzer | 0.015 | 229 |
| 6 | Raspberry Pi | 0.015 | 229 |
| **TOTAL WEIGHT OF UAV (including payload)** | | **1.097 kg** | |

# 7. DESIGN OF FIXED WING UAV

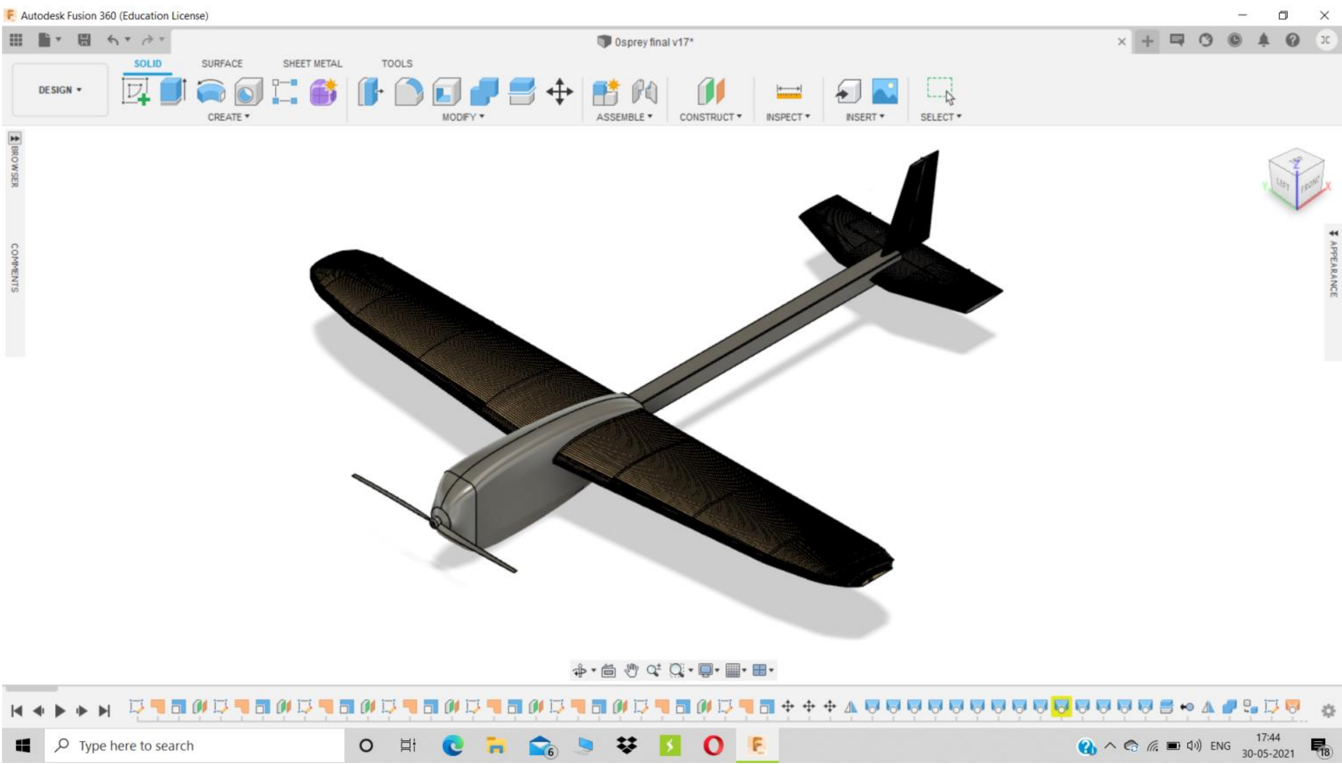


Fig 7.1 Prototype designed on fusion 360

# 8. APPLICATION

In a recent survey on Safety of Women, a study was released that ranked India as the most dangerous place because of its high incidences of sexual violence, lack of access of precautionary security measures. Problems may come from any direction such as women walking on the road, after the work, going to super market or for many other reasons for which they go alone. People at home are not sure of their return safely.

Our design mainly focuses on the safety of Women 24x7 by using fixed wing UAVs to avoid the crime against women. As a first response to a Safety, women are asked to install an app for their safety. Registration to this app should be done using their respective Aadhar ID's. This will make them connected. Now whenever a risk or problem is faced by them, they just need to click on the panic button on them, this will provide a signal to the control centre. The GPS coordinates of the victim can be found out easily and from the nearest service point, the UAV will be launched. The UAV will reach the location using GPS tracking and will provide necessary assistance to the police and alert the nearby areas using the buzzer present in it. The Cameras along with the night vision camera will help in the surveillance and tracking the incident. This is done by GSM modules, camera and Arduino.

