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PRESIDENCY UNIVERSITY

Private University Estd. in Karnataka State by Act No. 41 of 2013

Itgalpura, Rajankunte, Yelahanka, Bengaluru – 560064

DESIGN AND DEVELOPMENT OF SHORT-RANGE PACKAGE DELIVERY DRONE

A PROJECT REPORT

Submitted by,

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PRESIDENCY SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

BONAFIDE CERTIFICATE

Certified that this report "**DESIGN AND DEVELOPMENT OF SHORT-RANGE PACKAGE DELIVERY DRONES**" is a Bonafide work of "Devendra Naidu(20221ISE0001), Manoj HK(20221ISE0081), Sai Dorababu Reddy(20221ISE0005)", who have successfully carried out the project work and submitted the report for partial fulfilment of the requirements for the award of the degree of BACHELOR OF TECHNOLOGY in INFORMATION SCIENCE AND ENGINEERING during 2025-26.

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DECLARATION

We the students of final year B-Tech in INFORMATION SCIENCE AND ENGINEERING at Presidency University, Bengaluru, named, Gorthi Devendra Naidu, Manoj HK, Sai Dora babu Reddy hereby declare that the project work titled "**DESIGN AND DEVELOPMENT OF SHORT-RANGE PACKAGE DELIVERY DRONES**" has been independently carried out by us and submitted in partial fulfilment for the award of the degree of B-Tech in INFORMATION SCIENCE ENGINEERING, during the academic year of 2025-26. Further, the matter embodied in the project has not been submitted previously by anybody for the award of any Degree or Diploma to any other institution.

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Abstract

The increasing need to have fast, reliable, and cheap delivery systems in particular the campuses, institutions, and small-range settings have stimulated the adoption of unmanned aerial vehicles (UAVs) to carry small packages. The conventional delivery systems are usually subject to delays due to traffic, human factor, and accessibility. The current project is aimed at the design and development of a low-cost, fully autonomous, and simple short-range delivery drone designed around the Pixhawk flight controller as the main control system, no companion computers or sophisticated onboard processing. The idea is to develop a viable prototype that will be capable of flying specific routes, carrying small amounts of cargo safely, and back to the initial location in autonomous mode.

The drone is constructed with a simple multi-rotor frame and consists of all the required elements like brushless motors, electronic speed controllers, Pixhawk 2.4.8 flight controller, a GPS module that provides its navigation, Li-Po battery, and a simple servo-based payload-release system. Every independent mission is set and uploaded via the Mission Planner, which supports waypoint navigation, geofencing, altitude control and return-to-launch (RTL) capabilities. It is built with simplicity, stability, and safety in mind and is therefore applicable in the academic and prototype-level logistics field.

The test substance has been done with controlled field trials and in simulated settings to test the stability in the flight, the accuracy of waypoints, the battery life and the reliability of the payload-release. The drone had a stable hover, stable GPS-based navigation and reliable short-range delivery. The system has a typical flight duration of approximately 10-12 minutes in normal payloads scenario which can be considered sufficient in terms of small range logistic operations, e.g., document delivery, small package transportation, or intra-campus applications. In general, the given project proves that an inexpensive, Pixhawk-driven autonomous drone could be used successfully to meet the short-range delivery requirements without the need to use complicated hardware, such as Raspberry Pi or powerful processors. The prototype emphasizes the possibility of UAV-based logistics in the campuses and closed settings. Additional enhancements in the future could be on growing landing accuracy, increased battery duration, and lighter material, as well as vision-guided navigation in case of more elaborate delivery conditions.

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Abbreviations

Abbreviation	Full Form
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aircraft System
GPS	Global Positioning System
ESC	Electronic Speed Controller
IMU	Inertial Measurement Unit
RTL	Return to Launch
PID	Proportional–Integral–Derivative
LI-PO	Lithium Polymer Battery
GCS	Ground Control Station
RC	Remote Controller
MAV	Micro Aerial Vehicle
PWM	Pulse Width Modulation
PDB	Power Distribution Board
COG	Center of Gravity

Chapter 1

INTRODUCTION

The blistering development of e-commerce, campus delivery, and short-range delivery has given an opportunity to demand more efficient and quicker ways of delivery. At times, the challenge that traditional delivery systems encounter includes traffic jam, insufficiency of staff and delays during peak hours. In most cases particularly within big campuses, institutions, industries or gated communities a small piece or document has to be transported in a short distance and in a fast way. The traditional ground delivery processes may not necessarily meet these requirements. This has led to adoption of unmanned aerial vehicles (UAVs) also referred to as drones as viable and dependable remedy.

Drones have a number of benefits in comparison to ground transport. They are able to fly straight to a point without having to experience traffic, road congestion, and human inconveniences. Their power usage is not very high within short range and they are capable of working independently upon being programmed. These benefits enable drones to be very appropriate in short distance deliveries like moving documents, identification cards, small foodstuff, medicines, lab samples and lightweight packages within a campus or a fenced setting.

The project is based on the design and development of an autonomous drone that is simple and low-cost enough to deliver small packages over short distances (usually less than 1 kilometer). The construction of the system is done based on Pixhawk flight controller which serves as the brain of the drone. Pixhawk offers level flight, waypoint navigation using GPS, altitude control, and return-to-launch (RTL) without use of complex processors or companion computers such as Raspberry Pi. The method makes the project cost-effective, less complex to construct, and applicable to the academic and prototype level.

A lightweight multi-rotor frame, brushless motors, electronic speed controllers (ESCs), a GPS module, Li-Po battery and a simple servo based payload release system are some of the core elements used in the drone. The entire process of mission planning and autonomous navigation is conducted by ground-control software including Mission Planner. This enables the operator to determine waypoints, the delivery point, establish safety values, and transfer the mission to the Pixhawk. When the drone is armed, it is capable of flying off, using a predetermined route, dropping the package at the target site and returning safely without one operating it manually.

Introduction of autonomous drones in the local delivery systems can decrease staff workloads, enhance the speed of deliveries and provide a more efficient setting. In the case of educational institutions, the project is also a learning project in that it learns the concept of aerodynamics, electronics, embedded systems, safety measures and autonomous navigation. In addition to this, such drones are also sustainable in regard to cutting down on the carbon footprint of short-range vehicle deliveries.

This report details the overall design, development, and testing of an autonomous delivery drone, which runs on a Pixhawk platform. It encompasses background motivation, literature review, hardware and software design, test methodology, results and consideration of social and ethical issues. The goal is to deliver an easy to use, repeatable and affordable model which may be utilized in the academic field of study and further enhancement of the autonomous drone logistics.

1.1 Background

Over the last decade, drones have moved from being hobby devices to becoming powerful tools in industry and research. Their ability to fly independently, reach difficult locations, and perform quick tasks has created new opportunities in many fields such as agriculture, photography, inspection, and logistics. One of the most promising applications is **short-range package delivery**, where a small parcel needs to be transported quickly and safely over a limited distance. Traditional delivery systems whether manual or vehicle-based often face barriers such as traffic, slow response times, dependency on human resources, and lack of flexibility. These issues make drones a practical alternative for short-distance logistics.

Many organizations today operate across large campuses, including universities, research parks, hospitals, and industrial complexes. Delivering documents, ID cards, small equipment, or medical items within these areas often requires staff to walk or use vehicles. This results in lost time, higher effort, and inefficient resource usage. A lightweight autonomous drone can overcome these challenges by flying directly from one point to another, avoiding obstacles and road conditions. Since such deliveries usually involve small weights and short ranges, drones provide a suitable, fast, and cost-effective solution.

Globally, autonomous drones have become an emerging part of last-mile logistics. Companies like Amazon, UPS, and Zipline have shown that aerial delivery can significantly reduce delivery time and operational costs. However, most commercial systems are expensive and rely on advanced onboard computers, high-precision sensors, and complex communication systems. These setups are often beyond the reach of academic projects or low-budget prototypes. This gap has created a need for **simpler, more affordable drone designs** that still provide reliable autonomous functions for small-scale delivery tasks.

In this project, the focus is on building a **budget-friendly autonomous drone** using only the essential components required for stable flight and navigation. The Pixhawk flight controller acts as the central control system, providing all the necessary features such as stabilization, GPS waypoint navigation, geofencing, and return-to-launch (RTL). By avoiding the use of companion computers like Raspberry Pi, the project remains simple, easier to assemble, and ideal for demonstration and experimentation. This approach also helps students understand core drone concepts without the complexity of advanced processing hardware.

