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Design and Development of Vertical Take-Off and Landing (VTOL) Drone for Surveillance

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Abstract*: It is a difficult task that necessitates a multidisciplinary approach to build and develop vertical take-off and landing (VOTL) drones for surveillance. This paper details the entire design development process, with the aim of explaining the design steps and performance analyses, including energy consumption, of a quadcopter, fixed wing (FW), (VTOL), and unmanned aerial vehicle (UAV), from the identification of the requirements and Specification through the selection of the proper material and components to the implementation of the control system. Typically, fixed-wing unmanned aerial vehicles can fly for longer than multi-copter aircraft. although one is required. since it is unlikely that the city region will have wide runways. The creation of a fixed-wing capable of vertical take-off and landing (VTOL) is required. Our aim was to create a steady transit flight in a VTOL aircraft. We created a test VTOL plane in order to accomplish this. The creation of the drone includes choosing strong, lightweight materials, such as EPP (Expanded Polypropylene) for the body and aluminium for the square bar pipe. It also entails developing the internal structure. Four BLDC motors and propellers are used for take-off, while one BLDC motor and propeller are used for propulsion. A flight controller (Pixhawk cube orange) is in charge of maintaining control and stability during flight. The drone's onboard system is used to implement the control system. The transmitter (Fly Sky i6s) and receiver (10 channels) that make up the onboard system regulate flying parameters. The result of this project is a highly effective and capable VTOL drone for surveillance that may be utilized for a variety of tasks, including delivery, disaster management, infrastructure inspection, and mapping.

***Keywords*: VTOL, Quadcopter, Fixed wing, UAV, Pixhawk cube orange.**

1. Introduction

Unmanned aerial vehicles UAVs are also known as isolated and reusable powered aerial vehicles [1]. These vehicles are remotely controlled, semi-autonomous, and autonomous and have a mixture of these capacities. The unmanned aerial vehicle (UAV) development has led to a revolution in the surveillance and reconnaissance industry.

The ability of vertical take-off and landing (VTOL) drones to take off and land in limited space without the need for a runway or launch or recovery mechanism has drawn a lot of attention among the various type of UAVs. This paper provides an overview of the design and development of a VTOL drone for surveillance purposes highlighting the crucial design aspects, such as the choice of the proper parts and material the implementation of the control system, and testing and validation of the drones performances and also the research highlights the significances of a methodical and iterative design process, which includes the identification of the requirements and specification.

The conceptual design and the detailed design of the manufacturing and assembly of the drone. The project's end product is a highly effective and competent VTOL drone for surveillance that may be utilized for a variety of reasons including border control, law enforcement, and disaster management with little danger to people to their property. This study aims to design and develop a vertical take-off and landing (VTOL) UAV, Utilizing both quadcopter and fixed-wing advantages while minimizing their respective drawbacks. The VTOL drone represents a highly efficient solution for aerial surveillance and reconnaissance mission

A. Objective

1. With a launching space requirement of only 9 sq. meters, our drone can take flight in even the tightest of spaces.
2. Our drone's ability to land in a Symmetric terrain and take off without needing a level launching pad gives it unparalleled flexibility.
3. Boasting a high endurance of up to 60 minutes and an operational radius of 10 km, our drone is built to go the distance.
4. Thanks to its quick swappable design, our drone is capable of handling multiple payloads with ease and efficiency.

B. Theory

What is a drone? A drone is an Aerial/Ground/underwater vehicle without a human pilot on board. Known as an Unmanned Aerial Vehicle (UAV) or a Remotely piloted Vehicle (RPV). the entire system is known as an Unmanned aircraft system (UAS) or remotely piloted aircraft system (RPAS). The Unmanned aerial vehicle is classified into two main types: multicopper and fixed-wing. Using this combination, we created a new category of drone known as a VTOL. This paper is based on the hybrid drone.

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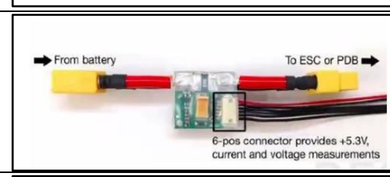
Table 1
VTOL drone components

Component	Description	Image
BLDC Motor	A motor with extended lifespan and high efficiency that is commonly used for rotating propellers in drones. It is important to consider factors such as speed, thrust value, and compatibility.	
Propeller	A rotating blade that provides thrust to move the vehicle forward. Propellers can be pusher or puller type and are designed to work with specific motors and ESCs.	
ESC	An electronic circuit that controls the speed of an electric motor and can provide braking and reversing capabilities. ESCs are available in both brush and brushless versions.	
Flight Controller	A circuit board with sensors that tracks drone motion and user commands to control the motor speed and direction. Popular models include DJI NAZA, Pixhawk 2.4.8, and Pixhawk Mini.	
Battery	A rechargeable lithium-ion battery with high energy density, low self-discharge, and no memory effect, commonly used in drones and other portable electronics.	
Power Module	A high-power electrical component that regulates voltage and provides 5-6.5 volts to the flight controller. It is connected to the battery and power distribution board (PDB).	
Power Distribution Board (PDB)	A board that distributes battery power to the ESCs and motors and generates power supplies for the autopilot and peripherals at various voltage levels.	
Transmitter and Receiver	A set of devices that wirelessly transmit and receive commands using radio signals, allowing for remote control of the drone.	

2. Aerodynamic Design Methodology and Analysis

Required Specification: Based on the market analysis of Fixed-wing VTOL UAVs we identified the basic performance capabilities and finalized them as below. All Up Weight – 2kg (Estimated from historical data) Max payload 0.500 kg Endurances 60 min Cruise Speed 20m/s operation range 10 Km radius

Aerofoil Selection: To select the right aerofoil for the wing, we calculated the design lift coefficient using W=L = 1/2 ρ V2 × S × CL Design lift coefficient was calculated as 0.544 Now based on the Design lift Coefficient the aerofoil selected is NACA4418 with reference to pre-analyzed graphs from NACA Aerofoil’s Official Website.

