Unmanned Aerial Vehicle For Surveillance

S. N. Teli, Madan Jagtap, Ritesh Nadekar, Prashant Gudade, Rupesh More, Pranit Bhagat

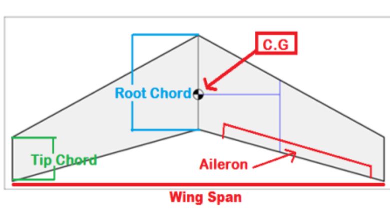
Abstract: UAV (Unmanned Aerial Vehicle) is an air vehicle which is largely used for surveillance, monitoring, reconnaissance, data relay, and data collection or to enter the area which is not safe for human i.e. flood affected or virus affected area. Present paper discusses the systematic design, data analysis, different property calculations and then manufacturing of delta wing type of UAV with low cost which successfully flew in the sky in Mumbai. It measures the altitude, captures the real image as well as videos that used for the surveillance purpose.

Introduction:

Birds can fly in sky due to their inherent characteristics. They are the dominant in the sky. It is human characteristics to dominate or rule over other. So they tried their best to fly in sky from dawn of civilization. And they got it through the success of Wright brother's in 1903. Subsequently many modernization and invention had done through 19th century and now a day's fly without pilot is one of the most important topics of study worldwide for national, international, military purposes under the banner of Unmanned Aerial Vehicle (UAV).Aircraft concept designers have been constantly looking for new concepts that can bring high efficiency to aviation industry. Flying-wing concept is one of the most attractive configurations. The flying wing is tailless design that integrates the wing and fuselage. Generally, flying-wing aircraft may be categorized in three types, flying wing (FW), blended wing body (BWB) and delta wing (DW). A flying wing is a tailless fixed-wing aircraft which has no definite fuselage, with most of the crew, payload and equipment being housed inside the main wing structure. Blended Wing Body (BWB) aircraft have a flattened and airfoil shaped body, which produces most of the lift with the wings contributing the balance. The body form is composed of distinct and separate wing structures, though the wings are smoothly blended into the body. The delta wing is a wing plan form in the form of a triangle. It is named for its similarity in shape to the Greek uppercase letter delta (Δ). The delta wing aircraft is also called "Blue Bird" because of their shape. The reason why flying-wing aircraft have been attracting so many engineering efforts is that they are believed to possess substantial potentials, aerodynamically, economically and environmentally.

1. Aircraft Design:-

1.1 Basic plan form:-



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1.2 Wing Geometry:-

Selection of root chord, tip chord, sweep angle and span for delta wing aircraft as follows, Basically, taper ratio is defined as the ratio of width of wing at the tip to width of wing at the root. Its range for delta wing is 0.4-0.6. Therefore we selected root chord as 16.5 inches and tip chord as 6.5 inches.

$$\text{Taper Ratiio} = \frac{\text{Width Of Wing At The Tip}}{\text{Width Of The Wing At the Root}} = \frac{6.5}{16.5} = 0.4$$

For selection of a span we generally consider the aspect ratio. Aspect ratio is defined as the square of the span divided by the wing area. Its range for delta wing aircraft or glider is 4-6. Consider span is 48 inches.

$$\text{Aspect Ratio} = \frac{(\text{span} * \text{span})}{\text{Area}}$$

$$\text{Area} = \text{Span} * \text{chord Lenth}$$

The chord length for the delta wing aircraft is average of the root chord and tip chord.

$$\text{Chord Length} = \frac{(\text{Root Chord} + \text{Tip Chord})}{2} = \frac{(16.5 + 6.5)}{2} = 11.5 \text{ Inches.}$$

$$\text{Aspect ratio} = \frac{(\text{Span} * \text{Span})}{(\text{span} * \text{chord length})} = \frac{\text{span}}{\text{chord length}} = \frac{48}{11.5} = 4.17$$

$$\text{wing area} = \text{Span} * \text{chord length} = 48 * 11.5 = 552 \text{ sq Inches.}$$

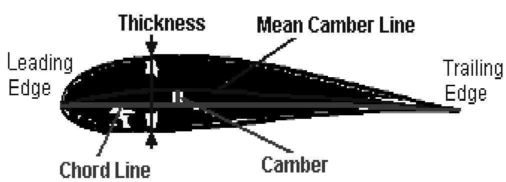
Aspect ratio is between the ranges 4-6. Therefore, span is 48 inches selected. Swept angle is normally measured by drawing a line from root to tip 25% of the wing back from leading edge and comparing that to the longitudinal axis of the aircraft. We selected swept angle is 35 degrees.