Short-range delivery drones have several advantages: they reduce human effort, cut down travel time, and offer a contactless delivery method an important requirement in today's fast-paced environments. They also reduce the carbon footprint associated with ground vehicles and contribute to sustainable campus operations. In controlled spaces like university campuses, drones can be safely tested, monitored, and improved over time.

Overall, the background of this project lies in the growing need for quick and reliable short-distance deliveries, the increasing acceptance of drones in logistics, and the opportunity to create a simple, low-cost, and educational model using the Pixhawk controller. This project aims to explore how autonomous drones can be used effectively in small-scale logistics, while also providing a foundation for further research and innovation in UAV technologies.

1.2 Statistics

Short-range drone delivery 6 has become increasingly popular over the last few years as it is the result of the rapid rise of e-commerce, campus services, and digital logistics. The world market indicates that the market of drone is growing at an impressive rate, and the market is projected to be worth above USD 40 billion by the year 2030. The big share of this growth is associated with the last-mile delivery, in which the drones can deliver small goods faster than the traditional approach. In large campuses like in universities, hospitals, or industrial facilities, nearly 7080 percent of in-campus deliveries are of lightweight products, often less than 500 grams, that are therefore perfect demonstrations of the application of drone-based transportation. These are very small yet repetitive tasks that are time and manpower consuming when carried out manually, but can be executed by an autonomous drone in a fraction of the time. In different institutions, the time spent on delivering a small item manually in a radius of 1-kilometer is 10-15 minutes on average depending on the place and availability of personnel. An autonomous drone, conversely, is able to accomplish the same task in about 2-5 minutes since it does not have to go through all the traffic, road geometry, and latitudes, but instead fly directly to the desired location. Comparative studies of energy use also show that drones use approximately 60 per cent less energy than small vehicles or two-wheelers over the same distance, not only being fast but also more efficient in environmental use. Another aspect of significance that is backed by statistics is navigation performance. The GPS modules consist of what are typically low priced drones have a positioning accuracy of about +-2 to 5 meters which is sufficient to operate in an open field like a campus or a park. This precision makes navigation with waypoints and controlled landing reliable even in low-complexity environments. Regarding flight speed, other small multi-rotor drones like this one normally can fly at a range of 10 to 15 minutes with lightweight payloads, which enables them to fly short missions numerous times before they require a recharge. This is in harmony with the operational requirements of short-range delivery systems where speedy trips and shipments with low weight of the shipment are the order of the day. On the cost aspect, it is comparatively cheap to construct an autonomous delivery drone to be used in academic or prototype demonstrations. The majority of the working prototypes cost around 15,000 to 25,000 rupees, assemblies with various frames, motors, flight controller, and battery size. This is comparatively very cheap compared to commercial delivery drones, which usually cost a couple of lakh dollars. Although it is cheaper, Pixhawk-based drones can provide a high degree of stability and safety when tuned properly, and autonomous missions tests have a successful rate of between 85 and 95 percent. The predictions of the industry also indicate that drones will be able to manage between 15 and 20 percent of last-mile deliveries by 2028, particularly in the case of controlled campuses, where few legal limitations exist. These tendencies indicate that the autonomous drone designed in the present project is not merely technologically applicable but also in accordance with the world progress and perspectives on the sphere of logistics.

1.3 Prior Existing Technologies

Before developing autonomous delivery drones, several technologies and system architectures were already being used across the industry for aerial logistics. Commercial drone companies like DJI, Amazon Prime Air, and Zipline originally pioneered the concept of drone-based package delivery by integrating advanced sensors, powerful processors, and long-range communication modules. These systems rely heavily on complex onboard computers, high-precision vision sensors, and proprietary flight controller Zipline, one of the leading names in medical drone delivery, uses fixed-wing drones equipped with custom autopilot systems capable of long-range flight and weather resistance. Their drones are designed to deliver blood and medical supplies across remote regions with high accuracy. However, these systems require specialized launch and recovery setups and are engineered for large-scale operations rather than small-range campus environments. Similarly, Amazon's Prime Air project uses custom multi-rotor drones with advanced computer vision and AI-based navigation to deliver small parcels directly to customers' homes. While highly sophisticated, these platforms depend on expensive sensors like LiDAR, depth cameras, and multiple onboard processors, which increases cost and complexity.

In the open-source domain, the Pixhawk flight controller has become one of the most widely adopted technologies for research and academic drone development. Pixhawk, along with firmware such as ArduPilot and PX4, offers all the essential features required for autonomous flight stabilization, GPS waypoint navigation, geofencing, failsafe mechanisms, altitude control, and return-to-launch. Because of its affordability and modular design, many student projects and low-cost prototypes rely on Pixhawk as the core component. These systems support Mission Planner or QGroundControl for uploading waypoints, monitoring telemetry, and configuring flight parameters. This eliminates the need for companion computers and reduces the learning curve for beginners.

Another category of existing technologies includes consumer-grade drones like DJI Phantom, Parrot ANAFI, and Yuneec models. These drones offer reliable flight performance, GPS positioning, and stable hovering but are generally not designed for customizable payload release mechanisms or autonomous delivery tasks. Most of them are built primarily for photography and surveillance, lacking the hardware interfaces needed to integrate delivery mechanisms such as servo-based release hooks. Their closed firmware systems also limit the user's ability to customize missions beyond predefined modes.

Overall, existing technologies show a clear separation between highly advanced commercial delivery drones and simpler academic systems. This project positions itself in the middle by using Pixhawk a reliable, open-source, and cost-effective platform to build an autonomous short-range delivery drone without the complexity or cost of high-end commercial systems. The prior technologies provide a strong foundation and demonstrate that simpler, lighter, and affordable drones can still be efficient for controlled environments such as campuses and research institutions.

1.4 Proposed Approach

Some of the technologies and system architecture used by the aerial logistics industry were in place before developing autonomous delivery drones. Commercial drone delivery firms such as DJI, Amazon Prime Air, and Zipline were initially the pioneers with their concept of using drones to deliver packages by developing advanced sensors, high-speed processors, and long-range communication packages. They are based on sophisticated onboard computers, precision vision cameras and proprietary flight controller Zipline, which has been a pioneer in medical drone delivery, flies on fixed-wing drones that have custom autopilot systems that can fly over long ranges and survive in the weather. They have drones that are able to deliver medical supplies and blood to the remote areas with high precision. Nevertheless, such systems will need special launch and recovery facilities, but are designed to operate at the large scale and not at the small-range campus conditions. Equally, the success of Amazon Prime Air utilizes its own multi rotor drone technology with high-level computer vision and artificial intelligence-guided flights to ship small packages to consumers at their doorsteps. Although very advanced, they are based on costly sensors, such as the LiDAR, depth cameras, and numerous processors on board, making them more complex and more expensive. The Pixhawk flight controller is now one of the most popular technologies in the field of research and academic drone development in the open-source field. Pixhawk, with firmware like ArduPilot and PX4, has all the features needed to perform autonomous flight stabilization, GPS waypoint navigation, geofencing, failsafe, and altitude control, as well as, returning to the launch point. Due to its low cost and modularity, numerous student projects and low-budget prototypes use Pixhawk as the platform. These systems can be used with Mission Planner or QGroundControl to upload waypoints, telemetry control and adjust flight parameters. This will do away with the use of companion computers and minimise the barrier to entry of beginners. The other type of technologies that are currently used is the consumer-grade drones such as DJI Phantom, Parrot ANAFI and Yuneec. These drones have a good flight performance, GPS positioning and stable hover capability and are not usually intended to be customized with payload release systems or autonomous delivery missions. The majority of them are designed to be used in photography and surveillance only, they do not come equipped with the hardware interfaces to allow them to be integrated into the delivery mechanisms, like the servo-based release hooks. The fact that their firmware is predominantly closed also restricts the customization of the user to do anything other than being in the pre-established missions. In general, there is a discernible divide between highly commercial delivery drones and more basic academic ones in the existing technologies. The project fits between the high-end and low-end projects by relying on Pixhawk, a stable, open source and low cost platform to construct an autonomous short range delivery drone without involving complex and expensive high-end systems. The previous technologies give the right footing and show that even more simple, lightweight and affordable drones may be effective in managed conditions on the campuses and research facilities.