Based on this analysis and research we designed the wing with the above-selected aerofoil (NACA4418).

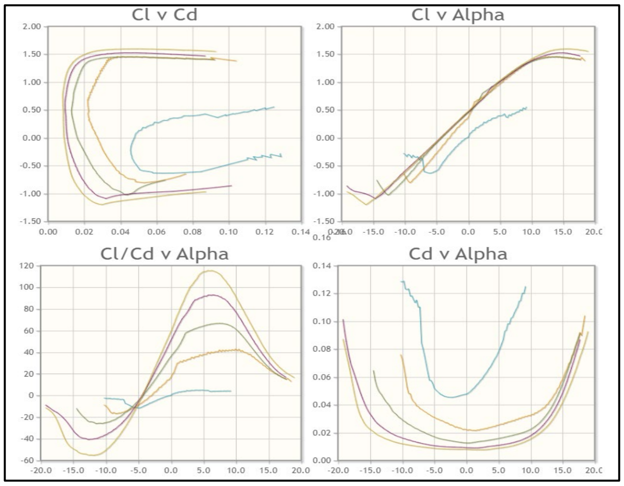


Fig. 1. Analysis of aerofoil NACA 4418

3. Result and Discussion

A. Design Parameter

The body of the airframe is made from EPP foam. The 4 motors are mounted on an Aluminium square bar. The wing is supported by a rod made from Aluminium. The body is attached using the Strong Solution Araldite adhesive to strengthen the structure due to high vibration when hovering. As shown in Fig. 2 the total weight of all the components excluding the payload adds up to a total of 2 kg. Based on the software calculation and the weight of the aircraft.

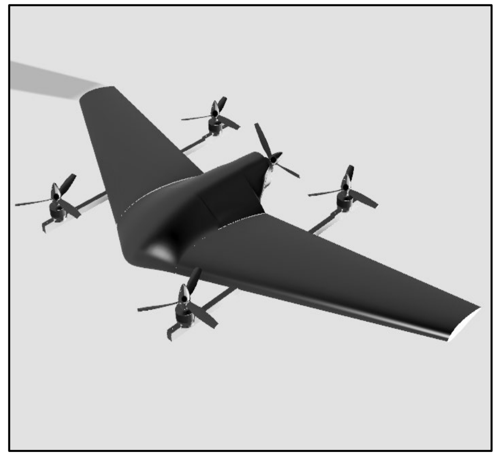


Fig. 2.

B. Component Layout

Once installed with the component, the end design is shown in Fig. 3 locations, where all major components are installed, labeled by alphabet A-H and the detail of the components are listed in Table 1.

Table 4

S. No.	Image	Transition Mode
1		Take off like multirotor
2		Transition from multirotor to fixed-wing configuration Operation (Fixed wing) Transition from fixed wing to multirotor config
3		Landing like multirotor

Table 2

Parameter	Value
Wing Span	0.900 m
xyProj. Span	0.900 m
Wing Area	0.147 m²
xyProj. Area	0.147 m²
Plane Mass	2 kg
Wing Load	10.218 kg/m²
Root Chord	0.350 m
MAC	0.185 m
TipTwist	0.000°
Aspect Ratio	5.518
Taper Ratio	0.257
Root-Tip Sweep	27.575°

Table 3

Alphabet	Indication
A	Fuselage
B	Main Wing
C	Elevon
D	Aluminium Square Rod
E	BLDC Motor
F	Propeller
G	Pusher Motor with Propeller
H	Transmitter

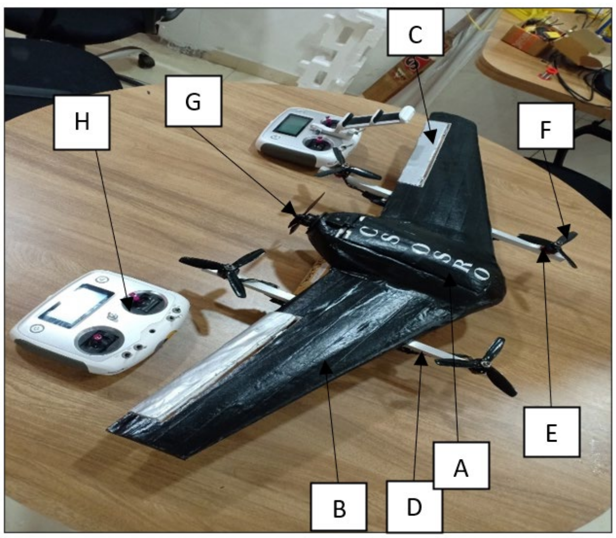


Fig. 3.

C. Flight Test

It is discovered that all five of the drone's motors are spinning at various rotations per minute (RPM), using a combined KV of 2300KV, when the drone tries to hover in manual flight mode. KV is a measurement unit for the rotations per minute (RPM) of an electric motor per volt applied. This drone has five motors in total.

4. Conclusion

With a focus on fixed-wing vehicles, a synopsis of VTOL development was presented. In order to verify the suggested design parameter, a test of the drone motions, including roll and pitch, is also done using flight charts. When providing input to the flight controller, the motion graph with the same orientation of the motor is more steady. The drone typically flies better when the motor is moving in the same direction as the drone rather than turning in a different direction due to increased stability. It is difficult to deploy the prototype in a way that fully achieves the stated goals due to a lack of facilities, resources, and equipment.

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