

# Hexacopter Food Delivery Drone

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**Abstract**—The rapid evolution of unmanned aerial vehicle (UAV) technology has positioned multirotors as a transformative solution for urban logistics, particularly in the food delivery sector. This paper presents the design, integration, and performance analysis of a high-stability hexacopter system optimized for autonomous payload delivery. Utilizing an F450 frame modified for a six-rotor configuration, the system is governed by the Pixhawk Flight Controller, which manages complex stabilization algorithms and mission planning.

Precision navigation is achieved through the integration of an MN8 GPS Module, ensuring high-accuracy waypoint adherence, while a dedicated Telemetry Module provides real-time data link capabilities for ground station monitoring. The propulsion system comprises high-efficiency brushless motors regulated by Electronic Speed Controllers (ESCs), powered by a high-discharge Lithium-Polymer (Li-Po) Battery. Centralized power management is facilitated by a Power Distribution Board (PDB) to ensure electrical stability across all subsystems.

Experimental results demonstrate that the hexacopter configuration offers superior redundancy and lifting capacity compared to traditional quadcopters, maintaining flight stability even in the event of partial motor failure. The study concludes with an evaluation of flight endurance, payload-to-weight ratios, and the efficacy of autonomous delivery missions in simulated urban environments.

**Index Terms**—Li-Po Battery, Pixhawk Flight Controller, MN8 GPS Module, Electronic Speed Controller (ESC), F450 Frame, Telemetry Module, Power Distribution Board (PDB)

## I. INTRODUCTION

The rapid evolution of Unmanned Aerial Vehicle (UAV) technology has transitioned from military applications to a transformative force in the

commercial logistics sector. In an era where "on-demand" services define consumer expectations, traditional ground-based delivery methods increasingly struggle with urban congestion, high carbon emissions, and rising fuel costs. To address these challenges, autonomous aerial delivery systems specifically multirotor drones have emerged as a viable solution for the "last-mile" delivery of perishable goods and medical supplies.

This project focuses on the design and development of a high-performance Hexacopter optimized for food delivery. Unlike standard quadcopters, the six-rotor configuration provides enhanced payload capacity and critical redundancy; in the event of a single motor failure, the hexacopter can maintain stability and perform a controlled landing, ensuring the safety of both the cargo and the public.

## II. SYSTEM OVERVIEW

The proposed system integrates a robust hardware stack designed for reliability and autonomous navigation:

- **Flight Control & Navigation:** At the heart of the UAV is the Pixhawk Flight Controller, paired with the MN8 GPS Module to facilitate high-precision waypoint navigation and stable hovering.
- **Propulsion & Power:** The system utilizes a high-discharge Li-Po (Lithium Polymer) battery and high-efficiency Electronic Speed Controllers (ESCs) to manage power distribution across the six brushless motors.
- **Structural Integrity:** The airframe is built upon a modified F450-style geometry expanded for six-arm support, providing a lightweight yet rigid chassis.

- Communication: A dedicated Telemetry Module allows for real-time data exchange between the drone and the Ground Control Station (GCS), enabling the monitoring of flight vitals and manual override capabilities.

By leveraging the Power Distribution Board (PDB) to streamline current flow and minimize electromagnetic interference, this project aims to demonstrate an efficient, scalable, and autonomous drone architecture capable of navigating complex environments to deliver food items swiftly and safely.