Wing Geometry Table

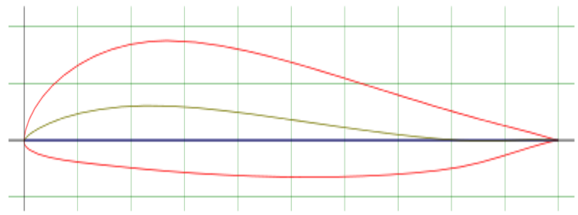
Specification	Dimension
Taper Ratio	0.4
Root Chord	16.5 inches
Tip Chord	6.5 inches
Aspect Ratio	4.17
Wing Span	48 Inches
Wing Area	552 sq. inches
Sweep Angle	35degrees

2. Aerofoil selection:-

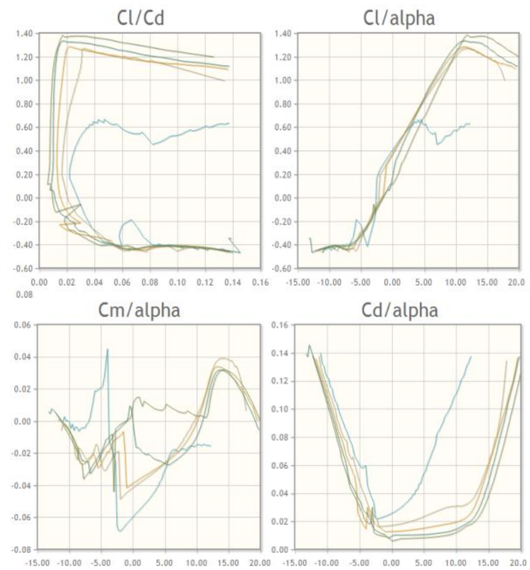
The cross sectional shape of the wing is called the airfoil. The front of the airfoil which is tangent to the lower and upper surface is identified as the leading edge while the back of the airfoil is defined as the trailing edge. Sharp or nearly sharp leading edge airfoils are generally more suitable for supersonic flow due to decrements of wave drag which occur during supersonic regimes. The longest straight line from the trailing edge to the leading edge is defined as the chord length. The mean camber line is a curvature line which is located between the upper and lower surface of the airfoil. This line is the maximum distance between leading and trailing edge. Also, the maximum perpendicular distance between the upper and lower chamber is called thickness. All these aerodynamic parameters are illustrated in figur



Airfoils produce lift by changing the velocity of the air passing over and under itself. By changing the airfoil angle of attack the air velocity changes as it travels slower over the top of the wing and travel faster underneath the wing. Bernoulli's law of pressure equation states that the lift is generated by the pressure difference between the upper and lower surface of the airfoil. When the fluid passes through the leading edge of the airfoil, it speeds up. This exerts less pressure on the top of the airfoil. The performance of the airplane is associated with the airfoil selection. The lift force which is produced by the wing and tail surfaces is directly related to the design of the airfoil. As a result, the airfoil selection requires intensive computational efforts along with extensive research. We selected standard aerofoil Eppler 332 for delta wing aircraft. The characteristics of aerofoil Eppler 332 as follows, The characteristics of aerofoil Eppler 332 as follows



Plot	Airfoil	Reynolds #	Max Cl/Cd	Description
☑	e332-il	50,000	17.4 at α=1.75°	Mach=0 Ncrit=9
☑	e332-il	100,000	40.7 at α=10.75°	Mach=0 Ncrit=9
☑	e332-il	200,000	64.3 at α=9.25°	Mach=0 Ncrit=9
☑	e332-il	500,000	95.6 at α=8.5°	Mach=0 Ncrit=9
☑	e332-il	1,000,000	107.9 at α=8.25°	Mach=0 Ncrit=9



Calculation for Reynolds No:-

One of the most important parameter that affects the airfoil characteristics is the Reynolds number. The Reynolds number is the function of velocity, the length of the fluid that has traveled down the surface and the kinematic viscosity of the fluid. This relationship can be seen in

$$Re = \frac{\rho v l}{\mu} = \frac{v l}{\nu}$$

Where:

v = Velocity of the fluid
l = The characteritics length, the chord width of an airfoil
ρ = The density of the fluid
μ = The dynamic viscosity of the fluid
ν = The kinematic viscosity of the fluid

The Reynolds number can determine whether the flow is laminar or turbulent. The value of Reynolds number for the wing can be obtained by dimension of the chord length, flight altitude and the airspeed.