The design helps to support gender equality by providing a safe environment to women in the society, and allows them to work till late nights. Anyone before doing any crime against the women will be deterred and it helps reduce the crime rate against the women.

# 9. FABRICATION

Fabrication was done in four phases

I. **Procurement**
II. **Construction**
III. **Assembly**
IV. **Finishing**

**I. Procurement**

Finding the raw materials needed is the main aim of this phase on several discussion we choose balsawood to create the skeleton of the plane. Balsawood were of length sheet where of la length 1 metre and the width 15 centimetre with 0.3 centimetre thickness which was purchased online. OHD sheets were used to cover the aircraft skeleton.

**II. Construction**

Aerofoil that was selected was fed to an aerofoil potter tool by this its coordinates were obtained from this aerofoil picture was created. 40W CO2 laser cutter was used to cut the aerofoil cross sections and this was done by inserting the created aerofoil pictures into the system along with balsawood sheet. The entire fuselage was divided into 3 part the cross-section for both the sections were also cut from balsawood sheet by the method similar to that done in aerofoil . The whole phase lasted about one and half hour.

**III. Assembly**

This phase was started after balsa parts and OHP sheet was done. The construction of the various components could be prioritized and that there was smooth integration into the final product. Team was divided into three groups.First group would focus on the assembly, which after completion would be handed over to the second group which will cover the skeleton components with the OHP sheet. The third group would ensure the final touch up of the component and assembly. Eachgroup were coordinator to get a successful build.

For joining balsa and OHP pieces, Impact Strength Instant Gorilla Glue was used at all junction. It dried rapidly with minimal expansion, which allowed assemblies to be constructed rapidly. We used a precision knife and box cutter to cut the balsa wood spars to size. A construction tooling was used in order to guarantee that ribs were positioned and oriented accurately.

To construct the stabilizer a balsawood spar with length equal to the span wise length of the stabilizer was cut out. A series of airfoil cross sections were precisely positioned along the spar using the help of the construction tooling. The rudder and elevator were also constructed in a similar manner. The next section constructed was the fuselage and it was designed to be as simple as possible. The rib-longer on design made assembly of the parts similar to a jigsaw puzzle. Once constructed, the parts were glued. Some parts were left open for the electronics integration. Along with that, facilitate electronics integration; cutouts were designed into the ribs for running wiring and placing components.

Construction of the wing was divided into two parts: central wing section and ailerons. The wings, however, required more effort and attention to detail, it was vital that they be oriented properly and to be of nearly perfect condition and orientation for successful operation. The balsawood spar was cut and sanded for the same reason to ensure smooth transition through the hole. The airfoil cross sections were gradually added to the spar and thereby a skeleton of the wing was obtained. It was then kept aside for later covering with OHP sheets.

The ailerons were built using the same procedure as the rudder and elevator. The wing tips were essentially just an extension of the central wing that need to include a 10-degree angle. To achieve a proper 10 degree angle a protractor was used to establish a reference angle. This was usually drawn directly onto the table cloth. Two balsawood spars were then joined together at a 10 degree angle. After each component was constructed, the various section and junctions were glued with a strong adhesive. The final component payload box was fixed by using M-Seal as its bottom is a part of fuselage

**IV. Finishing**

OHP sheet was used to cover the skeleton of aircraft after construction phase. In order to connect the final parts strong adhesive was used. The main components that forms the structure was glued in an order. Starting from the horizontal stabilizer that was first attached to the body, and the vertical stabilizer was put tint place.  The wing tips were attached to the central wings.

During this step in the entire process, electronics were integrated into the body. Special care was taken to ensure the correct orientation and fit of electronic components. This required cutting wires to proper length, and mounting the servos, speed controller and the receiver. By running the wires through holes in the ribs of the body, it was ensured that the wiring was neat and easy to follow without interfering with the payload. Except battery every electronic component were glued as battery should be removable.

# 10. CONCLUSION

Upon completion and evaluation of the project, it can be concluded that the design met all the specifications required by the SAE Aero Design Competition rules and speculations. We understood the need for a good and capable design that could mitigate the real-life problems our world is dealing with and how much our design can be helpful in this scenario.

Our team started with the design of the wing by taking appropriate measures to maintain the wing loading of aircraft within the permissible range. Manyaerofoils were compared using Cl/Cd vs alpha plot to choose Clark Y as the suitable one for our design. Since we found that elliptical planform is most efficient aerodynamically even its manufacture is difficult, we decided to provide a slight taper from root to tip of the wing and an elliptical curve at the leading edge near the strips and these were analyzed on XFLR5. The wing is designed by Autodesk Fusion360 and XFLR5 using Clark Y aerofoil.
Then we designed the fuselage by giving much importance as it act as the backbone of an aircraft. Horizontal and vertical tails were designed after analysis in XFLR5 by giving proper attention and analyzation to pitch stability and directional stability respectively. Centre of gravity was adjusted in suitable way for a stable aircraft and its approximate value was obtained from XFLR5.Different plots were also taken into account for the design. Onwhole, our team focused on implementing effective ways to fulfill our design requirements.