1.5 Objectives

The development of an autonomous short-range delivery drone requires clear and well-defined goals to guide the engineering process. This project focuses on designing a reliable, low-cost, and practical drone system based entirely on the Pixhawk flight controller without depending on companion computers or advanced sensor systems. The following objectives outline the technical, functional, educational, and practical intentions behind this work. Each objective contributes to the drone’s performance, safety, and feasibility for real-world applications, especially in controlled environments like university campuses, hospitals, or industrial layouts.

Objective 1: To Design a Stable and Lightweight Autonomous Drone Platform

A major objective of this project is to create a stable aerial platform capable of carrying small payloads while maintaining structural efficiency. The drone must be lightweight enough to achieve sufficient flight time yet strong enough to handle vibrations, weather variations, and repeated missions. This includes selecting the appropriate frame, motors, propellers, ESCs, GPS module, and power system. The design focuses on achieving smooth takeoff, reliable hovering, controlled navigation, and safe landing under autonomous flight modes. Stability is central to the overall performance because all other functions navigation accuracy, payload delivery, and mission success depend on the stability of the drone.

Objective 2: To Implement Fully Autonomous GPS-Based Navigation

Another core objective is to enable the drone to navigate automatically using GPS-based waypoint missions created in Mission Planner. The idea is to allow the drone to take off, follow a predefined flight path, reach the delivery location, perform the package drop, and return home without requiring manual piloting. This involves configuring flight modes, tuning the Pixhawk parameters, setting appropriate altitude levels, and ensuring that the GPS lock is strong enough for mission reliability. Achieving consistent waypoint accuracy is essential for real-world deliveries, and this project aims to demonstrate that even a simple Pixhawk-based system can handle these navigation tasks with confidence.

Objective 3: To Develop a Reliable Payload Holding and Release Mechanism

A practical delivery drone must carry a package securely and release it at the correct time and location. This project aims to create a simple, robust, and cost-effective mechanism using a servo motor controlled directly by the Pixhawk. The design must ensure that the payload remains firmly attached during flight, does not affect the center of gravity, and can be released smoothly without destabilizing the drone. Testing different servo positions, mount designs, and release angles forms part of this objective to ensure that the drop mechanism is dependable under repeated missions.

Objective 4: To Ensure Safety Through Failsafe Systems and Geofencing

Safety is one of the most important elements in drone operations. An essential objective of this project is to configure and test all necessary failsafe features in the Pixhawk, including low-battery return-to-launch (RTL), GPS-loss failsafe, radio-signal failsafe, and emergency motor cutoff. Geofencing is also enabled to keep the drone within a safe flight perimeter, preventing accidental entry into restricted or risky areas. These safety features ensure that the drone operates responsibly and reduces the risks of crashes, loss of equipment, or harm to people nearby.

Objective 5: To Evaluate Mission Performance Through Simulations and Field Testing

The project aims to validate the drone's performance using both Software-In-The-Loop (SITL) simulation and real-world testing. Simulations help tune the drone's behavior before actual flights and allow safe experimentation with flight parameters, waypoint layouts, and emergency recovery situations. Field tests are then conducted to evaluate hover stability, waypoint accuracy, payload release reliability, battery endurance, and mission success rates. Through continuous testing and refinement, the project seeks to achieve practical and repeatable delivery results.

Objective 6: To Develop a Cost-Effective and Educational Prototype

One of the primary intentions of this project is to show that a functional autonomous delivery drone can be built at a low cost using open-source components and easily available parts. Expensive commercial drones often limit experimentation, whereas a low-cost design allows students and researchers to build, modify, troubleshoot, and enhance the system easily. The objective here is to keep the total cost within an affordable range while delivering strong performance, making this system ideal for academic learning and hands-on engineering education.

Objective 7: To Explore the Feasibility of Short-Range Drone Delivery in Controlled Environments

Finally, the project aims to understand whether autonomous drones can genuinely improve short-range delivery tasks in environments such as university campuses, medical institutions, or secured industrial parks. By demonstrating faster delivery times, reduced human effort, and repeatable autonomous behavior, the project evaluates the real-world viability of using drones for routine transport of small items. The goal is not just to build the hardware but also to assess how this technology could be integrated into everyday operations in a safe and sustainable manner

1.6 Sustainable Development Goals (SDGs)

This project is highly relevant to many of the United Nations Sustainable Development

Goals (SDGs) and makes a significant contribution to international efforts in building inclusive, resilient and tech-centered societies. By digitalizing the museum and modernizing experience of it through clever robotics and digitization, the system contributes substantially to several SDGs.

Fig 1.1 Sustainable development goals

The development of an autonomous short-range delivery drone directly supports several Sustainable Development Goals (SDGs) defined by the United Nations. Although this is a small academic project, its impact aligns with global efforts to improve infrastructure, reduce environmental damage, and promote technological innovation. The drone system designed in this project contributes to these goals by offering a cleaner, faster, and more efficient alternative to traditional short-distance transport methods such as motorbikes, cars, and manual delivery systems.

This project strongly aligns with **SDG 9: Industry, Innovation, and Infrastructure**, which focuses on building resilient infrastructure and promoting sustainable technologies. By developing a low-cost, autonomous drone capable of performing practical delivery tasks, the project demonstrates how innovative engineering can reduce human effort and improve operational efficiency within campuses and controlled spaces. It also highlights how open-source systems such as Pixhawk can create affordable technological solutions that can be adopted by institutions, students, and research groups.

The work is also relevant to **SDG 11: Sustainable Cities and Communities**, as drones offer a smarter and more efficient alternative for short-range logistics inside urban campuses, medical facilities, and research parks. Traditional ground-based deliveries contribute to congestion, delays, and unnecessary vehicle movement. Autonomous delivery drones reduce these issues by flying directly to destinations without using roads or causing crowding. They support the vision of cleaner, more organized, and technology-enabled communities.

Additionally, this project contributes to **SDG 13: Climate Action**, which emphasizes the reduction of greenhouse-gas emissions. Conventional delivery systems especially when using petrol or diesel vehicles generate carbon emissions even for very short trips. In contrast, drones operate on electric power and consume far less energy for transporting lightweight parcels. For controlled, short distances, drone-based delivery can reduce carbon emissions significantly while providing faster service. Developing such systems encourages broader adoption of electric and low-emission delivery methods, especially for small-scale operations.

Beyond direct environmental and infrastructure-related goals, the project also supports educational and research-driven objectives connected to **SDG 4: Quality Education**. By building a functional autonomous drone using affordable hardware, students gain hands-on experience in robotics, aerodynamics, electronics, and automation. The project encourages innovation, critical thinking, and technical skill development among engineering students, helping them contribute to future sustainable technologies.

Overall, the drone delivery system demonstrates how small-scale engineering projects can meaningfully align with global sustainability goals. Through reduced energy usage, improved operational efficiency, and promotion of green technology, the project shows that even simple autonomous systems can contribute to cleaner, smarter, and more sustainable communities.

1.7 Overview of project report

This project report is organized into a structured sequence of chapters that walk the reader through the complete development of an autonomous short-range delivery drone using the Pixhawk flight controller. The report begins by establishing the motivation and background for adopting drone-based delivery systems, especially in environments where conventional transportation is slow, resource-heavy, or inefficient for short-distance tasks.

It explains why drones are becoming an attractive alternative for small parcel movement and how this project fits into the broader shift toward autonomous and sustainable logistics solutions. The introductory chapter also presents the project objectives, the sustainable development goals supported by this work, and the rationale behind developing a low-cost, GPS-based autonomous drone system. These foundational elements provide context for the rest of the report and help the reader understand both the practical relevance and academic value of the project.

Following the introduction, **Chapter 2 presents a detailed literature review** that examines the advancements made in drone technologies over the years, with a particular focus on delivery applications. This chapter discusses earlier systems, commercial drone platforms, and research contributions that have shaped the evolution of autonomous aerial delivery. It highlights important technologies such as waypoint navigation, GPS modules, flight controllers, and safety protocols used across various studies. The literature review shows the gap between high-end commercial drones and simple, budget-friendly prototypes, reinforcing the need for affordable designs like the one developed in this project. It also sets the theoretical foundation that supports the design decisions made in the later stages of the report.

Chapter 3 outlines the methodology adopted to design, assemble, and validate the drone. It explains how the V-Model or systematic engineering flow was used to ensure that hardware decisions, software configuration, and mission planning aligned with the overall goals of the project. This chapter describes requirement gathering, conceptual design, component selection, and the iterative process of testing and refining the system. By dividing the development into clear phases problem analysis, design, integration, simulation, and field testing the methodology ensures that each stage of the project is logically linked and thoroughly validated.

