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A New Design and CFD Analysis of UAV for Military and Other Applications

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Abstract

The new era of unmanned aerial vehicles (UAV) started long back. The purpose of this project was to make a new innovative approach to the designing of UAVs for better use in the field of surveillance and commercial photography and videography. The UAV was designed in such a way that holds the camera connected to a wireless transmission system, this feeds the live information to the ground station. This UAV housing with many sensors such as GPS and IMU sensors. CATIA v5 tool was used to design this UAV and Autodesk flow was used for simulation and testing. This UAV can be used in military and civilian applications such as aerial photography, videography, field surveillance, disaster relief, and many more. However, most of the UAVs in the present market are expensive and have more weight. To overcome these issues, we introduced a new lightweight and cost-effective UAV which can be able to perform surveillance and feed the data in real-time to the user. Our team did deeper background research on UAV and come up with a new UAV approach that can have 3105 grams of weight with 5 to 10 KM of range and 45min of endurance. This gives strong competition to many UAVs which exist in the market.

Keywords: UAV, GPS, Autodesk flow, Inertial Measurement Unit (IMU)

INTRODUCTION

The design approach of unmanned aerial vehicles (UAVs) has been growing rapidly over the past many years. This project is to make a new innovative approach to the designing of UAVs for better use in the field of surveillance and commercial photography and videography [1, 2]. It has a camera with a wireless transmission system, this system telecasts live video to the ground station. This UAV Includes GPS and IMU sensors. This project has Design, simulation, and testing [3, 4]. However, most UAVs are expensive and weigh more [5]. So, this project has been made with a lightweight drone capable of performing surveillance [6]. The main purpose of this project is to reduce drone weight, be more cost-effective, and have high endurance which can perform good surveillance [7]. Every air vehicle structure undergoes torsion and bending loads while flying at high speed and UAVs are undergoing deformation by ultraviolet radiation and intense solar heat. So, the UAV has a high strength-to-weight ratio, flexible to handle at high speed, and has good thermal resistivity. The UAV wing structure is made from Foam sheets [8, 9]. A foam cutter was used to cut them. The solid foam was used to build the wing to achieve proper airfoil shape and to gain structural strength and it is easy to machine. Balsa wood was used during wing fabrication [10, 11]. Foam sheet was the main material that has been used for manufacturing most of the parts because it's very ductile which helps in absorbing shock loads during landing [12]. The XPS foam is the high-density foam this was used to mount the motor because this is vibration-resistant material and provides better strength for holding the motor. Fiber tape was used in the joints because fiber tape gives good strength to joints and Glue is used to mount the GPS, IME

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sensors. Thus, the selection of the material was done carefully so that they can provide enough strength to withstand the load. For wings, first, we calculated and decided the dimensions of the wing, Solid foam, and Balsa wood were used for manufacturing the wing. A high-lift NACA 6412 airfoil [13] was used in this UAV which produces a high lift at the tip of the wing and a comparatively low lift at the root. We used hotwire while fabricating the wing. Finally sanding, and glue was applied over the whole wing to get more strength and good surface finishing. The same procedure was used while manufacturing the fuselage and given its dimensions. Likewise, many parts of the UAV were fabricated and assembled using adhesives [14, 15]. Housings were given in each part to maintain the CG.

METHODOLOGY

A design and analysis methodology expressed with the help of flow chart right from conceptual design till production for easy understanding (Figure 1) and our design requirements and instruments to be used are listed below (Table 1).

