



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 3, March 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com



Designing of Air Taxi Vehicle Adoptable to Ambulance and Rescue Operation

Yash Dhaduk¹, Deep Patel², Himanshu Pithiya³, Rajeev Baghel⁴

U.G. Student, Department of Aeronautical Engineering, Parul University, Vadodara, Gujarat, India¹

U.G. Student, Department of Aeronautical Engineering, Parul University, Vadodara, Gujarat, India²

U.G. Student, Department of Aeronautical Engineering, Parul University, Vadodara, Gujarat, India³

Associate Professor, Department of Aeronautical Engineering, Parul University, Vadodara, Gujarat, India⁴

ABSTRACT: We are going to design an Air taxi Vehicle; able to carry 3 members and having a maximum take-off weight of 700kg. This Air Taxi is adoptable to use for Transportation, Ambulance as well as for Rescue operation. In this project we are estimating various parameters of the aircraft and design it by using CAD software, doing CFD analysis and at last from the obtained result modify the design.

KEYWORDS: Air taxi, Mathematical calculations, Conceptual Design, CFD.

I. INTRODUCTION

In this paper the designing of an Air taxi of maximum takeoff weight (MTOW) of 700 kg is designed and we had determined all the designing parameter for the same.

Basic Concept and fundamentals: An air taxi is a small commercial aircraft which make short flight on demand. One concept has been the use of air taxis smaller plane that can take passengers between local airports upon request bypassing the traffic and delays of major airports. Air taxis, formally the small Aircraft transportation system. Today, there are only 20 or so major airports in the India and as many as 100 million people might go through just one of them in a year. With so many people choosing to fly, many airports are operating above their capacity and are overwhelmed, causing delays and cancellations. It is also very expensive to run major airports and major airlines. To help ensure a profit, airlines schedule flights so as to fill as many seats as possible. This limits the option for travellers, forcing them to conform to these schedules and destinations. As a result, many travellers choose to drive instead of fly, overloading yet another transportation system: highways.

Advantages of air taxi :

Less congestion in major airports. Less congestion on highways. Greater flexibility in travel schedules. More points of departure and arrival. Lower operating costs for smaller airlines.

Start up and R&D on Air Taxi :

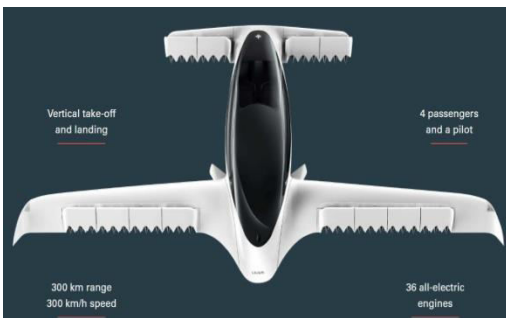
Globally Many Start up & Research are working on air taxi topic. Liliu jet, City airbus, Vahana (Airbus corporation), Aston Martine etc. has a potential to be used as a flying taxi or for air travel.



II. RELATED WORK

In related work we had discuss some examples of the Air taxi vehicle which are under research and development phase in the entire world.

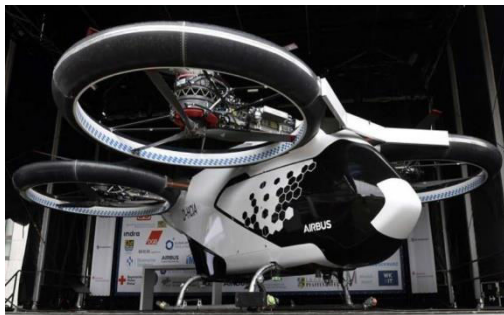
LILIUM JET



Ref. [1]

capacity	2 passengers
Empty Weight:	970 lb (440kg)
Max takeoff weight	1411 lb (640kg)
Power plant	36 × Vertical Electric 320 kw Duct fan
Max speed	190 mph (300 km/hr)
Cruise speed	170 mph (280 km/hr)
Range	188.41 mi (300 km)

