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Autonomous Agricultural Drone with Sprinkling System

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Abstract
The quadcopter is one of the most widely used varieties of Unmanned Aerial Vehicles, or UAVs. This paper aims to build a drone with autonomous navigation capabilities. A sprinkling system was installed over the quadrotor to spray the desired fertilizers in the given area. The process of creating a quadrotor using a mechatronic design methodology—which considers the design of mechanical, electrical, software, and control components simultaneously—is explained in the article. The simulation findings for pitch and roll altitude control are also presented in the study. The investigation's findings include suggestions for choosing motors, propellers, batteries, and electrical speed controls wisely so that anyone with a desire might construct one by themselves.
Keywords : *Agricultural Drone; World Health Organization; X-frame; Power plant selection.*

1. Introduction
The World Health Organization (WHO) estimated that manually applying pesticides to crops could result in up to one million illness incidents. WHO. Manual spraying of pesticides is time-consuming and inefficient as compared to automated sprinkling. Unmanned Aerial Vehicle (UAV) is one of the most important developments in agricultural production. Crop monitoring can be extensively performed using these devices. [1]. Drones prove to be of great assistance in precision farming which includes data collection using high-precision sensors and remote satellite technologies. Deployment of UAVs is preferred in the agricultural field due to modest maintenance and acquisition costs, reduced set-up time, and ease of flying. [2]. With the proper application of drone technology, drones can cover 10 to 15 times the area that can be covered by conventional land-based methods. Drones are used to perform various tasks on the field such as estimating soil conditions, planting future crops, fighting infections and pests, agriculture spraying, crop surveillance, and livestock monitoring. [3]. To Make the technology user-friendly, the integration of Wi-Fi with a GPS module has proved to be successful for drone navigation by the pilot. [4]. In the future, autonomous technologies will become more beneficial and sustainable in the field of agriculture. [5] Autonomy in drone flight implies that it can operate independently with minimum human intervention. B. [6] Autonomous robotic vehicles promise substantial development in agricultural production using various sensors like altitude sensors, positioning sensors, etc. [7]. The use of drones and their integration with recently developed technologies like the Internet of Things (IoT), Big Data Analytics (BDA), blockchain technology, etc. can increase overall agricultural production. [8]. Drones implemented with augmented reality (AR) technology are used to analyze soil samples and create topsoil maps of the field. [9]. 1. To maintain spraying accuracy, technologies like edge intelligence are in use. It identifies the locations in real-time with the maximum pests and sprays in those locations only to reduce the wastage of energy and pesticides. [10]

2. Methodology
Implementing an autonomous agricultural system on a drone involves precise calculations, power plant selection, CAD (Computer Aided Design) modelling, drone dynamics, and experimental testing to ensure

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successful development and deployment of the drone. In our research, [11] we employed a structured implementation process for configuring and deploying a Pixhawk flight controller using Mission Planner software. Initially, we opened Mission Planner and proceeded to set up the Pixhawk device within the software environment. Firmware setup was conducted meticulously to ensure compatibility and optimal performance. Calibration procedures were rigorously performed, encompassing accelerometer, gyro, and compass calibration for precise sensor readings. The establishment of a reliable connection between the receiver (RX) and transmitter (TX) was pivotal, utilizing a FlySky 10-channel RX-TX system. Telemetry integration with the Pixhawk facilitated real-time communication and data exchange, crucially indicating readiness for mission planning upon achieving GPS 3D fix confirmation. Subsequently, waypoint missions were meticulously planned within the Mission Planner interface, defining specific navigation points for autonomous flight operations. Upon completion of mission planning, the mission was seamlessly uploaded to the Pixhawk via telemetry transmission. Furthermore, the implementation encompassed assigning three distinct tasks to a designated three-way switch on the transmitter: stable flight mode, mission execution mode, and automated landing mode. With these preparations concluded, the system was primed for safe and efficient flight operations. The detailed procedure for the development of autonomous agricultural drones is given in this section. Figure 1 shows the project flow diagram for the development of the proposed drone.

