1) Project reference number:- 46S_BE_4902

2)Title:- DESIGNING AND FABRICATION OF TAIL SITTER DRONES TO USE THEM FOR SURVEILLANCE AND MAPPING WITH LONG-RANGE COVERAGE. ADVANCEMENT OF TAIL SITTER AND USE IT FOR INDUSTRY USAGE

3) Name of the College: BMSCE
Department: Mechanical Engineering

4) Details of students and guide:-
Project members:-
Name: AHMED ZEEDAN
Email id: ahmedzeedan.me19@bmsce.ac.in
Mobile No:+917295895522

Name: ISHAN JAIN
Email id: ishanjain.me19@bmsce.ac.in
Mobile No.:+918770461177

Name: SANKET SINGLA
Email id:sanketsingla.me19@bmsce.ac.in
Mobile No.:+917377562217

Name: SUSHANT SINGH PAGARIA
Email id: sushantsingh.me19@bmsce.ac.in
Mobile No.:+918058950005

Name of Project Guide:- Dr. Sudarshan B.
Email id: bsudarshan.mech@bmsce.ac.in
Contact No.: +919480232406

5) Keywords :- VTOL, Tail-sitter, Hovering, Transition, Level flight

6) Introduction:-

A Tailsitter UAV is a fixed wing system capable of vertical takeoff and landing without using runways like traditional fixed wing aircraft. It has 3 phases of flight namely hover, transition and level flight. The transition phase occurs between hover to level flight and vice-versa. During transition the vehicle transverses a 90 degree angle to its new orientation.[1,6]

The quadrotor tail-sitter UAV consists of a off the shelf airframe called X5 flying wing and four motors that are symmetrically located around the airframe thus reducing the effect of slipstream in turn reducing loss of lift[3,4]. The developed aircraft uses only the four rotors for full attitude and altitude control for both hovering and level flight.[2,3]

The developed tailsitter was designed taking in consideration aspects that meet industry requirements hence the design of the tailsitter was developed by combining aspects of a glider for greater aspect ratio and increased range and the maneuvering capability of a quad-rotor drone[5].

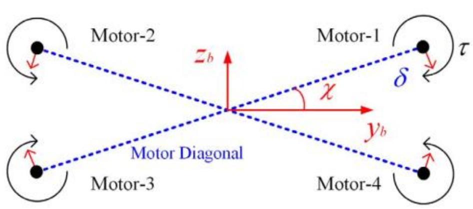
This design can maneuver without the use of control surfaces such as aerolons by only varying rpm of motors thus reducing the complexity of design and control system and also reducing the overall cost by eliminating the use of servo motors which are used for controlling the control surfaces.[3,4]

7) Objectives:-

1. Design and fabrication of a tail-sitter drone to use them for surveillance and mapping with long-range coverage.
2. Advancement of tail-sitter and use it in industry and integration of fixed-wing aircraft and fixed rotor mechanisms.
3. Flight testing of the fabricated tailsitter with various mission objectives. Recording and analysis of performance parameters for optimization

8) Methodology:-

8.1) Configuration selection- The tail-sitter airframe employs an astrix configuration .Four rotors are used for full attitude and altitude control for both hovering and level flight. The motor was inclined along the motor diagonal axis by δ=15 deg to augment the roll moment induced by motor thrust . The motor inclining direction is properly arranged such that the moment direction produced by thrust is the same as motor torque τ . χ is the azimuthal angle of the first motor. The other three motors are symmetrically located around the airframe.



8.2) Material Selection-

Carbon fiber was chosen as body and frame material due to its various properties such as strength, stiffness, lightweight and its ability to be 3d printed.

8.3) Mass Estimation-

Item	Mass (g)	Quantity	Total Weight (g)
Motor	75	4	300
LiPo battery	500	1	500
ESC	30	4	120
FCU, GPS, power module, receiver and transmitter, gyroscope,BEC	130	1	130
Propeller,Consumables (bolts, cables, nuts, cable ties, glues,etc)	150	4+1	180
Carbon fiber tube and rods	2.5	1	2.5
Carbon fiber frame	500	1	500
Payload	1	190	190
Total All-Up-Weight			1922.5g

8.4)Airfoil Analysis and Selection-

Individual analysis of different airfoils was performed using the XFLR-5 software to determine various factors such as Cd, Cl, Cm as well as Cl/Cd. Curves against angle of attack were analyzed for a given range of Reynolds no. (20 thousand -3 million) and MH60 airfoil was selected for wings and MH92 for fuselage.

8.5) Fabrication-

CAD model of the drone structure was developed and 3D printing is underway, after which all electronic components will be integrated.