CITY AIRBUS



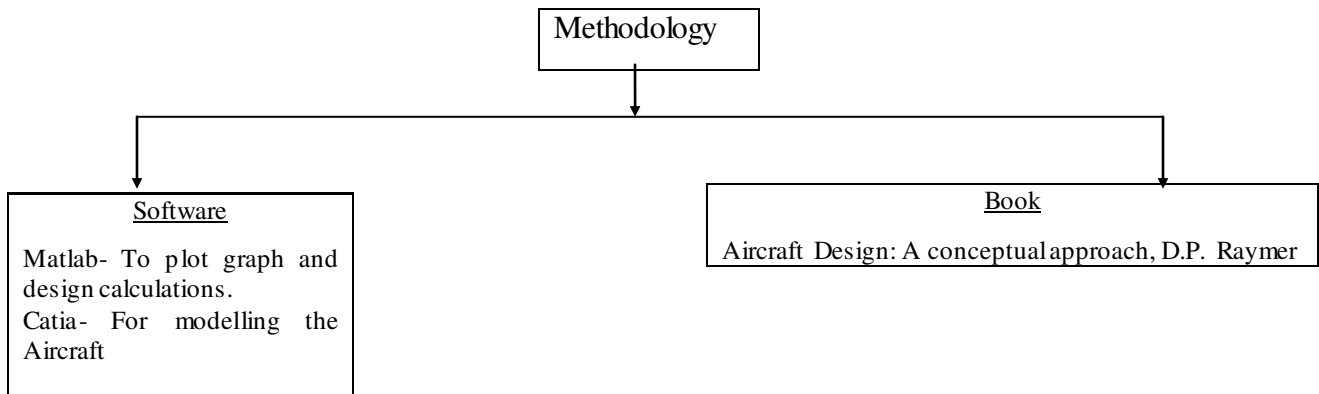
Ref. [2]

capacity	4 passengers
Max takeoff weight	4850 lb (2200 kg)
Power plant	8 × Electric Duct fan (4×140kw of 140hp & 4× 100KW of 130hp)
Cruise speed	75 mph (120 km/hr)
Endurance	15 Min



III. METHODOLOGY

In Methodology we had uses software for calculation and design purpose and used book to obtained formula to calculate the parameters as discuss below in chart



IV. DESIGN PROCESS

Calculation of Density and Temperature at design Altitude :

Our design altitude is 5000 meters.

$$a = \frac{dT}{dh}$$

Lapse rate upto 11km from MSL is - 6.5 k/km.

$$\frac{T_2 - T_1}{h_2 - h_1} = - 6.5$$

$$(T_2)_{5km} = 255.66 \text{ k}$$

$$\frac{\rho_2}{\rho_1} = \left(\frac{T_2}{T_1} \right)^{-\left(\frac{g_0}{a \cdot R} + 1 \right)}$$

$$(\rho_2)_{5km} = 1.0868 \text{ kg/m}^3$$



Wing Calculation :

For different Aspect ratio and wing loading, the value of span & chord is calculated as below.