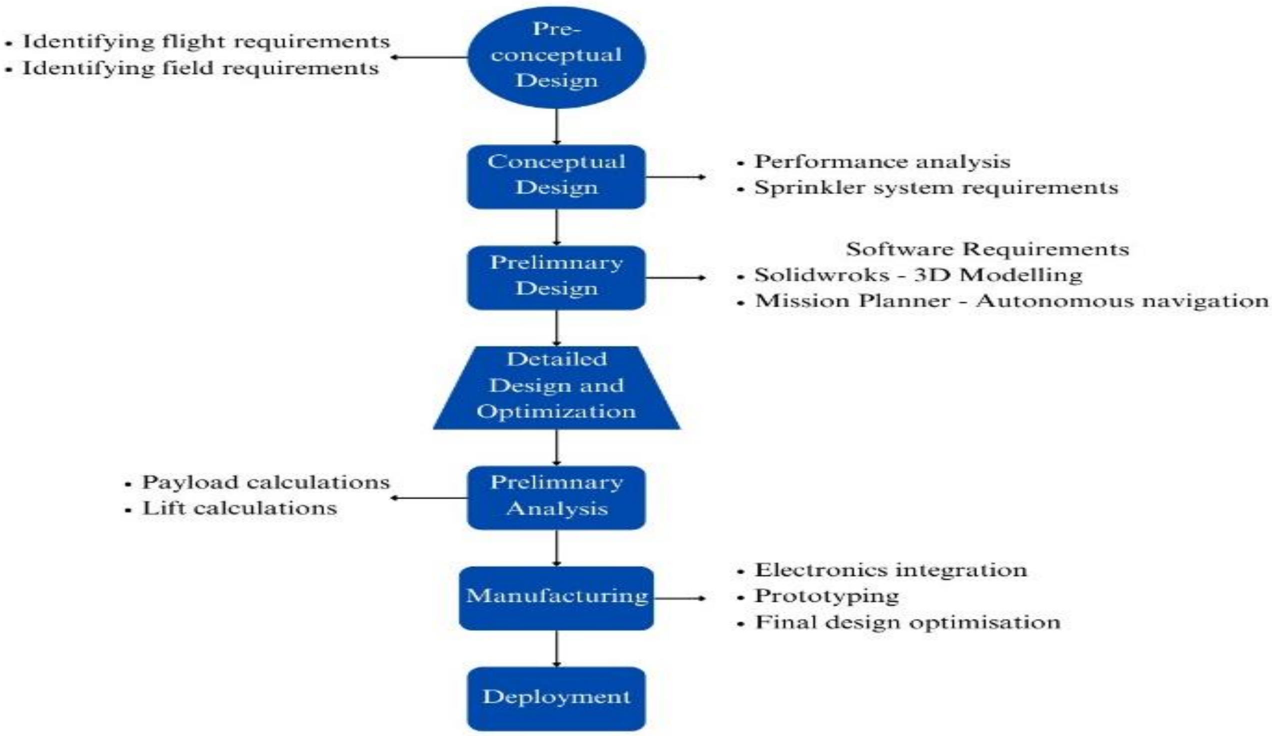

Figure 1 Process Flow Diagram

2.1 Frame Selection

Opting for an X-frame configuration for the agricultural drone offers benefits for efficient and effective operations. With its symmetrical design, the X-frame provides inherent stability during flight, essential for precise maneuvering and data collection in agricultural settings. The frame chosen by us for this drone is an ff450 frame made of glass fiber and polyamide nylon. Figure 2 shows the dimensions of the drone frame.

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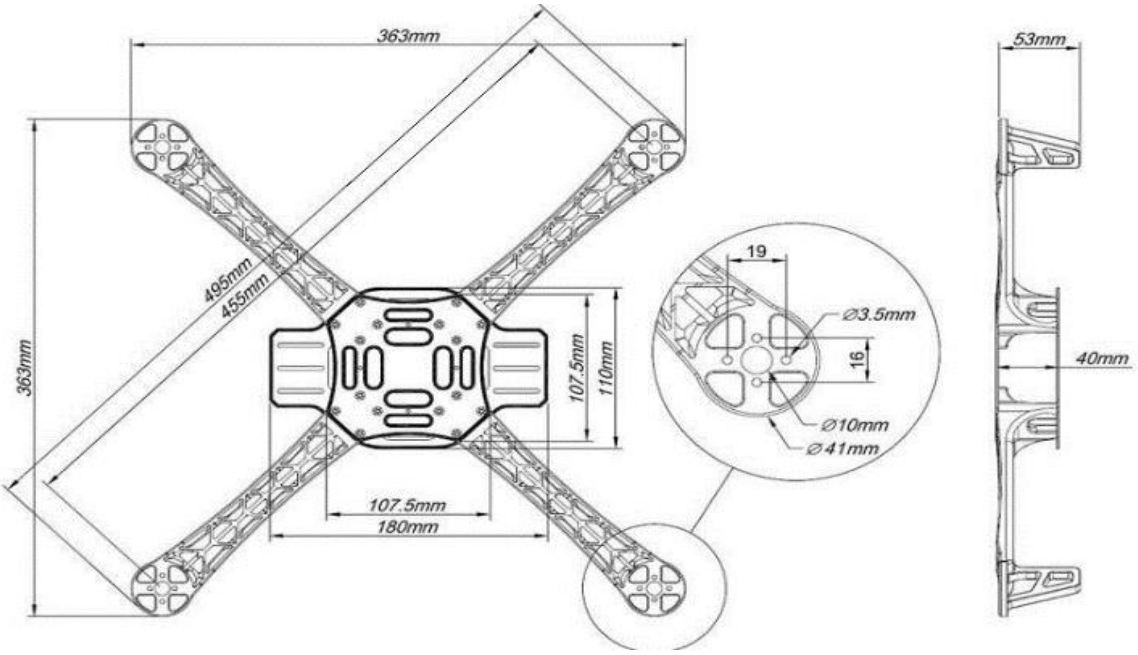