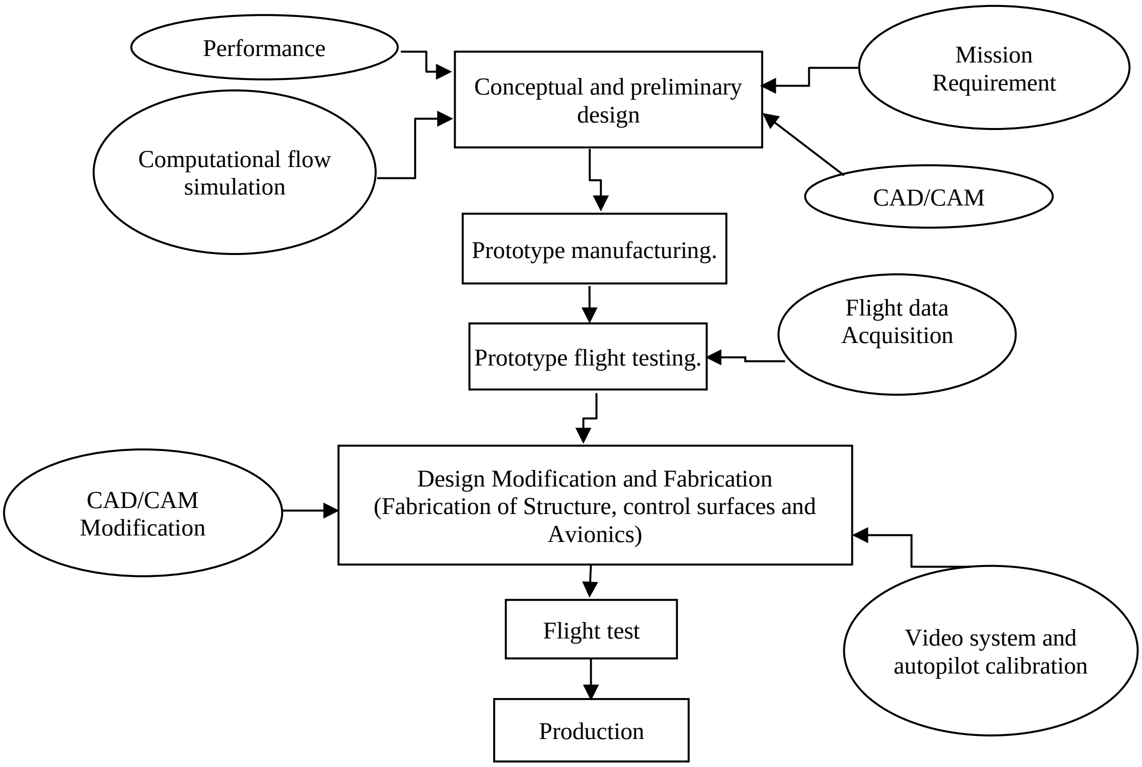


Figure 1. Design process.

Table 1. Design requirements.

Navigation	**GPS/RC UAV**
Endurance	45 min
Payloads	CCD camera, motherboard, and sensors
Data transmission range	5-10 km
Cruise speed	40 Km/h
Climb rate	2 m/s
Camera system	Stabilization camera in a safer location
Operation	One Man Operable
Airframe	Strong construction, repairable, inexpensive.
Propulsion	Electrical motor
Take-off and landing	Short Runway take-off and landing
Wingspan	2m

EXPERIMENTATION WORK

The UAV was designed and analyzed using various tools and software and its preliminary conceptual design was completed but as it was an advanced UAV so it's manufacturing required a lot of capital investment and resources which were not available so because of these reasons we decided to make another alternative generic design.

Weight Estimation

UAV weight distribution, (Table 2)

$W_0 = W_{Empty} + W_{Avionics} + W_{Battery} + W_{Propulsion}$

$W_o = 3.105$ Kg

Airfoil selection: The airfoil is a must for any airplane, which affects the take-off, landing, cruising, stall speed, aerodynamic efficiency, L/D, and many more. In this project, we focused on the cruising phase, not on the landing, take off, and loiter phase because the purpose of this UAV is surveillance, so the cruising phase is considerable. Considering this NACA 6412 (Figure 2) meets the required stall speed at the estimated Re. The upper surface showing in a yellow-colored line and the lower surface showing in a green-colored line, from this graph we can see the lower surface experiences more pressure, and the upper surface experiences less pressure resulting this produces the lift. The main reason for choosing the NACA 6412 airfoil is, this is more effective and suitable for small unmanned aerial vehicles, and from our background research we noted that most of the small unmanned aerial vehicles are using the NACA 6412 airfoil to get enough lift coefficient, from the Figure 2 we can see this producing enough lift even at zero degrees angle of attach, coefficient of lift is producing about 0.0678, the coefficient of drag is very negligible [13], using the CATIA we also calculated location of C.G in x-y-z coordinate system (Figure 3) and all the moments were balanced against C.G (Figure 4), the final C.G location is shown in Figure 5. Using CATIA we designed and assembled various model link wing, fuselage, landing system, internal structure components, the final model is demonstrated in Figures 6, 7, 8.