Aspect Ratio(b/c)							
w/s	4	5	6	7	8	9	10
55	7.13/1.78	7.97/1.59	8.73/1.45	9.73/1.34	10.08/1.26	10.69/1.18	11.27/1.12
56	7.87/1.58	7.90/1.58	8.66/1.44	9.35/1.33	10/1.25	10.60/1.17	11.08/1.11
57	7.00/1.75	7.83/1.56	8.58/1.38	9.27/1.32	9.91/1.23	10.15/1.16	11.08/1.10
58	6.94/1.73	7.76/1.55	8.50/1.41	9.18/1.31	9.82/1.22	10.41/1.15	10.98/1.09
59	6.88/1.72	7.70/1.54	8.43/1.40	9.11/1.30	9.74/1.21	10.33/1.14	10.89/1.08
60	6.82/1.70	7.63/1.52	8.36/1.39	9.03/1.29	9.65/1.20	10.24/1.13	10.79/1.08
61	6.77/1.69	7.57/1.51	8.29/1.38	8.96/1.28	9.57/1.19	10.16/1.12	10.70/1.06
62	6.72/1.68	7.51/1.50	8.29/1.36	8.98/1.25	9.50/1.18	10.08/1.12	10.62/1.06
63	6.66/1.66	7.44/1.49	8.16/1.36	8.81/1.26	9.42/1.17	9.99/1.11	10.54/1.05
64	6.61/1.65	7.39/1.47	8.09/1.35	8.74/1.25	9.35/1.16	9.91/1.10	10.45/1.04
65	6.56/1.64	7.33/1.46	8.03/1.33	8.67/1.24	9.27/1.16	9.84/1.09	10.37/1.03

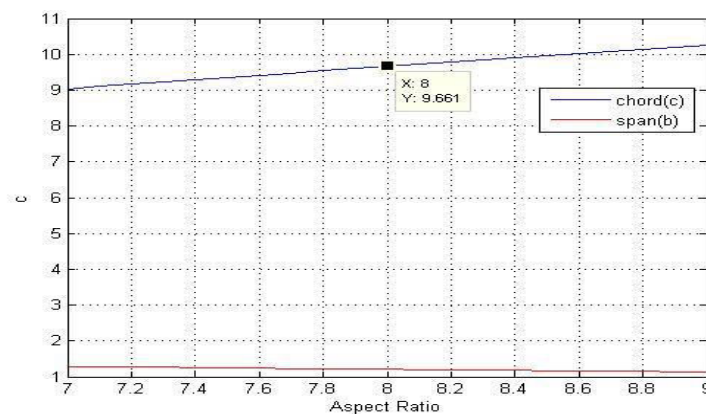
Table span and chord value for different wing loading and aspect ratio

From the above data we have selected a wing loading for our aircraft as; $\frac{w}{s} = 60$.

Then, surface area of wing is calculated from;

$$S = \frac{w}{w/s} = \frac{700}{60} = 11.66 \text{ sq. meters}$$

From selecting the Aspect ratio for the wing the matlab graph is plotted by varying the AR from 7 to 9. From this the value of span and chord is calculated for different AR.



Variation on span and chord with respect to Aspect ratio for wing

From the matlab graph AR is selected as 9.02

$$AR = \frac{b^2}{s} ; b = (S \times AR)^{1/2} = 10.26 \text{ meters}$$

Firstly, we assume wing as a rectangle, $C = \frac{b}{AR} = 1.1364 \text{ meters}$

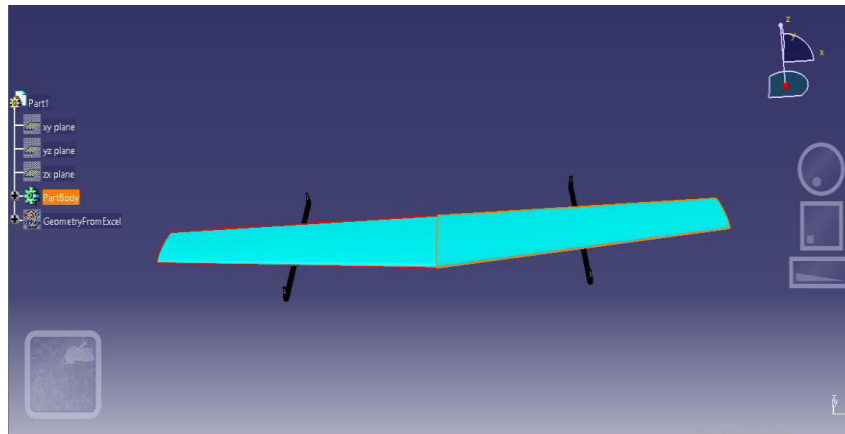


This above dimension is for rectangular wing, and as per the aerodynamics it will produce large tip vortex which will contribute to increase in induced drag. So to overcome this the wing is designed as a tapered wing. The tapered ratio for the wing is selected by using below matlab plot. By plotting a graph the selected value for taper ratio is 0.63 For $\lambda = 0.63$, the value of span and chord is calculated by using below equations. We know the surface area of trapezoid is given by:

$$S = \frac{1}{2} * (C_t + C_r) * b, \quad C_r = 1.3944 \text{ meters} \quad \& \quad \lambda = \frac{C_t}{C_r} \quad C_t = 0.8784 \text{ meters}$$

Mean Aerodynamic chord of wing: Mean aerodynamic chord and area for tapered section of wing is;

$$MAC_{tapered \text{ wing}} = \frac{2}{3} * C_r * \left(\frac{1 + \lambda + \lambda^2}{1 + \lambda} \right) = 1.1599 \text{ m}$$



Final design of wing in CATIA

Airfoil selection: Total C_L is

$$C_{L_{cruise}} = C_{L_{\alpha}} * \alpha_{cruise} + C_{L_0}$$

From this graph the airfoil whose $\alpha_{C_{L=0}} = -2$ is good for our requirement, So the airfoil selected for the wing is 2412.

C_{L_0}	0.2442
α_{L_0} (degrees)	-2.25°
$C_{L_{\alpha}}$ (per radian)	5.6663
α_{stall} (degrees)	15.25
$C_{l_{max}}$	1.4070
$C_{m_{ac}}$	-0.0542

Details of 2412 Airfoil at $Re = 10 * 10^6$

Horizontal Tail (Stabilizer) : The area of horizontal tail is calculated by taking a appropriate as of wing. The surface area of horizontal tail is vary from 16 to 30 percentage of surface area of wing. And graph is plotted to calculate span and chord of tail by defining the Aspect ratio as 3. The S_{htail} is taken as 23% of S_{wing} . And from the above graph the value of span and chord for horizontal tail is selected as; $S_{htail} = 2.6703 \text{ sq. meters}$

$$AR = \frac{b^2}{S} = 3, \quad \& \quad b = (S * AR)^{1/2} \quad b = 2.836 \text{ meters}$$



For rectangular tail;

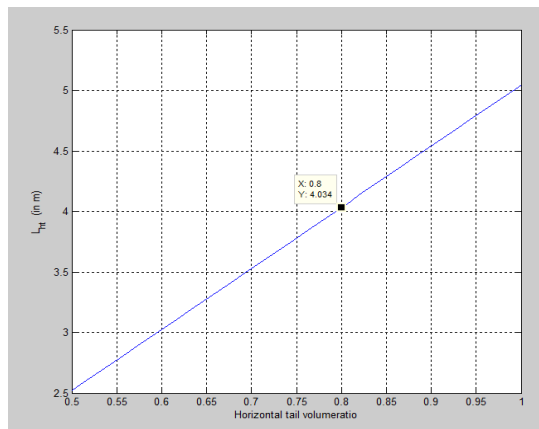
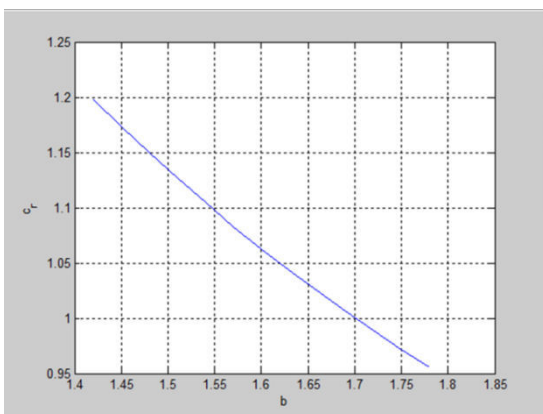
$$C = \frac{b}{AR} \quad \boxed{C = 0.9455 \text{ meters}}$$