Figure 2 FF450 Drone Frame

2.2 Power Plant and Electronics

Power plant selection includes the electronic and electrical components used for the design. Table 1 and 2 shows the electronic components used for the application.

Table 1 List of Components Used and its Specification

Components Used	Quantity	Specifications
Ready to Sky BLDC Motor	4	920 KV
Electronic Speed Controller	4	40 A
FLY SKY FS i6x Radio Receiver	1	10 Channel
Orange 1500 mAh 3S Lithium Polymer Battery	1	11.1 V 1500 mAh 30C
XT60 Plug	1	-
Pixhawk	1	32-bit ARM Cortex M4 Core with FPU
GPS Module	1	NEO-M8N GPS
Telemetry Module	1	915 MHz 100 MW Power
Power Module	1	-
Hydraulic Pump	1	12 V, 5 A

Table 2 Specifications of the Motor Used

Ready to Sky BLDC Motor		
	Propeller Used	10 x 4.5
	Thrust (gm)	617
	Rotations per minute	12,600
	Power (watts)	

2.3 Circuit Diagram

The apt correlation and combination of the above-mentioned components are done using an electrical circuit. The Pixhawk controller is the brain of the system. It is the main device used for autonomous navigation. The transmitter (and receiver), motors, GPS module, and battery are connected via the Pixhawk microcontroller.

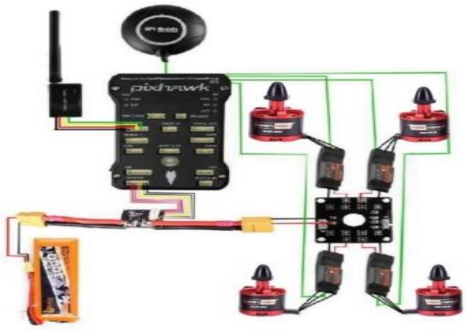

Figure 3 Circuit Diagram

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3 Implementation

3.1 Software

The primary objective of this drone is to fly autonomously with minimal human intervention. This task was achieved in Mission Planner software. GPS sensor, transmitter, and receiver data configuration were performed. Flight control software provides the drone with control algorithms and sensor fusion to fly it autonomously and accurately. Collecting mapping data and using algorithms to plan and track autonomous flight paths is the next task in flight in operation. Carefully generating waypoints and allocating coordinates helps in mission path generation. The drone precisely flies over the given coordinates following the described path at a known altitude. Figure 3 .