This competition and hence this project gave us a wonderful learning experience and provided us an opportunity to know lot about the field of designing and fabrication of aerodynamic structures.

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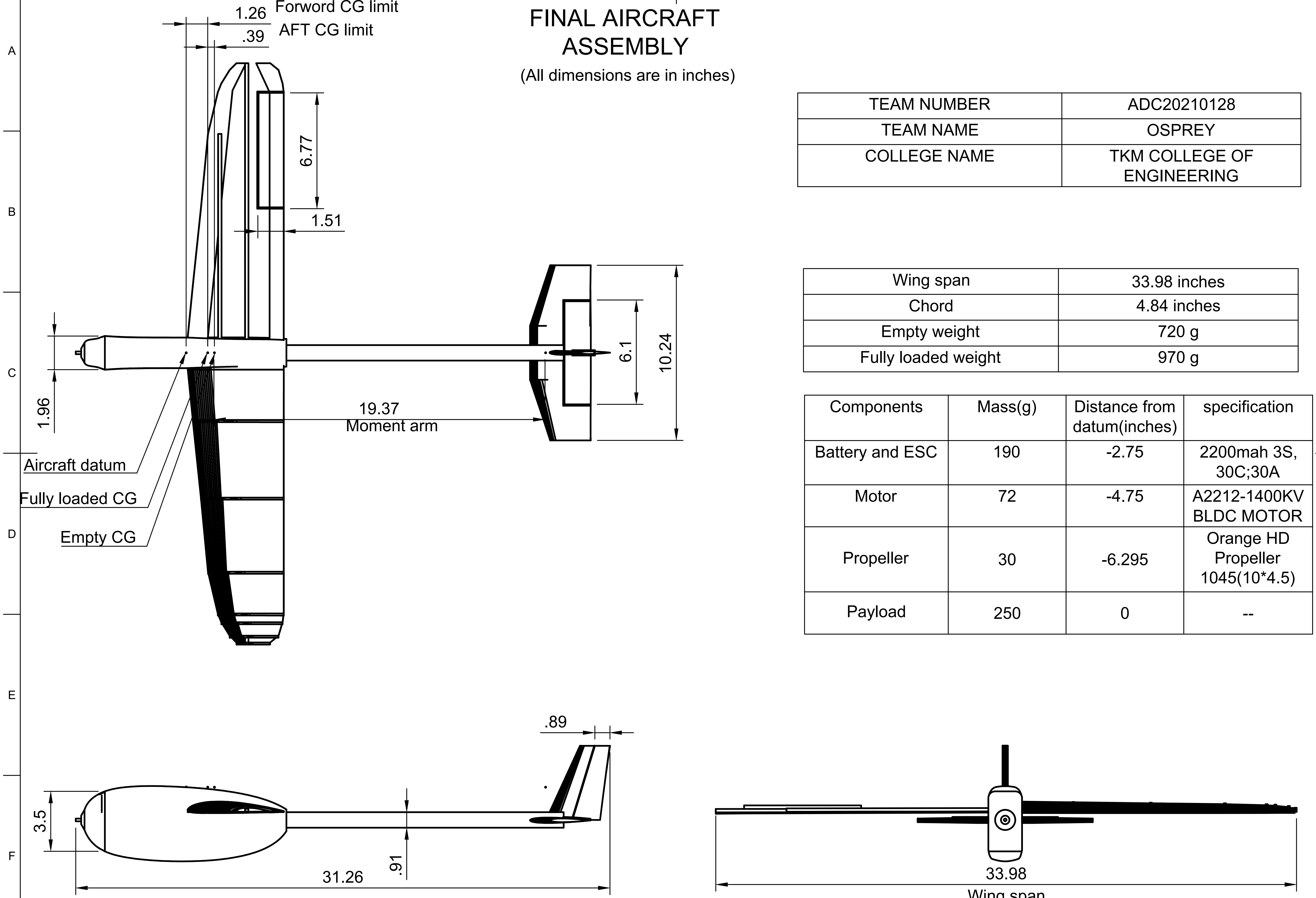
# FINAL AIRCRAFT ASSEMBLY