This above dimension is for rectangular horizontal tail, and as per the aerodynamics it will produce large tip vortex which will contribute to increase in induced drag. So to overcome this, we moving towards the tapered configuration. The graph is plotted to select taper ratio by varying it from 0.3 to 0.75. From matlab plot we select, $C_t = 0.5389$ & $\lambda = 0.57$. We know the surface area of half span (half trapezoidal section) is given by;

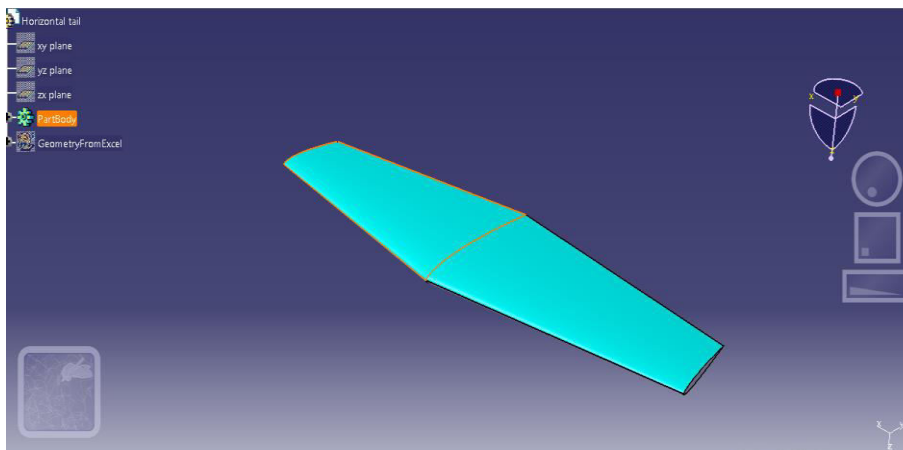
$$S = 1.3351 \text{ sq.meters (23\% of wing area).}$$

Now graph is plotted by varying the half span and root chords below . From that graph we get the result;

$\left(\frac{b}{2}\right)_{\text{halfspan of horizontal tail}} = 1.54 \text{ m}$, $C_r = 1.104 \text{ m}$ $\lambda = \frac{C_t}{C_r} = \frac{0.5389}{1.1041} = 0.488$. As taper ratio (λ) decreases, to maintain same surface area of horizontal tail we need to recalculate b (span). So final span is $b_{\text{horizontal tail}} = 3.2510 \text{ meters}$



Horizontal tail volume ratio: Its formula is given by $V_{ht} = \frac{S_{HT} * l_{ht}}{S_w * \bar{c}_w}$. The below Graph is plotted between V_{HT} & l_t by varying V_{HT} from 0.5 to 1. From the above graph; $V_{ht} = 0.8$ & $l_{ht} = 4.034 \text{ m}$



Final design of Horizontal Tail in CATIA



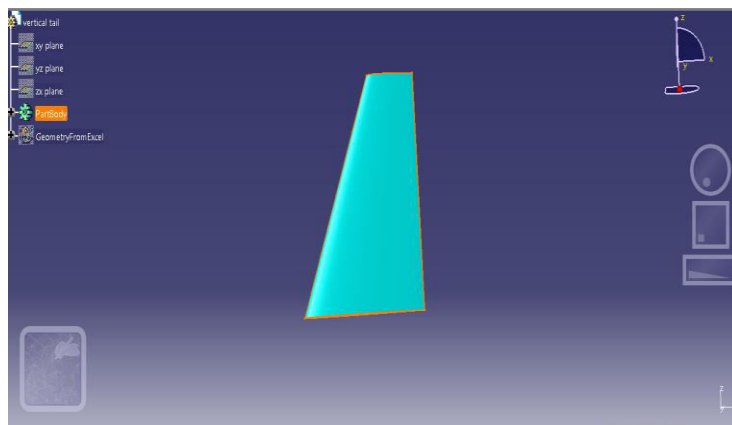
Vertical Tail (Stabilizer) : The area of vertical tail is calculated by taking a appropriate as of wing. The surface area of vertical tail is vary from 5 to 15 percentage of surface area of wing. And graph is plotted to calculate span and chord of tail by defining the Aspect ratio as 2. The S_{vtail} is taken as 10 % of S_{wing} . And from the matlab plot the value of span and chord for vertical tail is selected as; $S_{vtail} = 1.166 \text{ sq.meters}$ and $AR = \frac{b^2}{S} = 2$, we get