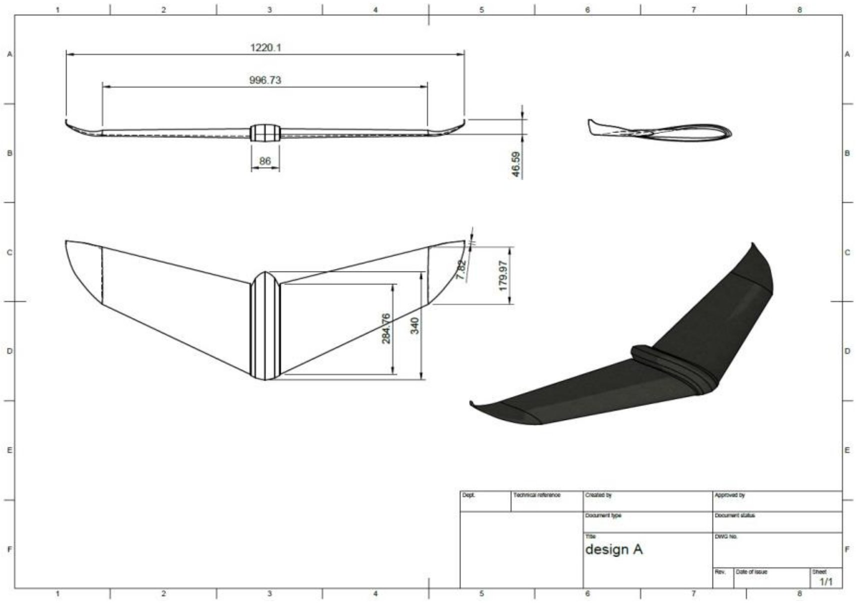


Fig 2- CAD model

8.6) Control System configuration-

Pixhawk(v2.4.8) flight controller was selected with ardupilot firmware for calibration of flight parameters, a 5v BEC provides backup power in case of a failure, other components include a GPS module, power distribution board, ESCs, Li Polymer battery and PPM receiver with Transmitter.

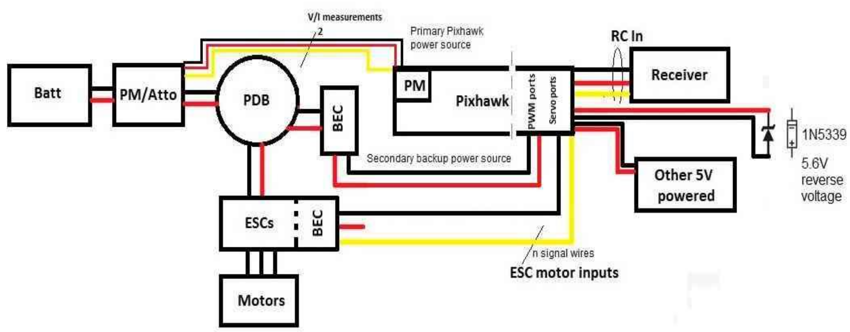


Fig 3- Pixhawk connections

8.7)Flight testing :- flight tests will be carried out and results will be recorded.

9) Results and Conclusions:-

1) Lift, Drag and Wing loading were calculated for the CAD model on XFLR5 software.

Projected Wing Span	1.2 m
Projected Area (A)	0.266 m^2
Cl at 4 degrees AoA	0.45 at 15 m/s or 54 km/hr
Lift Generated	16.26 kg
Cd at 4 degrees AoA	0.011
Drag Generated	397 g
Wing Loading	7.107 kg/m^2

[eq.1-$Lift = \frac{1}{2} \times Cl \times d \times v^2 \times A$] [eq.2- $Drag = \frac{1}{2} \times Cd \times d \times v^2 \times A$]

2)Result of Component configuration analysis done on Xcopter from ecalc software

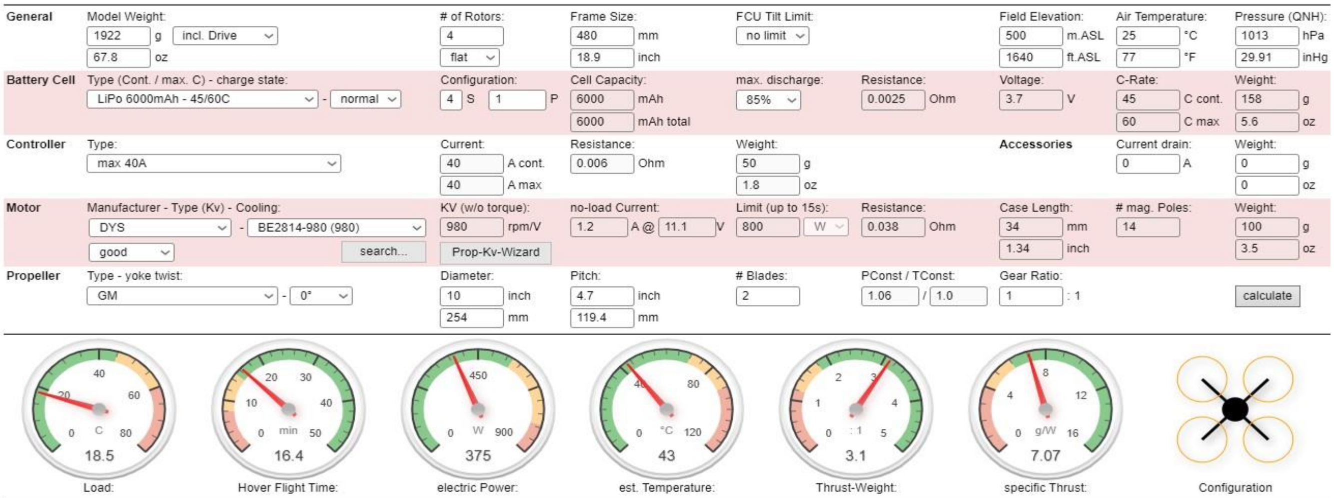


Fig 4- Xcopter analysis

3) Conclusion will be drawn after flight testing is performed and data is recorded and analysis is performed.

10) What is the innovation in the project:-

This novel design combines the aspects of gliders to produce higher lift value than previous designs which increases Range of the drone. Complete elimination of control surfaces reduces the complexity of design and control system.

11) Scope for future work:-

1. Increasing the load carrying capacity for pick up and delivery usage.
2. Increasing range and speed for optimal performance.
3. Quicker transition from hover to level flight and vice-versa without gaining or losing much altitude.

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