Chapter 4 focuses on project management, including the planning, scheduling, budgeting, and risk assessment involved in developing the autonomous drone. It outlines the project timeline from the initial concept to final testing and report preparation. It also includes risk analysis covering technical, economic, environmental, regulatory, and safety-related risks. The budget estimation presented in this chapter demonstrates how the entire drone can be built at an affordable cost using readily available components, making it feasible for student projects and research-level prototypes.

Chapter 5 covers the system design and analysis. This chapter details the hardware architecture, flight-control configuration, block diagrams, flow charts, communication model, and operational logic behind the drone. It explains how the Pixhawk flight controller interacts with motors, ESCs, GPS, battery modules, and the servo-based payload mechanism.

The system flow describes how the drone transitions through various phases from pre-flight checks to autonomous takeoff, waypoint traversal, package release, and return-to-launch. The chapter also includes functional views, domain models, deployment levels, and standards used during the design stage, offering a comprehensive look at the technical backbone of the project.

Chapter 6 explains the hardware and software implementation in detail. It describes each component used in the drone such as the frame, motors, ESCs, GPS module, Li-Po battery, Pixhawk controller, telemetry radio, and servo mechanism and discusses how they were integrated to form a functional system. The software section focuses on firmware configuration, parameter tuning, mission planning, and simulation using Mission Planner or SITL tools. This chapter shows how both hardware assembly and software configuration come together to create a reliable autonomous flight system.

Chapter 7 presents the evaluation and results, covering all the tests performed on the drone. These include hover stability tests, waypoint accuracy checks, payload release reliability tests, flight-time measurements, and overall mission success rates. The results demonstrate how well the drone performs under real conditions and validate whether the objectives set in the earlier chapters were met. The insights at the end of the chapter highlight where the system performed strongly and where improvements can be made, such as increasing battery endurance or enhancing landing precision.

Chapter 8 addresses the social, legal, ethical, sustainability, and safety aspects related to drone development and deployment. This section explains how drone operations must comply with different guidelines, especially the DGCA Drone Rules in India. It also discusses the ethical considerations around privacy, noise, safety, and user awareness. The chapter shows that even though this is a prototype-level project, real-world deployment requires careful consideration of environmental impact, community acceptance, and safety protocols.

The report concludes with **Chapter 9**, which summarizes the achievements of the project and reinforces its relevance as a practical and educational model for short-range delivery systems. The conclusion also outlines potential future enhancements such as precision landing, extended flight range, better aerodynamics, or multi-drone coordination that could be explored in future work.

Chapter 2

LITERATURE REVIEW

In recent years the creation of autonomous drones used in short-range delivery has increased, which is facilitated by flight control system development, GPS positioning, multi-rotor design, and autonomous navigation algorithms. Many studies have been conducted to understand the application of drones in logistics, medical delivery, campus deliveries, and last-mile connectivity. This literature review is a detailed discussion of the past studies and technologies under various headings. The review introduces the current solutions, outlines shortcomings of commercial solutions and demonstrates how autonomous drone projects like ours are able to fill in critical gaps by creating simple and affordable drones based on open-source flight controllers such as Pixhawk.

2.1 Evolution of Drone Delivery Systems

Drones are used to deliver products to customers, anti-drone devices interrupt these systems, and the reverse can also hold true. Initial experiments on drone deliveries were primarily centered on manually controlled quadcopters that were meant to be used in aerial photography and entertainment. With the increase in the accuracy of GPS modules, and with the development of multi-rotor frames into more stable frameworks, scientists started to consider the prospect of utilizing drones in small parcel transportation. As an initial analysis by Otto et al. (2018) reports, multi-rotor drones showed a high potential of last-mile logistics because of their vertical take-off, hover capability, and low cost of maintenance. The researchers noted that even simple drones were capable of bringing down the delivery time greatly in a controlled setting, like on a university campus, in a medical facility or in a manufacturing park. Subsequent development by Saunders et al. (2021) revealed that autonomous aerial delivery needed to have stable flight controllers that could manage waypoint navigation, altitude control, and failover measures. This redirected the attention towards the drones that are piloted manually to the fully autonomous ones. Nonetheless, commercial drones used then were costly and hard to tailor, so the scholar switched to open-source controllers like Pixhawk and ArduPilot, which left full control of navigation, mission logic. The development of drone delivery systems is evident as a process involving the transition to the manual mode of control to the GPS-based automation and, ultimately, to the fully autonomous and multi-drone logistics network.

This project is based on these developments, and it will introduce an affordable prototype based on Pixhawk to make short-range deliveries within the campus.

2.2 Autonomous Navigation and GPS-Based Path Planning

A number of studies discuss the importance of GPS in facilitating autonomous navigation. As Liu et al. (2023) note, most academic delivery systems rely on waypoint-based navigation, in which the mission is structured in advance and uploaded to the drone. GPS accuracy of +-2-5 meters is generally good enough to be used in operations in the open area, which is why it is applicable to campuses and areas of controlled outdoor operations. More sophisticated systems employ RTK-GPS or computer vision to achieve centimeter-level accuracy, although these technologies are very expensive and complicated. As an example, Kannan and Min (2022) suggested a vision-assisted landing system, which was more precise but a special onboard computer and camera system was needed. Although such solutions are effective, they cannot be used in low-budget academic projects. The most popular is still the use of simple GPS based navigation because of its cost and ability to be flexible. Controllers based on Pixhawk firmware (ArduPilot or PX4), as well as autonomous waypoint missions, are natively supported by the ArduPilot or PX4 firmware, and thus they are well suited to student-built drones. This approach is followed by the system applied in this project that proves that credible autonomous navigation could be attained without sophisticated sensors.

2.3 Flight Control Systems and Open-Source Platforms

The discovery of open-source autopilot systems like ArduPilot and PX4 was a breakthrough in the study of UAV. According to the research of the ArduPilot Development Team (2020-2023), Pixhawk-based autopilots help with numerous flight modes, stabilization algorithms, geofencing, battery management, and failsafe management. These are characterized by the fact that developers can create autonomous drones without relying on powerful processors. Zhang et al. (2024) developed a cheap low-cost drone-based logistics controller based on Pixhawk and proved that in case of proper tuning, even cheap components would be able to provide stable flight control and correct navigation. The work notes that open-source platforms democratize the research of drones, making them accessible to students and small laboratories in order to build working prototypes. Patil (2024) compares the open-source flight stack to the commercial systems such as DJI and notes that with open-source flight stacks, a researcher can more easily customize their system than with commercial options, particularly when it comes to academic work, where the researcher must access firmware parameters, tuning options, and mission-planning interfaces. This is in line with the design approach of the current project where

Pixhawk is employed as the only control factor rather than the closed-source proprietary systems.

2.4 Payload Release Systems and Delivery Mechanisms

Other research papers also outline various payload-release schemes of delivery drones. Research that was carried out by Williamson (2022) on campus logistics points out that small-parcel deliveries can be attained by a mere servo-motor mechanism. The main aspects are keeping the center of gravity of the drone, not moving the load in the air and controlled release at the point of delivery. More modernized delivery systems like those which Zipline uses use mechanical claws or parachute drops to do longer missions. Prototypes on a small scale academic level, however, do not need such mechanisms. Sanjib et al. (2017) claimed that servo-controlled release hooks are preferred in lightweight models that need more reliability in controlled conditions and the position of drops are not a major concern.

2.5 Battery Endurance and Power System Efficiency

One of the most popular limitations related to multi-rotor drones has concerned battery efficiency. Pimenta et al. (2022) examined the environmental and energy impact of drone delivery and concluded that drones require a significantly smaller amount of energy per delivery than road vehicles, particularly over a short distance. Nonetheless, flight duration is also an issue whereby multi-rotor flyers can only cover a distance of 10-15 minutes with a standard Li-Po battery. The article by Nurgaliev (2023) talked about the case of simple drones equipped with 3S or 4S Li-Po batteries that are able to deliver goods to the campuses in a steady and stable manner. Past studies indicate that light frames, propellers with good efficiency, and low KV motors are great to enhance battery life. The current project implements the same concept through incorporation of balanced power system that can facilitate safe and stable autonomous operations within a distance of 1 kilometers. In addition, research indicates that the long flight endurance does not apply in most short-range logistical mission. Rather, the trick of rapid charging, swapping of the batteries in a modular way, and missions of less than 10 minutes are all efficient. This is in tandem with our prototype operational design.