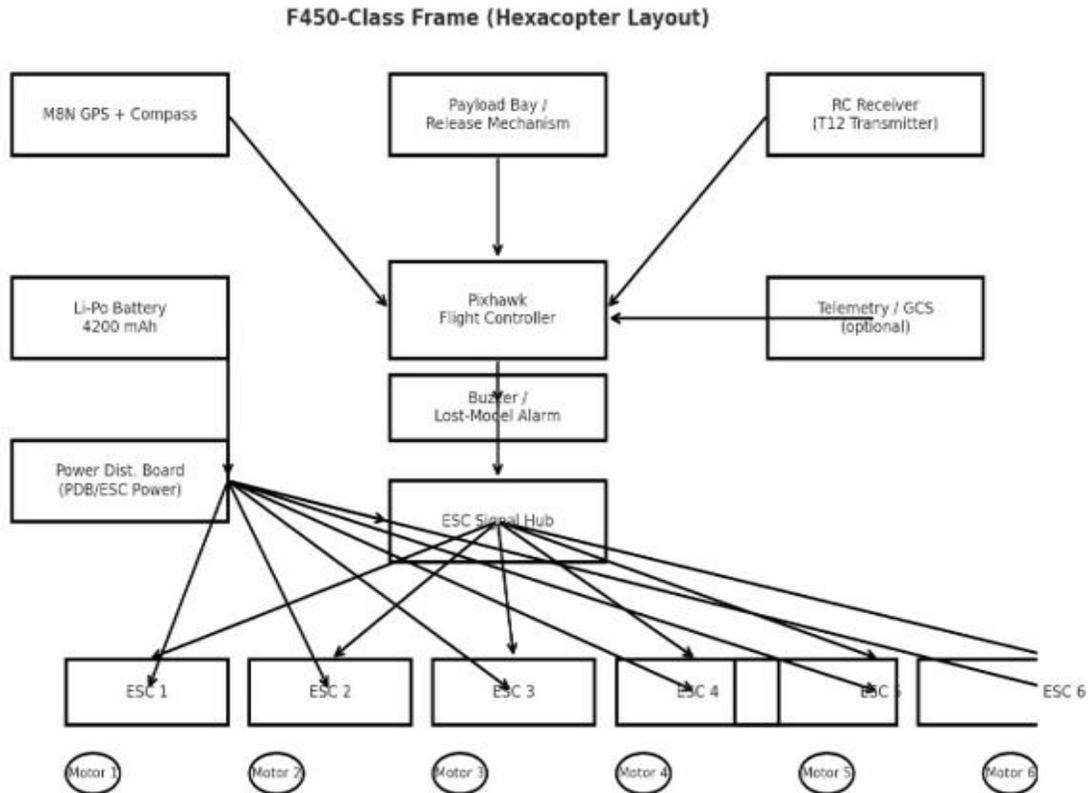


Figure 1: Block Diagram

**Li-Po Battery:**

The Lithium-Polymer (Li-Po) battery serves as the primary energy reservoir for the hexacopter, selected specifically for its high energy-to-weight ratio which is vital for payload-bearing delivery missions. In this architecture, the battery connects directly to the Power Distribution Board (PDB), which regulated and routed current to the six Electronic Speed Controllers (ESCs). These ESCs demand high instantaneous current (C-rating) to drive the motors under the increased load of food delivery packages.

The Li-Po's nominal voltage provides the necessary potential for the Pixhawk Flight Controller and the MN8 GPS Module, typically stepped down via a power module to ensure a stable 5V supply. During flight, the Telemetry Module transmits real-time

voltage and current consumption data from the battery back to the ground station, allowing for fail-safe triggers such as "Return to Launch" (RTL) if levels drop below a defined threshold. Because a hexacopter utilizes six rotors, the battery must maintain a consistent discharge curve to prevent thrust asymmetry.



Figure 2: Li-Po Battery

**Pixhawk Flight Controller:**

The Pixhawk Flight Controller serves as the high-performance "brain" of the hexacopter, executing complex flight algorithms required for stable autonomous delivery. In this architecture, it integrates data from the MN8 GPS Module to achieve precise coordinates, ensuring the food payload reaches the exact delivery waypoint. The controller processes pilot inputs or pre-programmed missions to send PWM signals to the Electronic Speed Controllers (ESCs), which manage the thrust of the six motors.

To maintain stability under varying payload weights, the Pixhawk utilizes its internal Inertial Measurement Unit (IMU) to make micro-adjustments to the hexacopter's attitude. Power is managed via the Power Distribution Board (PDB) and a dedicated power module, allowing the Pixhawk to monitor the voltage levels of the Li-Po Battery in real-time. This monitoring is critical for "Return to Launch" (RTL) safety protocols if the battery drops below a threshold during a delivery.

The Telemetry Module facilitates a long-range data link between the Pixhawk and the Ground Control Station (GCS), enabling the operator to monitor flight health and delivery progress. While the F450 Frame provides the physical structure, the Pixhawk manages the hexacopter's specific motor mixing geometry to ensure balanced flight even in windy conditions. Its open-source firmware (ArduPilot or PX4) allows for the integration of custom delivery scripts, such as automated winch control or precision landing on delivery pads. Ultimately, the Pixhawk ensures the transition from manual flight to a fully autonomous, reliable logistics tool.