Table 2. Weight Estimation

Types of weight	S.N.	Part Name	Weight (grams)
Structural	1	Fuselage	160
	2	DC motor	155
	3	Controller	50
	4	Wing (right)	400
	5	Wing (left)	400
	6	Wing connector	60
	7	Elevator servo motor	30
	8	Rudder servo motor	30
	9	Power unit	600
	10	Propeller	20
	11	Stabilizer unit	250
	12	Tail pipe/boom	100
	13	Hatch	70
	14	Protective foam	40
	15	Other equipment	400
		Total	*3105*

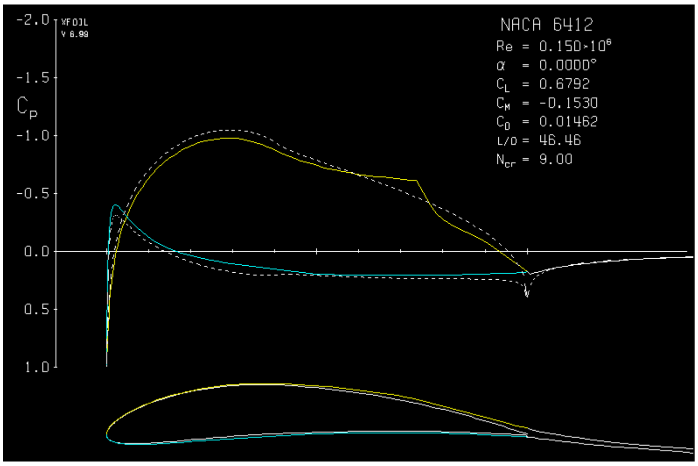


Figure 2. Pressure distribution graph.

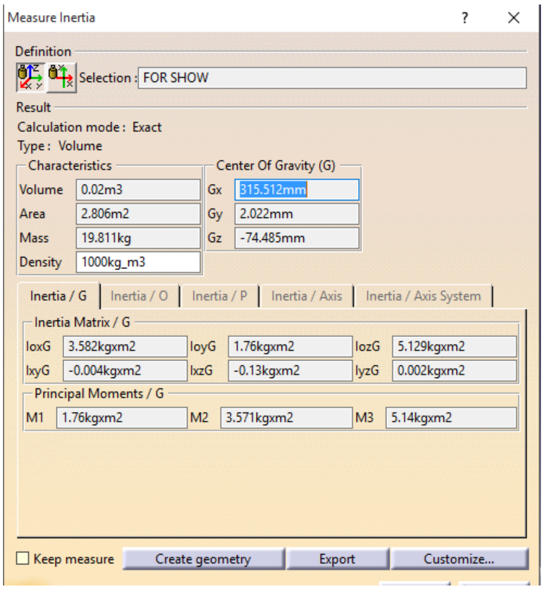
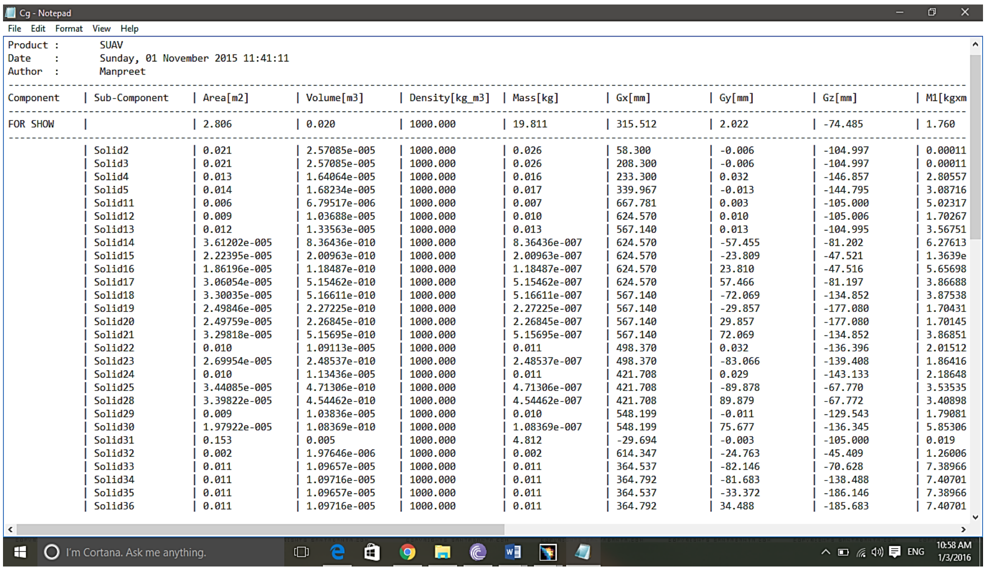