2.6 Safety, Regulatory, and Ethical Considerations

As drone delivery grows, concerns have been placed more on safety and regulations by researchers. Udvaros (2025) studied the use of drones in logistical facilities and raised such issues as collision prevention, data protection, and safe flight zones. Jahani (2024) also highlighted that it must comply with the national aviation regulations, including DGCA Drone Rules 2021 in India, that categorizes operations as green zones, visual line-of-sight operations, and safety inspections prior to each flight. The present project aligns fully with these recommendations by implementing RTL on low battery, GPS-loss failsafe, and geofence limits. By operating in a controlled campus environment, the project adheres to both academic safety protocols and practical regulatory constraints.

2.7 Summary and Gap Identification

The review of existing literature shows substantial progress in drone-based delivery systems, but also identifies certain gaps. Commercial drones offer high performance but are expensive and closed-source. Advanced research drones use complex sensors and processors, making them difficult to replicate for educational purposes. Many academic prototypes use GPS navigation but lack standardized safety features or cost-effective implementation strategies.

This project fills the gap by demonstrating that a **simple, low-cost, Pixhawk-only autonomous delivery drone** can achieve reliable performance in short-range logistics. It avoids unnecessary complexity while still maintaining stability, accuracy, safety, and practical usability. The design serves as a strong educational platform and a foundation for future enhancements.

Literature Review Table

Table 2.1 Summary of Literature Reviews

Sl. No.	Author(s) (Year)	Title (Clickable)	Summary	Drawbacks	Future Trends
1	A. Mohamed & M. Mohamed (2025)	https://www.mdpi.com/2504-446X/9/6/413	Comprehensive review covering environmental, economic, and social effects of UAV parcel delivery and gaps in field validation.	No experimental validation; high variability in assumptions.	Standard field trials and sustainable hybrid routing systems.
2	Eskandaripour et al. (2023)	https://www.mdpi.com/2504-446X/7/2/77	Surveys routing, communication, energy limits, and last-mile logistics case studies.	Broad but shallow; lacks post-2022 ML/sensor updates.	Hybrid truck-UAV delivery and improved battery technology.
3	Y. Zhang et al. (2024)	https://www.mdpi.com/2076-3417/14/11/4358	Presents ultra-low-cost UAV logistics design	Fixed-wing only, no VTOL capability; needs	VTOL-hybrid fixed-wing designs

			using inexpensive components .	landing area.	with lighter materials.
4	Chi et al. (2024)	https://www.researchgate.net/publication/388206696	LiDAR + depth camera fusion for obstacle avoidance and smoother navigation.	High cost, heavy sensors, calibration complexity.	Solid-state LiDAR and lightweight AI hardware.
5	Rahmani et al. (2025)	https://www.researchgate.net/publication/395560841	RL-based multi-objective UAV routing optimization in simulation.	Simulation-only; poor generalization to real flight.	Safe RL + sim-to-real transfer for field deployment.
6	Pimenta et al. (2022)	https://www.mdpi.com/2071-1050/14/19/12390	LCA comparison showing drones cleaner than vehicles for small parcels.	Scenario-sensitive results; depends on electric grid.	Renewable charging hubs; standardized LCA frameworks.
7	Saunders et al. (2021)	https://arxiv.org/abs/2110.02429	Survey of UAV delivery vehicle	Outdated for post-2022 AI-driven	Combined perception-routing systems

			types, navigation, and release methods.	navigation.	and automation.
8	Kannan & Min (2022)	https://www.researchgate.net/publication/357561880	AprilTag-based precision landing with decimeter accuracy.	Needs visual markers and good lighting.	Markerless landing via deep learning + RTK fusion.
9	Zhang et al. (2024)	https://ouci.dntb.gov.ua/en/works/4w0WwPbl/	Study on UAV logistics adaptability metrics like payload and endurance.	High-level guidelines; lacks hardware-specific testing.	Standard testbeds for drone delivery evaluation.
10	Yang et al. (2025)	https://www.ssrn.com/index.cfm/en/	Life-cycle costing comparing UAVs vs EVs vs vehicles; UAVs preferred for small loads.	Preprint; model assumptions vary widely.	Better batteries and policies for noise/privacy.
11	Alahmadi et al. (2025)	https://www.mdpi.com/	Proposes secure last-mile drone delivery with	Adds hardware cost; real-world scale tests	Secure OTA updates and intrusion

			hardware PUF authentication.	missing.	detection systems.
12	Zhou et al. (2025)	https://www.mdpi.com/	Multi-UAV coordination using imitation learning + MARL.	Only simulation; high computational load.	Real multi-UAV experiments with hybrid RL + classical control.

2.8 Gaps and Opportunities Identified for Research

The current literature on drone-based delivery systems demonstrates the outstanding advancement in autonomous flight, path-finding algorithms, perception frameworks, and safety control systems. But even with these developments, there exist a number of obvious gaps between the research models that are on the high end and the low-cost drones that can be deployed in an educational or controlled setting. The majority of business and academic research uses highly developed onboard computers, LiDARs, high-precision RTK-GPS, and complicated simulation models. Though these technologies are more accurate, they are very expensive, heavy, and cumbersome and are therefore not suitable in student projects or in institutions that require short-range deliveries at low prices. This leaves research of simple, scalable, and cost effective drone platforms that can still perform their missions reliably with minimal requirements of just Pixhawk, GPS, and a simple payload mechanism.

There is also another significant gap in the real-world validation. Numerous studies of drone delivery mainly use a simulation environment, algorithmic modelling, or controlled laboratory conditions. There are limited or absent field experiments particularly semi-open ones like those of campuses. The outcomes of a simulation are not necessarily similar to actual complications of operation, such as the problem of wind turbulence, battery fluctuations, GPS errors and inconsistencies of landing. This leads to a research opportunity focusing on the real-world testing, this practical testing, tuning and real-time mission analysis of autonomous drones under controlled yet realistic outdoor environments.

The literature also has a distinct gap of literature on lightweight delivery mechanisms that can be used in small payloads. Industrial solutions are typically elaborate mechanical mechanisms, parachute drops or robotic claws that are targeted at heavier loads or a longer range. These mechanisms cannot be used in small scale deployments where simplicity, weight savings and reliability are more important than sophistication. School projects have to have more basic payload-release hardware such as servo-driven hooks which can be controlled by flight controllers easily without companion computers. This offers the chance to come up with and experiment with minimalistic mechanisms that can still deliver safe and controlled package drops. There also exist gaps in the safety and regulatory compliance. Although the state-of-the-art research is on collision avoidance and airspace integration, very limited literature is on safety measures of campus-based or localized drone operations not based on costly sensors. This makes research avenues available in the design of software-based safety e.g. geofencing, altitude-cap, failsafe triggers, and return-to-launch behavior that can be done at the Pixhawk firmware level with no extra hardware support. Also, the issue of energy efficiency is ongoing. Majority of the studies recognize battery limitations, but the limited studies deal with the optimization of performance using low-cost and small capacity Li-Po batteries. Short-range delivery missions involve compromising between the flight time, cargo weight, and power. This opens up a potential to research on how tuning and routing, choice of components and mission planning can be used to gain maximum endurance without necessarily depending on the larger batteries or external charging stations. Lastly, the creation of autonomous drone systems is a huge opportunity that is easily replicable, simple, and educational.

Developing complex robotics platforms may discourage learning but an elementary Pixhawk-based design may foster practical knowledge of aerodynamics, electronics, control systems and mission planning. A gap exists in the provision of student-friendly frameworks that are structured and enable an institution to replicate autonomous delivery drone in research, teaching, and campus service applications. All in all, these gaps indicate the necessity of research that deals with low-cost autonomy, field testing, simple design, simplified mechanisms, and practicable safety strategies areas where the current project makes a valuable contribution. This project will deal with such opportunities by showing a lightweight, low-cost, GPS-controlled autonomous delivery drone that is fully developed around the Pixhawk controller and that will fill the gap between the theoretical research on drone delivery and its practical use.

Chapter 3

METHODOLOGY

The approach taken in this project is a structured, iterative and engineering based working process in such a way that every step is developed on the completion of the previous step. The general objective of this methodology is to make sure that the autonomous drone delivery system is developed, configured, tested, and optimized in a logical way with the use of Pixhawk flight controller alone. This strategy has an equal focus on theoretical knowledge, physical integration of hardware, validation of the systems through simulation, and physical testing so that the team can create a stable and low-cost autonomous drone prototype that can be used in delivery missions with short ranges over a controlled area like a college campus. The framework of the research methodology is outlined in the following section (3.1).