b = 1.527 meters

C = 0.7635 meters

This above dimension is for rectangular vertical tail, and as per the aerodynamics it will produce large tip vortex which will contribute to increase in induced drag. So to overcome this, we moving towards the tapered configuration. The graph is plotted to select taper ratio by varying it from 0.3 to 0.75. From Matlab Plot $C_t = 0.4199$ & $\lambda = 0.55$ Following the same procedure as in wing and horizontal tail, the values are $C_r = 1.01 \text{ m}$ & $b_{span \text{ of vertical tail}} = 1.6309 \text{ meter}$.

Vertical tail volume ratio: Its formula is given by $V_{vt} = \frac{S_{VT} * l_{vt}}{S_w * b_w}$. The below Graph is plotted between V_{vt} & l_{vt} by varying V_{vt} from 0.031 to 0.06. And the selected value from the matlab plot are $V_{vt} = 0.039$ & $l_{vt} = 4.001 \text{ m}$



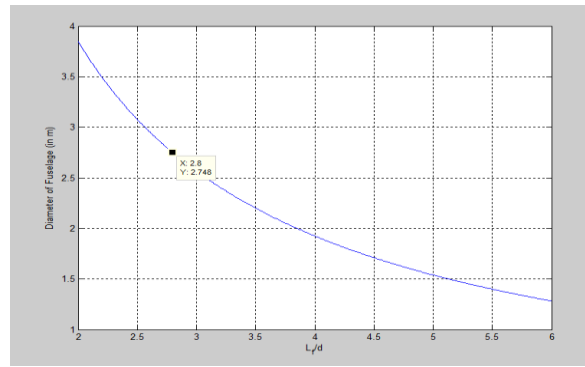
Final design of Verical Tail in CATIA

Airfoil selection for Tail: Airfoil uses for horizontal tail and vertical tail is symmetric Airfoil. NACA 0012 Airfoil is selected for the both Horizontal and vertical tail (Stabilizers).

C_{L_0}	0
α_{L_0} (degrees)	0
C_{d_0}	0.00540
C_{l_α} (per radian)	5.63832
α_{stall} (degrees)	15.5
C_{lmax}	1.3862
C_{mac}	0

Details of 0012 Airfoil at $Re = 10 * 10^6$

Fuselage Sizing : Fuselage length is approximately 75% of the wing span. $L_f = 0.75 * b_{wing} = 7.695 \text{ m}$. Now the graph is plotted between $\frac{L_f}{d}$ & the diameter of the fuselage



From the above graph $\frac{L_f}{d}$ is selected; $\frac{L_f}{d} = 2.8$ & $d = \frac{L_f}{2.8}$ $d = 2.7482 \text{ meters} = 9.016 \text{ ft}$

V. CONCLUSION

From our above designing work of an Air taxi vehicle for 700 kg class, we get the final designing parameters for various component of our aircraft are as below.