Figure 3. C.G location in X-Y-Z direction.



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Date : Sunday, 01 November 2015 11:41:11
Author : Manpreet

Component	Sub-Component	Area[m2]	Volume[m3]	Density[kg_m3]	Mass[kg]	Gx[mm]	Gy[mm]	Gz[mm]	M1[kgxm
FOR SHOW		2.806	0.020	1000.000	19.811	315.512	2.022	-74.485	1.760
	Solid2	0.021	2.57085e-005	1000.000	0.026	58.300	-0.006	-104.997	0.00011
	Solid3	0.021	2.57085e-005	1000.000	0.026	208.300	-0.006	-104.997	0.00011
	Solid4	0.013	1.64064e-005	1000.000	0.016	233.300	0.032	-146.857	2.80557
	Solid5	0.014	1.68234e-005	1000.000	0.017	339.967	-0.013	-144.795	3.08716
	Solid11	0.006	6.79517e-006	1000.000	0.007	667.781	0.003	-105.000	5.02317
	Solid12	0.009	1.03688e-005	1000.000	0.010	624.570	0.010	-105.006	1.70267
	Solid13	0.012	1.33563e-005	1000.000	0.013	567.140	0.013	-104.995	3.56751
	Solid14	3.61202e-005	8.36436e-010	1000.000	8.36436e-007	624.570	-57.455	-81.202	6.27613
	Solid15	2.22395e-005	2.00963e-010	1000.000	2.00963e-007	624.570	-23.809	-47.521	1.3639e
	Solid16	1.86196e-005	1.18487e-010	1000.000	1.18487e-007	624.570	23.810	-47.516	5.65698
	Solid17	3.06054e-005	5.15462e-010	1000.000	5.15462e-007	624.570	57.466	-81.197	3.86688
	Solid18	3.30035e-005	5.16611e-010	1000.000	5.16611e-007	567.140	-72.069	-134.852	3.87538
	Solid19	2.49846e-005	2.27225e-010	1000.000	2.27225e-007	567.140	-29.857	-177.080	1.70431
	Solid20	2.49759e-005	2.26845e-010	1000.000	2.26845e-007	567.140	29.857	-177.080	1.70145
	Solid21	3.29818e-005	5.15695e-010	1000.000	5.15695e-007	567.140	72.069	-134.852	3.86851
	Solid22	0.010	1.09113e-005	1000.000	0.011	498.370	0.032	-136.396	2.01512
	Solid23	2.69954e-005	2.48537e-010	1000.000	2.48537e-007	498.370	-83.066	-139.408	1.86416
	Solid24	0.010	1.13436e-005	1000.000	0.011	421.708	0.029	-143.133	2.18648
	Solid25	3.44085e-005	4.71306e-010	1000.000	4.71306e-007	421.708	-89.878	-67.770	3.53535
	Solid28	3.39822e-005	4.54462e-010	1000.000	4.54462e-007	421.708	89.879	-67.772	3.40898
	Solid29	0.009	1.03836e-005	1000.000	0.010	548.199	-0.011	-129.543	1.79081
	Solid30	1.97922e-005	1.08369e-010	1000.000	1.08369e-007	548.199	75.677	-136.345	5.85306
	Solid31	0.153	0.005	1000.000	4.812	-29.694	-0.003	-105.000	0.019
	Solid32	0.002	1.97646e-006	1000.000	0.002	614.347	-24.763	-45.409	1.26006
	Solid33	0.011	1.09657e-005	1000.000	0.011	364.537	-82.146	-70.628	7.38966
	Solid34	0.011	1.09716e-005	1000.000	0.011	364.792	-81.683	-138.488	7.40701
	Solid35	0.011	1.09657e-005	1000.000	0.011	364.537	-33.372	-186.146	7.38966
	Solid36	0.011	1.09716e-005	1000.000	0.011	364.792	34.488	-185.683	7.40701

Figure 4. Moment about CG.