Parameter	Value
Flight Altitude	229 m
Chord Length	0.2921 m
Air Speed	20 m/s
Dynamic Viscosity	1.4207E-5
Reynold No	411206

Based on the value of Reynolds number, the entire set of low Reynolds number and high lift airfoils was evaluated. This selection would consider parameters such as airfoil lift and drag, pitching moment characteristics, Stall, the thickness of the airfoil for structural purpose, ease of manufacturing. Therefore, we selected aerofoil which has Reynold No more than 411206 i.e. Reynold No 500000. The characteristics of aerofoil as follows Aerofoil Eppler 332 (Reynold No 500000) Characteristics Table

Parameter	Value
Angle Of Attack	8.5 degrees
Coefficient Of Lift	1.1817
Coefficient Of Drag	0.01236
Max. Ratio of Coefficient of Lift to Coefficient of Drag	95.61
Coefficient Of Pitching Moment	-0.0185

3. Neutral Point and Stability:-

We have already learned that the center of gravity must be located in front of the neutral point. While the *n.p.* of an unswept, rectangular wing is approximately at the *c/4* point, the *n.p.* of a swept, tapered wing must be calculated. The following procedure can be used for a simple, tapered and, swept wing. First, we calculate the mean aerodynamic chord length l_μ of a tapered wing, which is independent from the sweep angle:

$$l_\mu = \frac{2}{3}\frac{1+\lambda+\lambda^2}{1+\lambda}\cdot l_r$$

With the root chord *lr*, the tip chord *lt* and the taper ratio.

$$\lambda = \frac{l_t}{l_r}$$

$$= \left(\frac{2}{3}\right)*\left(\left(\frac{1+0.4+0.4*0.4}{(1+0.4)}\right)\right)*0.4$$

= 12.26 Inches

= 31.13 cm

We can also calculate the span-wise location of the mean chord l_μ , using the span *b*,

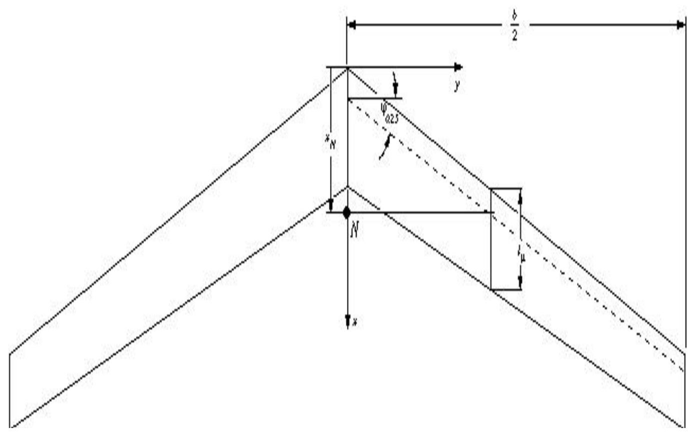
$$y = \frac{b}{2}\frac{l_r - l_\mu}{l_r - l_t}.$$

The *n.p.* of our swept wing can be found by drawing a line, parallel to the fuselage center line, at the span-wise station *y*. The chord at this station should be equal to l_μ. The *n.p.* is approximately located at the *c/4* point of this chord line (see the sketch below).

$$= \left(\frac{48}{2}\right)*\left(\left(\frac{(16.5-12.26)}{(16.5-6.5)}\right)\right)*0.4$$

= 18.18 Inches

= 25.85 cm



Geometric parameters of a tapered, swept wing

Instead of using the graphical approach, the location of the neutral point can also be calculated by using one of the following formulas, depending on the taper ratio:

$$x_N = \frac{l_r}{4} + \frac{2b}{3\pi}\cdot\tan\varphi_{0.25}$$, if *taper ratio* > 0.375

$$x_N = \frac{l_r}{4} + \frac{b\cdot(1+2\lambda)}{6\cdot(1+\lambda)}\cdot\tan\varphi_{0.25}$$, if *taper ratio* < 0.375.