Figure 3: Pixhawk Flight Controller

**MN8 GPS Module:**

The M8N GPS Module serves as the primary navigational sensor for the Hexacopter, providing the Pixhawk Flight Controller with essential real-time geospatial data. By leveraging concurrent reception of multiple Global Navigation Satellite Systems (GNSS) including GPS, GLONASS, and Galileo, the module ensures high-frequency positioning updates and superior signal sensitivity.

In the context of food delivery, this module is critical for executing Waypoints Navigation, allowing the drone to follow a pre-defined flight path from the kitchen to the customer's precise coordinates. The integrated IST8310 digital compass (magnetometer) within the M8N housing assists the Pixhawk in maintaining accurate heading and orientation, which is vital for stable flight in urban environments where magnetic interference is common.

Furthermore, the M8N enables advanced autonomous features such as Position Hold, which allows the Hexacopter to hover steadily during the payload release phase, and the Return-to-Launch (RTL) fail-safe. If the telemetry link is severed or the Li-Po battery reaches a critical threshold, the M8N provides the coordinates necessary for the drone to return autonomously to its takeoff point. Its low power consumption and rapid "Cold Start" time optimize the drone's operational efficiency, ensuring the delivery mission is both timely and accurate.



Figure 4: MN8 GPS Module

**Electronic Speed Controller (ESC):**

The Electronic Speed Controller (ESC) functions as the high-frequency power MOSFET bridge essential for translating low-power control signals into high-current motor drive. In this hexacopter configuration, six ESCs are mounted to the F450 frame, each receiving a Pulse Width Modulation (PWM) signal

from the Pixhawk Flight Controller. The ESC decodes these signals to vary the switching rate of the Li-Po battery current, thereby controlling the RPM of each motor individually.

Because a hexacopter requires precise differential thrust to manage pitch, roll, and yaw, the ESCs must provide rapid response times and high refresh rates (often 400Hz or higher). In a food delivery application, the ESCs are particularly vital for maintaining stability under varying payload weights; as the delivery package is released, the Pixhawk relies on the ESCs to instantly adjust motor speeds to compensate for the sudden change in center of gravity.

Furthermore, the ESCs are connected via a Power Distribution Board (PDB) to ensure a clean, parallel current draw from the Li-Po source. Modern ESCs also provide "Active Braking," which allows for more responsive deceleration, a key safety feature for navigating urban environments. By synchronizing with the MN8 GPS and telemetry data, the ESCs ensure the hexacopter maintains a steady hover and executes smooth transitions during autonomous waypoint navigation.



Figure 5: Electronic Speed Controller

**F450 Frame:**

The F450 frame serves as the central structural backbone of the delivery drone, providing the necessary rigidity to withstand the aerodynamic loads generated during heavy-lift food delivery missions. Engineered from high-strength polyamide nylon and glass fiber, the frame offers an optimal strength-to-weight ratio, ensuring that the hexacopter maintains

high payload efficiency without compromising structural durability.

Its integrated Power Distribution Board (PDB) on the bottom plate simplifies the electrical architecture, allowing for clean, low-resistance soldering of the ESCs and the Li-Po battery leads. The four-arm geometry of the F450 is strategically adapted into a hexacopter configuration in this project to enhance redundancy; should a single motor fail, the frame's symmetry helps the Pixhawk Flight Controller maintain stability.

- **Component Housing:** The spacious center plates provide secure mounting points for the MN8 GPS Module (isolated from electromagnetic interference) and the Telemetry Module for real-time data transmission.
- **Vibration Damping:** The composite material properties assist in absorbing high-frequency motor vibrations, which is critical for the precision of the Pixhawk's internal gyroscopes.
- **Aerodynamics:** The sleek arm profile minimizes drag during vertical takeoff and forward flight transitions, extending the battery life of the system.

Ultimately, the F450 frame acts as the mechanical interface between the propulsion system and the delivery payload, ensuring that the structural resonance remains within the operational bounds required for autonomous navigation.