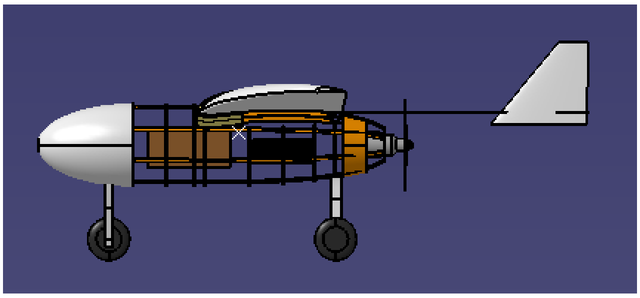

Figure 5. C.G location marked on 3D side view.

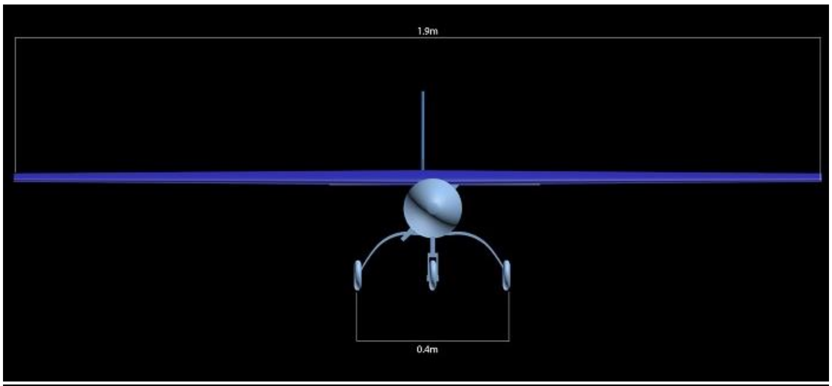

Figure 6. Front view of our designed UAV.

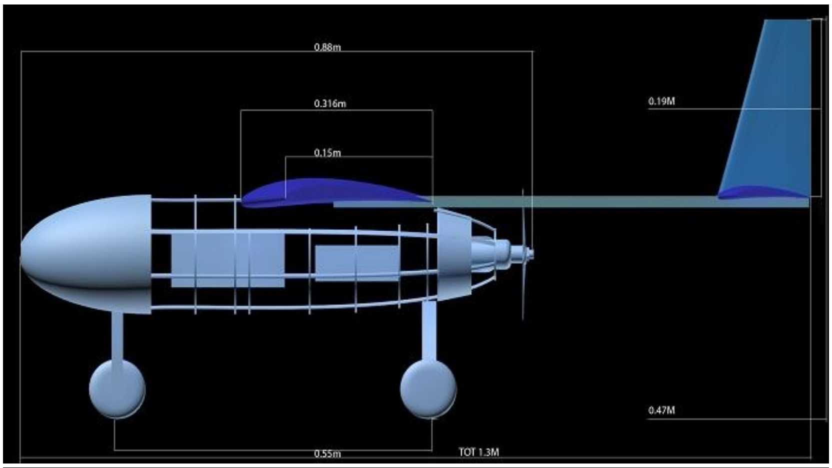

Figure 7. Side view of UAV.

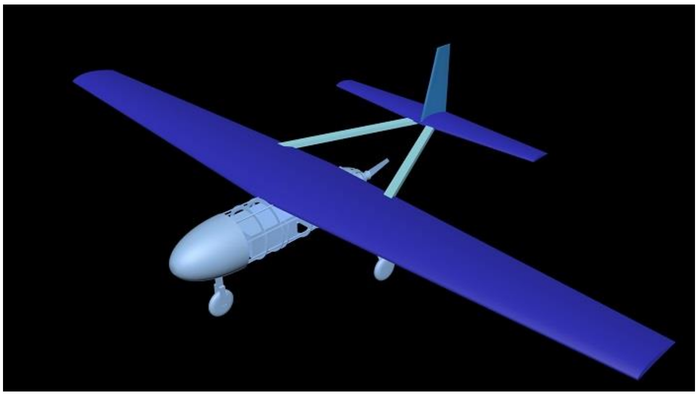

Figure 8. Isometric view of UAV.