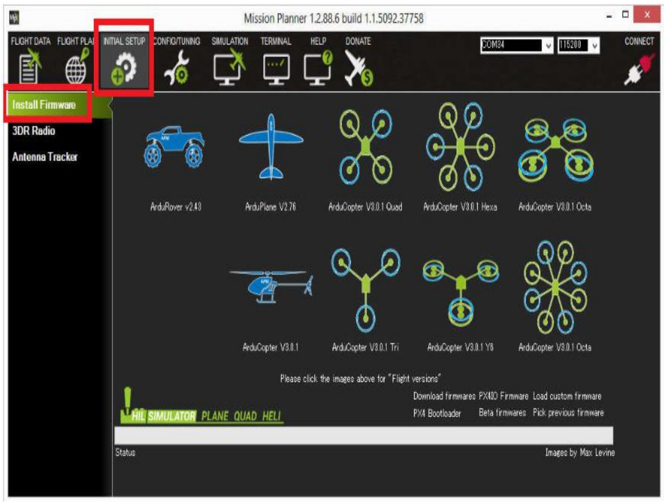

Figure 4 **Initial Setup and Drone Configuration**

Figure 5 **Fully Calibrated Drone Prepared for Path Allocation**

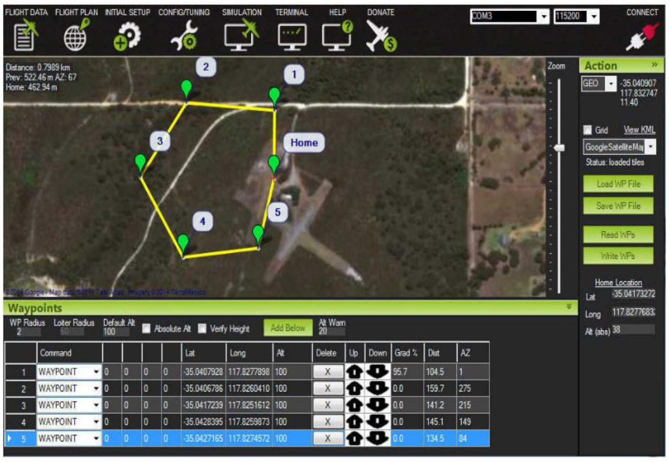

Figure 6 **Waypoint Generation for Flight**

3.2 Sprinkler Mechanism

The container is designed to hold 1-litre capacity. It is designed in such a way that it perfectly assembles at the base of the drone providing a sturdy grip and acting as a base of the drone. Figure 6 shows the container has two openings, first to which the hydraulic motor is connected for efficient spraying, and second, the one used to refill it. Figure 4 shows the container as well as its assembly with the drone. At higher altitudes to achieve perfect atomization of the contents inside the container, the motor must have the capability to suck the fluid and convert it into droplets using a sprinkler nozzle. Figure 7 and 8 shows the hydraulic pump with 60-watt power proves useful for the current application. The pump weighs 80 grams and has a volume of 10 cubic centimeters. Figure 5 shows the pump used for the application.

Figure 7 **12 Volt DC Hydraulic Pump**

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Figure 8 Sprinkler System Tank

4 Results and Discussion

The flight testing was performed at 40 m altitude at stable conditions. Figure 11 shows Flight testing simulation had also been performed on Mission Planner. The factors considered for the testing simulation are shown in Figure 9. and the results of the simulation are shown in Figure 10.

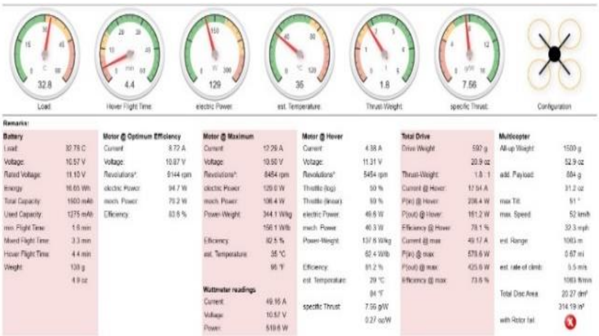

Figure 9 Flight Testing Simulation Parameters

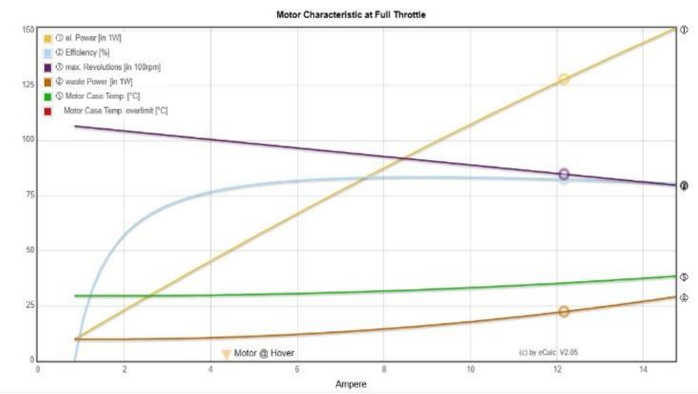

Figure 10 Flight Testing Result

Figure 11 Final Prototype

Conclusion

In conclusion, the manufacturing of autonomous agriculture drones represents a significant advancement in modern farming practices. The integration of cutting-edge technology into the agricultural sector brings forth a range of benefits, from precision farming to increased efficiency and sustainability. Here are key points summarizing the manufacturing process and the impact of autonomous agriculture drones. A possible paradigm change in agricultural practices is demonstrated by the creation and application of the autonomous drone system for pesticide sprinkling. This technology delivers unmatched precision and efficiency thanks to its utilization of LiPo batteries, BLDC motors, GPS, Mission Planner software, telemetry, and Pixhawk. Our testing findings show how the system applies pesticides selectively while lowering operating expenses and its negative effects on the environment. This independent approach reduces the number of pesticides that humans are exposed to while simultaneously increasing crop output as we move closer to sustainable agriculture. The potential for broad adoption is highlighted by the seamless integration of hardware and software components, which represents a critical turning point in the development of contemporary farming methods.

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