(All dimensions are in inches)




| | |
|---|---|
| TEAM NUMBER | ADC20210128 |
| TEAM NAME | OSPREY |
| COLLEGE NAME | TKM COLLEGE OF ENGINEERING |

| | |
|---|---|
| Wing span | 33.98 inches |
| Chord | 4.84 inches |
| Empty weight | 720 g |
| Fully loaded weight | 970 g |

| Components | Mass(g) | Distance from datum(inches) | specification |
|---|---|---|---|
| Battery and ESC | 190 | -2.75 | 2200mah 3S, 30C;30A |
| Motor | 72 | -4.75 | A2212-1400KV BLDC MOTOR |
| Propeller | 30 | -6.295 | Orange HD Propeller 1045(10*4.5) |
| Payload | 250 | 0 | -- |

# APPENDIX I

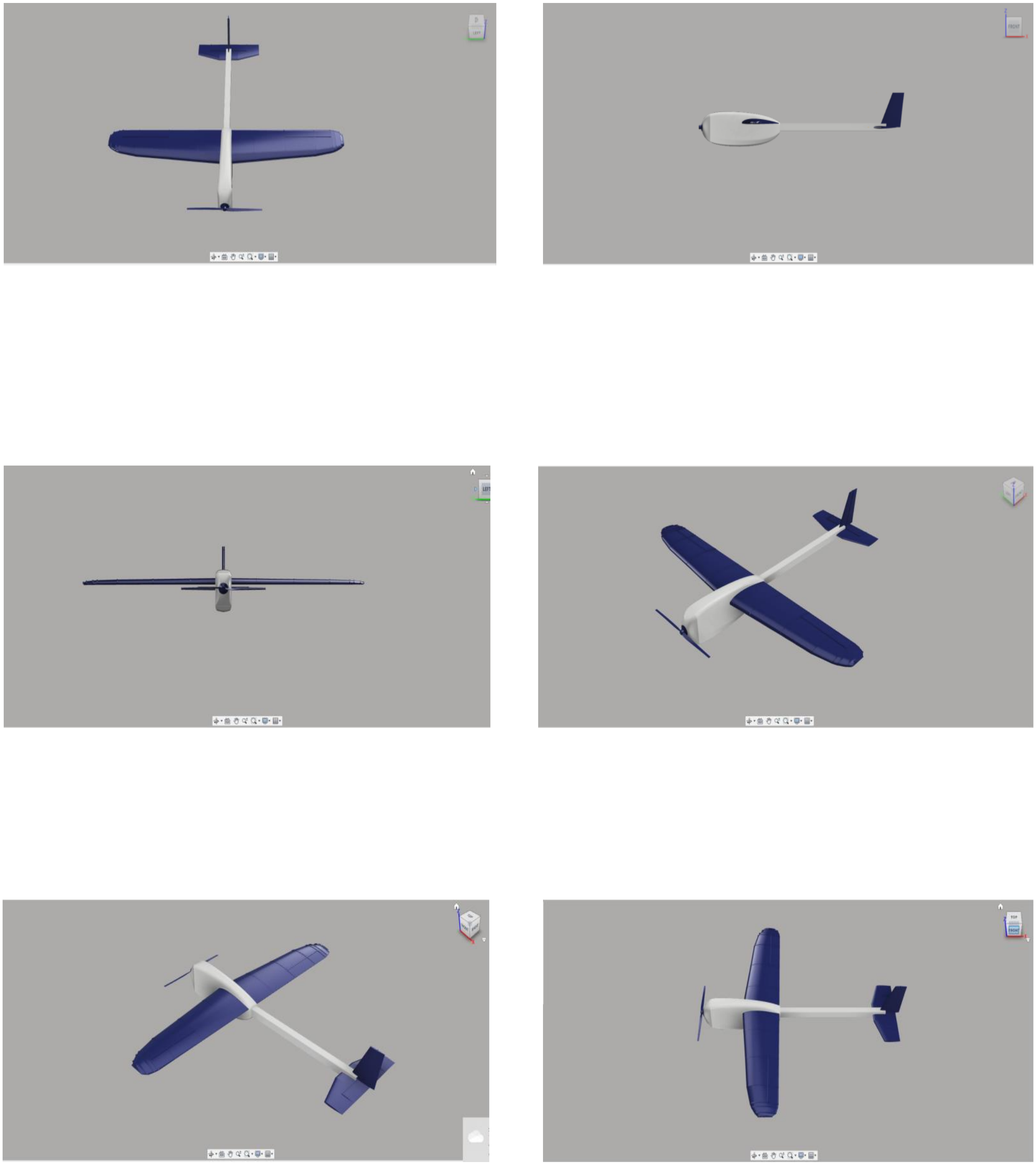


Fig A.1 Design of Fixed Wing UAV