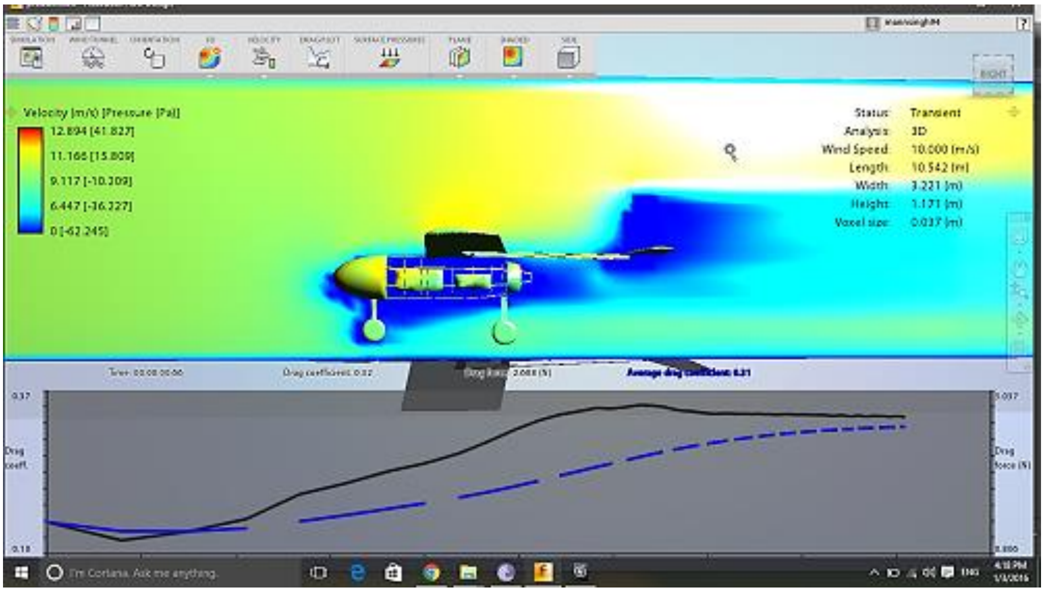

Figure 9. Velocity and pressure distribution.

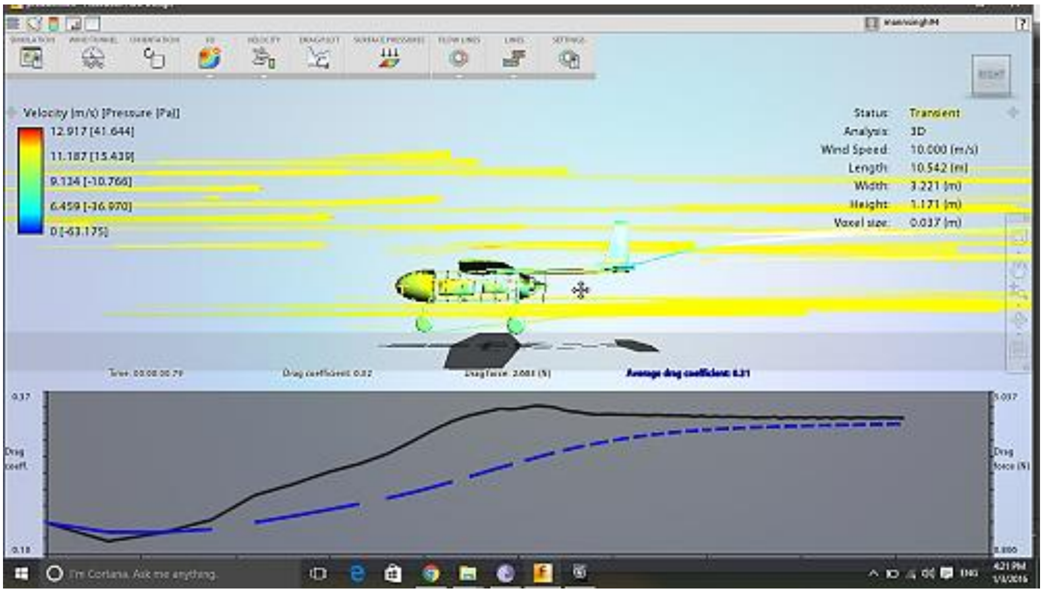

Figure 10. Flow lines visualization.