Figure 6: F450 Frame

**Telemetry Module:**

The Telemetry Module facilitates real-time, bidirectional data exchange, allowing the operator to monitor the drone's health and flight status beyond the

visual line of sight. Within this specific hexacopter architecture, its primary functions include:

- **Real-Time Data Monitoring:** It transmits critical flight parameters from the Pixhawk Flight Controller, such as altitude, airspeed, and GPS coordinates provided by the MN8 GPS Module.
- **Battery Management:** By relaying data from the Power Distribution Board (PDB), the module provides live updates on the Li-Po battery voltage and current consumption, which is essential for preventing mid-air power failures during delivery missions.
- **In-Flight Command Overrides:** It allows the GCS to send mission updates or emergency "Return to Launch" (RTL) commands to the Pixhawk without relying on a traditional RC transmitter.
- **System Diagnostics:** The module monitors the performance of the Electronic Speed Controllers (ESCs) and motor sync, ensuring the hexacopter maintains stability under the payload of the food delivery.
- **MAVLink Protocol Utilization:** It uses the MAVLink communication protocol to package complex sensor data into a lightweight stream, ensuring low-latency updates over long distances.



Figure 7: Telemetry Module

**Power Distribution Board (PDB):**

In the design of a high-performance food delivery hexacopter, the Power Distribution Board (PDB) serves as the central nervous system for electrical energy. Its primary function is to efficiently route high-current power from the Li-Po battery to the six Electronic Speed Controllers (ESCs), ensuring

synchronous motor operation. Beyond simple routing, the PDB acts as a critical bridge for voltage regulation, converting the high-voltage battery output into stable 5V and 12V rails. These regulated rails are essential for powering sensitive avionics, including the Pixhawk Flight Controller, the MN8 GPS Module, and the Telemetry Module, protecting them from voltage spikes.

By centralizing the wiring on a dedicated PCB, the PDB minimizes electromagnetic interference (EMI) and reduces "cable spaghetti," which is vital for maintaining the structural integrity and weight balance of the F450 frame. Furthermore, the integrated current sensors on modern PDBs provide real-time telemetry data to the Pixhawk, allowing the system to monitor battery consumption a crucial safety feature for long-range food delivery missions. Ultimately, the PDB ensures a clean, reliable, and scalable power architecture, preventing thermal overloads and ensuring the drone can handle the variable payloads associated with delivery logistics.

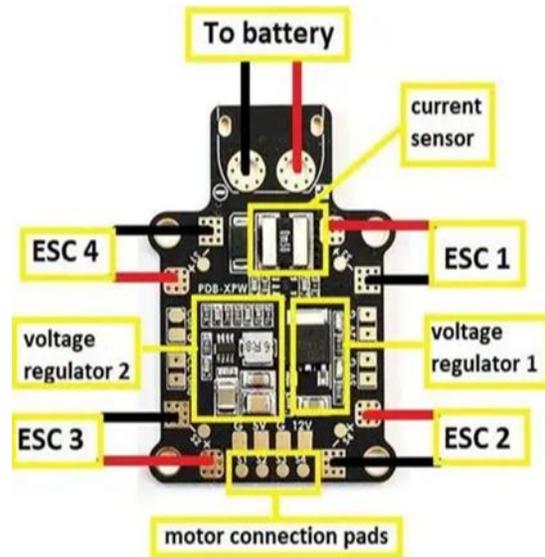


Figure 8: Power Distribution Board

### CONCLUSION

The development of this Hexacopter delivery system demonstrates the viability of utilizing high-stability multi-rotor platforms for last-mile logistics. By integrating the Pixhawk Flight Controller with the MN8 GPS Module, the system achieved high-precision navigation and autonomous waypoint

mission execution, essential for navigating complex urban or suburban environments.

The selection of the F450 Frame provided a lightweight yet durable chassis, while the Hexacopter configuration ensured crucial redundancy; the additional rotors offered superior lift capacity and stability compared to traditional quadcopters, ensuring the safety of the payload during transit. The power management system, centered around a high-capacity Li-Po Battery and a centralized Power Distribution Board (PDB), successfully balanced the high current demands of the six Electronic Speed Controllers (ESCs) with the need for sustained flight endurance. Furthermore, the integration of a Telemetry Module allowed for real-time monitoring of flight diagnostics, providing a critical fail-safe layer for ground station operators. Experimental results indicate that this hardware stack offers a robust, scalable, and cost-effective solution for food delivery, significantly reducing delivery times and carbon footprints compared to conventional ground-based methods.

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