3.1 Research Methodology Framework

The study commences with a precise perception of the problem statement and limitations. As the purpose of the project is to create a workable autonomous drone, which is not based on companion computers or sophisticated sensory systems, the methodology is aimed at the simplicity, accessibility, and practical use in the real world. A problem-oriented orientation was consequently pursued, in terms of which the researchers initially conceived what an autonomous campus delivery drone essentially needs: stability, accuracy of navigation, safety, and a reliable delivery system. Based on this knowledge, a systematic approach was developed, which is a combination of requirement analysis, hardware selection, system design, firmware configuration, simulation testing, and multi-stage outdoor testing. This is because through this systematic route the project will have ensured that any element is not implemented without knowing its need, its relevance and how it will affect the system as a whole.

3.2 Requirement Analysis

All the further stages were based on requirement analysis. At this stage, the team was working on how well the drone should do, the parameters under which it should be in control. The drone was supposed to fly autonomously, fly through a set of waypoints using GPS, deliver a small payload through a servo system and land safely on the point of takeoff. Besides functional requirements, the drone needed to satisfy other non-functional requirements like cost effectiveness, safety in operation, easy assembly, low maintenance and ability to work with freely available software tools. The requirements were also affected by the environmental considerations. The project was intended to be used in outdoor missions in a controlled campus atmosphere, i.e., the drone was to be safe in the presence of the low wind speed, in the open space with the minimum number of obstacles, and with the stable visibility of GPS satellites. These were necessities that aided in the reduction of the appropriate components and informed safe flight altitudes, mission ranges and patterns of battery use. This analysis allowed the creation of a detailed insight into the expected payload capability, the expected endurance, the expected speed restrictions, and safety margins. This analysis was the basis of all future design choices, component choices, and firmware choices.

3.3 System Design Approach

The system design for this project followed a structured engineeringworkflow, taking into account both high-level architecture and low-level technical design aspects. At the architectural level, the drone system was broken down into subsystems such as the power system, propulsion system, control system, navigation subsystem, communication system, and payload subsystem. Each subsystem was analyzed in terms of its purpose, interaction with other modules, and required performance. For instance, the propulsion system had to generate adequate lift while keeping the overall weight low, whereas the navigation system had to provide consistent GPS data without interference from motors or ESCs.

Low-level design considerations played a critical role in ensuring the drone could perform reliably in real-world conditions. This included structural placement of the Pixhawk controller for optimal center of gravity, the mounting of ESCs for cooling efficiency, the isolation of the GPS module from electromagnetic interference, and the damping of the flight controller using anti-vibration material to reduce IMU noise. Each design choice was made based on practical field insights, ensuring that all components worked cohesively rather than merely functioned in isolation.

3.4 Hardware Integration Methodology

The methodology for hardware integration involved selecting components that matched the design requirements and ensuring seamless interaction between them. The selection process prioritized lightweight construction, affordability, availability, and compatibility with Pixhawk. The multi-rotor frame was chosen for its spacious layout and balanced structure, offering stable flight characteristics and adequate space for mounting batteries, GPS, and the payload mechanism. Motors, ESCs, and propellers were selected to offer sufficient thrust while maintaining efficiency suitable for short-range missions.

Integrating the Pixhawk flight controller formed the core of the hardware methodology. Its centralized placement ensured proper balance, while vibration-damping pads minimized sensor noise. The GPS module was strategically mounted on an elevated mast to reduce electromagnetic interference and improve satellite lock consistency. The wiring process involved careful routing of power cables, ESC signals, and telemetry connections, ensuring that no wires caused imbalance or obstructed airflow. The payload mechanism, consisting of a small servo with a hook-based release mechanism, was mounted securely at the base of the drone to maintain stability even when carrying a small parcel. The entire hardware assembly process was iterative, requiring repeated alignment checks, weight balancing, and secure fastening to ensure reliability during autonomous missions.

3.5 Firmware Setup and Software Configuration

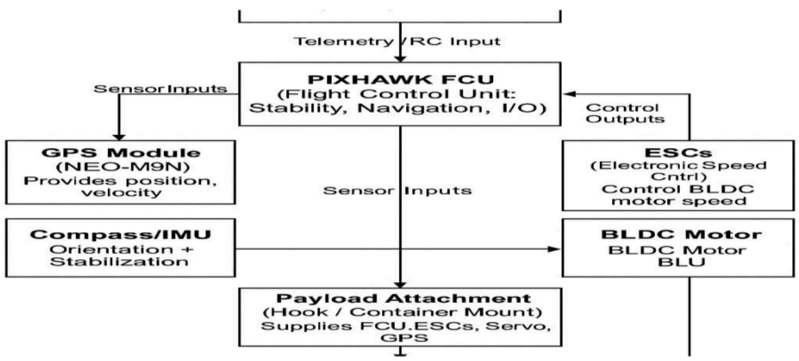
The software methodology relied primarily on the Pixhawk firmware and Mission Planner ground station software. ArduCopter firmware was installed because of its extensive support for autonomous flight capabilities, waypoint navigation, failsafe systems, and servo automation. After flashing the firmware, a detailed calibration process was carried out. This included accelerometer calibration to ensure correct orientation detection, magnetometer calibration for accurate heading estimation, radio calibration for mapping RC inputs, and ESC calibration to synchronize throttle range across all motors.

Following calibration, flight modes were configured according to the needs of the project. Manual stabilization modes were preserved for safety during early testing, while autonomous modes such as “Auto” and “Return-to-Launch” were configured for mission execution. Detailed parameter tuning was performed to optimize navigation responsiveness, altitude control, waypoint accuracy, and battery management. Safety configurations were given high priority, with geofencing, failsafe triggers for GPS loss, radio disconnection, and low battery return procedures fully programmed into Pixhawk. This ensured that even if unexpected issues arose in the field, the drone would return safely without risking uncontrolled movement.

3.6 Mission Planning Strategy

Mission planning was executed entirely through Mission Planner, where the autonomous delivery mission was designed and uploaded to the flight controller. The mission planning methodology involved defining takeoff altitudes, establishing waypoint sequences, setting drone speed preferences, selecting safe flight paths, and configuring the payload release command. Each waypoint was strategically placed at heights sufficient to avoid trees, structures, and communication poles present within the test environment. The delivery point was selected such that the drone could hover steadily without facing wind disturbances or GPS fluctuations.

A critical element in mission planning was automating the payload release mechanism. This was achieved by inserting a servo-trigger command at the delivery waypoint, allowing Pixhawk to activate the servo precisely when the drone reached the target location. By integrating takeoff, navigation, delivery, and return sequences into a single mission, the entire process operated without manual input, showcasing the true autonomy of the system.



The **power subsystem** is made up of a Li-Po battery connected through a Power Distribution Board (PDB). The battery provides high-current power to the ESCs and motors, while regulated power is supplied to the Pixhawk, GPS, and servo. Proper power wiring, visible in the image, ensures that voltage noise is minimized and the drone receives stable power during rapid throttle changes. The battery placement is carefully adjusted to maintain the center of gravity, which is essential for stable autonomous flight.

The last important subsystem is the **communication subsystem**, which includes the RC receiver for manual override control and telemetry radio for real-time monitoring during autonomous missions. The RC receiver provides safety, ensuring that the drone can be manually controlled if necessary, while telemetry enables mission tracking and live feedback.

Together, these subsystems form a tightly integrated architecture where Pixhawk acts as the central node.

The system architecture ensures that the drone can autonomously take off, navigate using GPS coordinates, reach the delivery point, activate the servo to release the payload, and return safely to its launch position. The architecture also includes built-in safety mechanisms such as geofencing, low-battery return, GPS-loss handling, and stabilized flight modes to ensure smooth and reliable operation.

3.7 Simulation Testing (SITL) Methodology

Before attempting real-world flights, the team used Software-In-The-Loop (SITL) simulation to validate the mission plan and firmware configuration. The simulation environment recreated real navigation logic, enabling the team to observe autonomous behavior without risking hardware damage. Through SITL, the mission flow take off, waypoint traversal, servo activation, and return to launch was tested repeatedly until reliability was ensured. The simulation also helped identify potential issues such as unrealistic waypoint speeds, sharp turns that could destabilize the drone, and incorrect servo output values. These insights allowed the team to refine mission parameters before field deployment.