RESULTS AND DISCUSSION

The Analysis of the design was carried out using software like Autodesk Flow Design. Autodesk flow Design is an interactive software application in which we can import our design and perform wind tunnel simulations for observing the pressure and velocity distribution around the aerodynamic body design when exposed to airflow. The basic parameters like the length of the wind tunnel and wind speed can be set as desired according to our requirements. Figure 9 clearly indicates the pressure and velocity distribution for the complete body, and Figure 10 shows the airflow type as a part of the wind tunnel simulation for the complete body.

CONCLUSION

This UAV has a lightweight of around 3000 grams, it is most efficient at a cruising speed of about 40km/s. A suitable motor was used to achieve a good range of about 5 to 6 km and a 40-minute endurance. However, the real data transmission range is about 5 to 10 km. The UAV is designed not only for flight requirements but also for an inexpensive product. The UAV costs much less than the

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other UAVs which are available in the market. It is very easy to replace any parts after being crushed. This UAV is durable, and it can withstand even after three crashes.

REFERENCES

1. Lee, K. (2004). Development of unmanned aerial vehicle (UAV) for wildlife surveillance (Doctoral dissertation, University of Florida).
2. Bowman, R. (2004). Large Unmanned Vehicles. Volume 9, 55-56.
3. Lennon, A. (2005). R/C Model Aircraft Design. Air Age Media Inc., United State of America.
4. Jung, S. (2004). Design and Development of Micro Air Vehicle: Test Bed for Vision-Based Control (Doctoral dissertation, MS thesis, Mechanical and Aerospace Engineering Department, University of Florida).
5. Erick Purwanto, Jeremy Smith Lightweight UAV Image Segmentation Model Design with Edge Feature Aggregation (, Conference: 2023 International Conference on Platform Technology and Service.)
6. Abdelrahman, M. M., Elnomrossy, M. M., & Ahmed, M. R. (2009, May). Development of mini unmanned air vehicles. In International Conference on Aerospace Sciences & Aviation Technology.
7. Parsch, A. (2004). AeroVironment FQM-151 Pointer. Directory of US Military Rockets and Missiles.
8. Tuton Mallick, Mohammad Ariful Islam Bhuyan, Mohammed Saifuddin Munna.;2016 International Conference on Innovations in Science, Engineering and Technology (ICISET), Design & implementation of an UAV (Drone) with flight data record
9. Thome, D. M., & Thome, T. M. (2000). Radio-controlled model airplanes: inexpensive tools for low-level aerial photography. Wildlife Society Bulletin, 343-346.
10. F.B. da Silva S.D. Scott M.L. Cummings ; Design Methodology for Unmannded Aerial Vehicle (UAV) Team Coordination.
11. Jones, G. P. (2003). The feasibility of using small unmanned aerial vehicles for wildlife research (Doctoral dissertation, University of Florida).
12. Raymer, D. P. (1992). Aircraft design. A conceptual approach. Ian R. McAndrew, Elena Visnehvskaya, and Kenneth L. Witcher Establishing Angle of Attach for NACA 6412 Twin-Wing on Take-off Downwash Influences on Lift and Drag
13. Zakaria, M. Y., Abdallah, M. M., & Elshafie, M. A. (2012, May). Design and production of small tailless unmanned aerial vehicle (SAKR 2). In Proceedings of the 15th AMME Conference.
14. Viieru, D., Albertani, R., Shyy, W., & Ifju, P. G. (2005). Effect of tip vortex on wing aerodynamics of micro air vehicles. Journal of Aircraft, 42(6), 1530-1536.