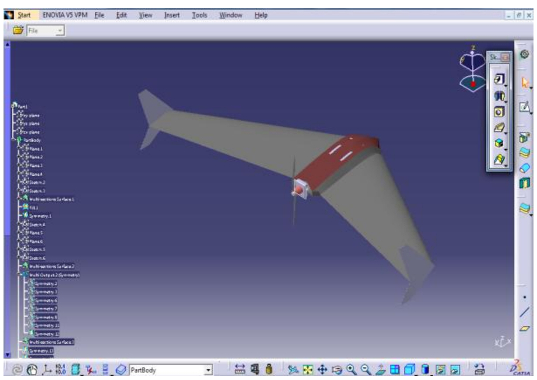
$$= \left(\frac{16.5}{4}\right) + \left(\left(\frac{2*48}{(3*\pi)}\right)\right) * \tan(35)$$

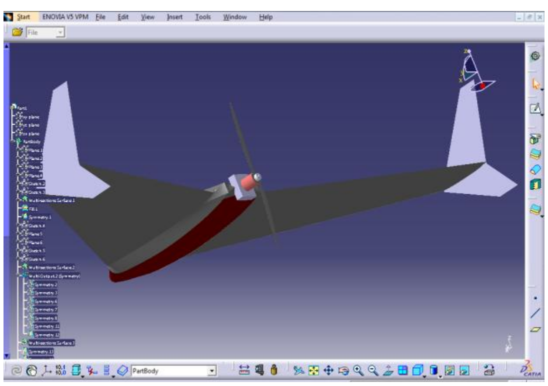
$$= 11.26 \text{ Inches}$$

$$= 28.59 \text{ cm.}$$

4. Simulation and Test:-

A. Design in catia :-





B. Model Construction:-

To construct the model and also maintaining low weight, chloroplast is used. First draw the basic plan form of an aircraft according to their dimensions. Then cut that sheet to get the aircraft wing by using blade. The mirror image of the wing draws above the centre line. Similarly, we design second wing. Joined both wing by using some glue. We selected an aerofoil only for the calculation purpose only. During the fabrication we made reverse engineering to get aerofoil shape. Sometimes reverse engineering give more better result than the actual engineering. Generally, aerofoil has its own CG at one third distance of the chord length. The thickness of the aerofoil is 10% of its chord length. We took one balsa wood strip and cut it into 10% of its chord length tapered shaped as wing is in tapered shaped and fixed it at one third distance of its chord length. Attach two servos for the aileron. Made complete body of wing then folded it. We got delta wing aircraft. Usually, the delta wing aircraft doesn't have a fuselage. But we made fuselage for this aircraft. It is used not only throwing the aircraft during the flight as well as safety purpose. All electronic instruments are also kept in the fuselage. We selected PVC pipe for the fuselage. The propeller of aircraft is also attaching to rare end of this fuselage. It also helped to reduce the drag during the flight. The front side of the aircraft camera is fixed so that it takes pictures as well as video. The all instrument added in fuselage and weight is balanced according their CG.

C. Model Test:-

First test was taken without fixing the camera to an aircraft for checked the CG is matched or not. CG was perfectly matched. Then second flight was tested with the camera and it captures the real images as well as videos. The range of our plane is 1 km radius.

D. Captured Images

5. Result:-

The coefficient of pitching moment is -0.0185. It is most stable than the other conventional aircraft. It took pictures which was used for the surveillance.

6. Conclusion:-

The delta wing body is tailless design that integrates the wing and fuselage. It is most efficient flight in the future due to intrinsic nature of its shape, its configuration shows some important aerodynamic advantages of lower wetted area to volume ratio and high power efficiency as compared to conventional type of UAV. Also delta wing may increase payload capacity. It also provide well guide if we cut off the power source so that it can save approximately 25% of power during flight. It provides sufficient stability for surveillance purpose.

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