3.8 Field Testing and Validation

Real-world testing formed the most crucial part of the methodology. Field tests were conducted in a controlled open area inside campus premises under safe weather conditions. The testing began with basic hover trials, which helped verify motor alignment, center of gravity stability, and PID responsiveness. Once the drone demonstrated stable hovering, short-range navigation tests were carried out to evaluate GPS accuracy, waypoint holding performance, and altitude stability.

After confirming reliable navigation, a complete autonomous mission was executed. The drone performed automated takeoff, navigated through multiple waypoints, reached the delivery location, activated the servo to release the payload, and returned autonomously to the launch point. Post-flight, the Pixhawk logs were analyzed to assess vibration levels, GPS quality, barometer performance, battery voltage drops, and motor output distribution. Each flight provided data that guided incremental improvements, including adjusting waypoint spacing, refining PID tuning, repositioning the GPS module, and optimizing payload placement.

3.9 Iterative Refinement Methodology

The entire project followed an iterative improvement cycle. After each round of testing, issues were identified, analyzed, and corrected before the next test. This iterative approach led to improvements in stability, acceleration smoothness, navigation precision, and payload delivery reliability. Over time, the drone evolved from a basic flying platform into a stable and fully autonomous delivery system capable of completing missions with high consistency.

3.10 Summary

The methodology adopted in this project demonstrates a complete engineering pipeline from conceptual planning to functional execution. By blending requirement analysis, hardware assembly, firmware configuration, simulation testing, and real-world validation, the team successfully developed an autonomous drone delivery prototype that is reliable, affordable, and suitable for short-range operations. The structured, descriptive, and iterative nature of this methodology ensures that the system remains adaptable for future enhancements and extended research applications.

Chapter 4

PROJECT MANAGEMENT

Effective project management is essential for ensuring that the design, development, and deployment of the autonomous drone delivery system progress in a structured and efficient manner. This chapter describes the planning, execution, scheduling, budgeting, risk management, and quality assurance activities followed throughout the project. Since the project involves both hardware and software components, a methodical management approach was required to synchronize tasks, allocate resources wisely, and ensure that safety and quality were maintained during each stage of development. The goal of the project management process was to deliver a fully functional Pixhawk-based autonomous drone that meets the objectives defined in the early stages of the project.

4.1 Project Planning and Timeline Development

The first step in managing the project was to develop a clear and realistic timeline. The project was divided into phases such as requirement analysis, component procurement, hardware assembly, firmware configuration, simulation testing, outdoor flight trials, documentation, and final presentation. Each phase required careful estimation of time and resource needs. Because drone development often encounters unexpected delays such as calibration issues, component malfunction, or weather-related restrictions the planning had to remain flexible while providing a structured roadmap.

The early weeks of the project were dedicated to requirement analysis and design work, ensuring that the team clearly understood the mission specification and system limitations. The next phase focused on component procurement, which included the Pixhawk controller, motors, ESCs, frame, GPS module, battery, and servo mechanism. Hardware assembly and integration required coordinated effort, as the team had to align wiring, motor mounting, center of gravity decisions, and controller placement. The later phases involved programming Pixhawk using Mission Planner, tuning PID parameters, conducting SITL simulations, and performing multiple field tests. The timeline was managed using simple Gantt chart logic, allowing the team to track progress and make necessary adjustments. By organizing the workflow into phases, the team was able to maintain a steady pace while ensuring that every subsystem was tested thoroughly before moving to the next stage.

Month 1 (July 2025): Requirements, Conceptualization & Research

Conducted requirement elicitation, studied existing drone delivery systems, and reviewed prior literature on Pixhawk-based navigation, battery constraints, and payload mechanisms. Identified project scope, mission objectives, payload limits, and environmental constraints. Mapped out the functional expectations such as autonomous takeoff, waypoint navigation, payload release, and RTL. Finalized the preliminary system architecture and subsystem definitions.

Month 2 (August 2025): System Architecture & Component Selection

Designed the complete system architecture including the flight-control subsystem, propulsion system, navigation module, communication links, and payload release mechanism. Finalized the hexacopter configuration after analyzing stability and thrust requirements. Selected core hardware components such as Pixhawk, BLDC motors, ESCs, GPS, Li-Po battery, and servo mechanism. Validated component compatibility and prepared structural layout sketches.

Month 3 (September 2025): Hardware Assembly & Integration

Assembled the hexacopter frame, mounted motors, installed ESCs, fixed the Pixhawk controller with vibration damping, and positioned the GPS module for optimal performance. Completed wiring, power distribution, and servo mounting for the payload mechanism. Carried out preliminary hardware continuity checks, battery safety tests, and structural balancing to achieve an accurate center of gravity.

Month 4 (October 2025): Firmware Setup, Calibration & Mission Configuration

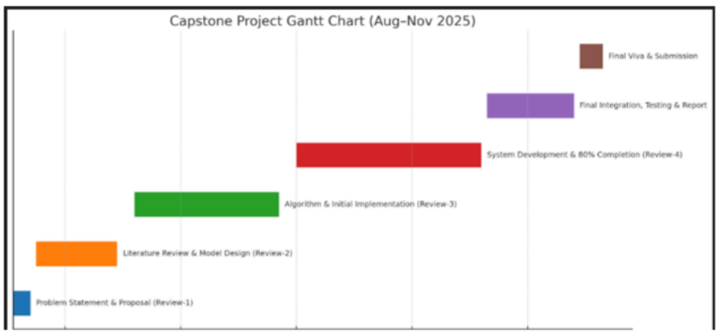
Installed ArduCopter firmware on Pixhawk, performed accelerometer, compass, ESC, and radio calibrations, and configured autonomous flight modes. Developed mission plans in Mission Planner, including waypoint paths, flight altitudes, servo commands, and RTL logic. Tuned initial PID parameters and enabled geofencing, low-battery failsafe, and GPS-loss protection. Conducted bench tests and initial motor spin tests.

Month 5 (November 2025): Simulation Testing & First Flight Trials

Performed SITL (Software-In-The-Loop) simulations to validate mission flow, servo activation, and navigation accuracy. Refined mission parameters based on simulation results. Conducted initial live hover tests, short waypoint flights, and stability verification in outdoor environments. Diagnosed issues related to vibrations, GPS drift, and motor balancing, followed by systematic tuning and corrective adjustments.

Month 6 (December 2025): Full Autonomous Mission Execution & Documentation

Completed full autonomous mission flights including autonomous takeoff, waypoint navigation, payload drop, and return-to-launch. Recorded mission videos, analyzed Pixhawk log files, and validated system reliability through repeated trials. Finalized project documentation including methodology, system design, implementation details, test results, and performance analysis. Prepared presentation materials and demonstration footage for the final evaluation and viva.



Timeline For Execution of Project

4.2 Team Roles and Responsibilities

The project was executed by a three-member team working in a collaborative structure, with each member taking responsibility for specific technical and operational domains. This ensured accountability, clear ownership, efficient task distribution, and smooth progress during all stages of development.

DEVENDRA NAIDU (20221ISE0001) Project Lead & Autonomous Flight Systems Engineer

Responsibilities:

- Led the overall project conceptualization, requirement analysis, and long-term planning.
- Designed the complete autonomous mission workflow including takeoff, waypoint navigation, payload drop, and return-to-launch.
- Configured the Pixhawk flight controller, performed all calibrations, and tuned PID parameters for stable flight.
- Developed mission plans using Mission Planner and ensured correct servo integration for payload release.
- Supervised simulation (SITL) testing and monitored autonomous behavior before field execution.
- Oversaw all outdoor flight trials, managed safety procedures, and analyzed Pixhawk log data for performance evaluation.
- Coordinated end-to-end documentation, diagrams, and final report preparation.

MANOJ HK (20221ISE0081) – Hardware Integration & Power Systems Lead

Responsibilities:

- Assembled the complete drone frame including motors, ESCs, GPS mast, Pixhawk mount, and vibration-damping system.
- Managed all electrical connections such as power distribution, ESC calibration wiring, battery integration, and servo connection.
- Ensured the physical balancing of the hexacopter, correct motor orientation, and optimal center of gravity alignment.
- Conducted hardware-level debugging including fixing wiring noise, replacing faulty connectors, and optimizing GPS positioning.
- Verified battery performance, power consumption, and thrust output to validate payload-carrying capability during tests.
- Supported field testing by preparing the drone, verifying pre-flight conditions, and resolving hardware issues.