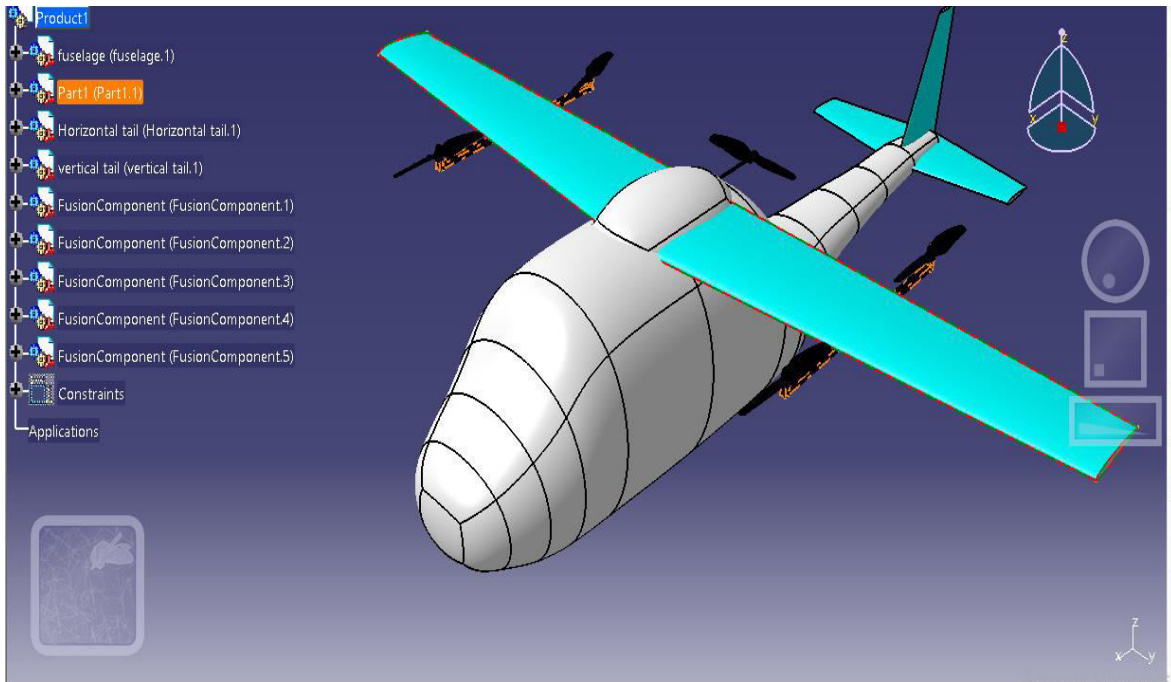
Wing Parameters	
Surface area of wing (S)	11.66 meters sq.
Aspect Ratio of wing (AR)	9.06
Taper ratio of wing (λ)	0.63
Wing span (b)	10.26 meters
Root chord (C_r)	1.3944 meters
Tip Chord (C_t)	0.8784 meters
Mean Aerodynamic chord (MAC_{wing})	1.1599 meters

Horizontal Tail Parameters	
Surface area of tail (S_{htail})	2.6703 meters sq.
Aspect Ratio of tail (AR)	3
Taper ratio of tail (λ)	0.488
Horizontal Tail span (b)	3.251 meters
Root chord (C_r)	1.104 meters
Tip Chord (C_t)	0.5389 meters
Horizontal Tail volume ratio (V_{ht})	0.8
Horizontal Tail moment arm (l_{ht})	4.034 meters

Vertical Tail Parameters	
Surface area of tail (S)	1.166 meters sq.
Aspect Ratio of tail (AR)	2
Taper ratio of tail (λ)	0.4157
Vertical Tail span (b)	1.6309 meters
Root chord (C_r)	1.01 meters
Tip Chord (C_t)	0.4199 meters
Vertical Tail volume ratio (V_{vt})	0.039
Vertical Tail moment arm (l_{vt})	4.001 meters



Fuselage Parameters	
Length of fuselage (L_f)	7.695 meters
Maximum Diameter of fuselage (d)	2.748 meters



Final Model of Air Taxi

REFERENCES

- [1] <http://lilum.com>.
- [2] <http://www.airbus.com.>innovation>
- [3] Aircraft Design: A Conceptual Approach, Daniel P. Raymer.
- [4] Aircraft performance and design John D. Anderson Jr.



INNO  **SPACE**
SJIF Scientific Journal Impact Factor

**Impact Factor:
7.512**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details