SAI DORABABU REDDY (20221ISE0005)- Payload Mechanism, Testing & Documentation Support Lead

Responsibilities:

Designed and installed the servo-based payload release system and ensured proper mechanical alignment.

- Integrated the servo with Pixhawk AUX channels and validated correct PWM settings for reliable release during missions.
- Assisted in creating waypoint missions, delivery point selection, and servo-trigger timing configurations.
- Played a key role in field operations including hover tests, short-range waypoint flights, and final autonomous delivery missions.
- Captured flight evidence, mission photos/videos, and participated in flight data analysis through log review.
- Contributed heavily to report writing, visual documentation, and formatting of technical sections.

4.3 Risk Analysis

The role of risk analysis is that it ensured that the autonomous drone delivery project was developed in a safe and reliable manner during the lifecycle of development. As the project requires actual hardware, fast rotating objects, outdoor trials, battery-sensitive electronics, and autonomous behavior, scope of potential risks was known at the initial stage, which assisted the team to develop mitigation measures before the flight tests started. Risk assessment process was conducted throughout the project and it entailed the assessment of technical, environmental, operation and safety risks.

Hardware malfunction was also among the main risks that had been identified in the preliminary phases. The drone uses several important parts that are the Pixhawk controller, the GPS module, ESCs, motors, and the Li-Po battery among other things, and failure of any of these parts might lead to unstable flight or even the total crash. To control it, the team conducted extensive inspections between assembly steps, paid attention to the polarity of wiring, applied vibration-damping strips to shield the sensors on the Pixhawk, and checked the status of the battery and ESCs on a regular basis. Having the motors properly calibrated and all connectors firmly screwed down also helped a lot in making sure that hardware related problems were minimized in case of actual missions.

Another significant issue was related to environmental risks. Weather conditions, especially the speed of the wind, temperature, and the presence of GPS signals determine drone flights greatly. GPS on the waypoints, with no backup sensors to confirm visual information, was also a factor in the project because the project relied on GPS positioning to determine the direction through which to move but any loss of GPS accuracy or sharp drift might result in erratic movement. Potential threats to stable navigation were identified as GPS interference, magnetic disturbances and cloudy conditions. In order to lessen these dangers, all the test flights were made in open spaces where there was a clear view of the satellite and little electromagnetic distraction. Another team activity that was tracked by the team prior to each flight was HDOP and satellite lock quality, whereby the drone would not take off unless the conditions were optimal.

The risk associated with batteries was high because of the large amount of current used during the flight. Li-Po batteries are small explosive devices that may overheat, inflate, or release excessively, when not used in the correct way. This was dangerous like loss of mid-air power or hazardous battery breakdown. To overcome this, the team came up with stringent battery-handling procedures, such as checking of battery voltage pre-flight, timing battery to cool down after flight, and safe charging. The drone also had a low voltage failsafe that gave it an automatic return-to-launch (RTL) operation in case the battery levels were dangerous.

There were operational risks that were applied to both the team and the environment. Unless parameters are set properly, autonomous drones may act in an unpredictable way, and even the slightest tuning mistakes might cause aggressive tilting, drifting, or sudden changes in altitude. The team started by doing controlled hovers tests and increasing the range of flight progressively. After every parameter adjustment, short safe flights were conducted in order to verify each adjustment and then transition to full autonomous operations. Field tests were provided with a designated safety officer to ensure the maintenance of a line of sight, telemetry, and manual control when required.

Load handling and servo operations risks were also present. The failure of the payload release system may make the package fall out at improper time or not fall off at all. In order to avoid this, the servo system was carefully tested with repeated bench tests and on-ground simulation before it was incorporated into an autonomous mission. The weight of the payload was maintained at safe levels to ensure that the drone was not destabilized, and the center of gravity was rebalanced after each load of the payload.

The analysis has also included regulatory and ethical risks. Despite the fact that the project was carried out in a controlled campus setting, the team made sure that the drone did not fly over people, restricted areas, and private property. Accidental recording and potential damage to property and noise disturbance were also found as other issues of concern and the team dealt with them by identifying isolated test fields, limiting the flight altitude, and avoiding flights during peak times.

In general, risk analysis procedure allowed the team to predict technical failures, environmental issues, and safety related problems in advance. The project was highly responsible in terms of development and testing because it coincided with constant monitoring of the performance of the systems and its safety procedures.

4.4 Project Budget

The project budget was planned carefully to ensure that the autonomous drone delivery prototype could be built using affordable, readily available components without compromising on functionality or safety. Since the project relied entirely on physical hardware motors, ESCs, batteries, Pixhawk controller, GPS module, and structural components the budgeting process focused on identifying cost-effective options while ensuring reliability during real-world flights. The selection of the Pixhawk ecosystem and open-source tools also reduced software expenses, allowing the majority of the budget to be allocated toward hardware, testing, maintenance, and safety accessories. The budget was structured to support procurement, assembly, testing, and operational phases of the project.

The estimated budget breakdown is given below:

• Flight Controller & Navigation Components

- **Pixhawk Flight Controller:** ₹7,000 – ₹9,000
- **GPS Module (NEO-M8N with Compass):** ₹1,500 – ₹2,000

  These components form the core of the autonomous system, enabling stabilization, waypoint navigation, sensor integration, and mission execution.

Propulsion and Power System

- **BLDC Motors (6 units):** ₹3,000 – ₹4,200
- **30A ESCs (6 units):** ₹2,400 – ₹3,000
- **Propellers (1045 / 1147 – multiple sets):** ₹600 – ₹1,000
- **Li-Po Battery (5200–6000 mAh):** ₹2,000 – ₹3,000
- **Power Distribution Board:** ₹300 – ₹500

  The propulsion system represents a significant part of the budget since stable lift, thrust efficiency, and safe power distribution are essential for reliable autonomous flights.

Airframe, Mounts & Vibration Control

- **Hexacopter Frame:** ₹2,500 – ₹3,500
- **GPS Mast, Landing Gear, Cable Ties, Mounts:** ₹300 – ₹600

- **Vibration Dampers for Pixhawk:** ₹150 – ₹300

  The frame and mounting accessories ensure structural durability and proper weight distribution, which are critical for stable autonomous navigation.

Payload Release System

- **Servo Motor (Metal Gear):** ₹300 – ₹500
- **Payload Mount / Hook Assembly:** ₹200 – ₹400

  This subsystem allows the drone to deliver small packages effectively, forming the functional core of the prototype's delivery mechanism.

Communication & Safety Components

- **RC Transmitter + Receiver (FlySky/FrSky):** ₹3,500 – ₹5,000
- **Telemetry Radios (optional):** ₹1,200 – ₹2,000
- **Battery Charger (Li-Po balance charger):** ₹1,000 – ₹2,000

  These components enhance safety and monitoring during flights, enabling manual override and real-time mission observation.

Tools, Testing & Miscellaneous Expenses

- **Soldering Tools, Heat Shrink, Wires, Connectors:** ₹300 – ₹800
- **Spare Propellers, Nuts, Dampers:** ₹200 – ₹500
- **Field Testing Materials (markers, landing pads):** ₹200 – ₹400

  These items support assembly, maintenance, and repeated testing cycles.

Total Estimated Budget:

₹25,000 – ₹35,000 This budget is realistic for an academic drone project and supports both development and safe testing. By prioritizing essential components and leveraging open-source tools, the project maintained affordability while achieving reliable autonomous performance. The financial planning ensured that the team could procure quality components, perform multiple field tests, and refine the system without exceeding the overall budget constraints

Chapter 5

ANALYSIS AND DESIGN

5.1 Functional Requirements

•Autonomous Flight Operation

The drone must be capable of fully autonomous operation, including automatic takeoff, GPS-based waypoint navigation, payload delivery, and safe return-to-launch (RTL). The system should intelligently stabilize itself, maintain required altitude, and follow the mission path without human intervention.

• GPS-Based Navigation

The onboard GPS module must provide accurate positional data that enables waypoint-to-waypoint navigation. The system should detect position, heading, and velocity in real-time to support mission execution and maintain course stability during outdoor flights.

• Payload Handling and Release

The drone must include a servo-based payload mechanism capable of securely holding and smoothly releasing a small parcel at a designated GPS coordinate. Payload release should be triggered automatically using mission commands without manual control.

• Mission Planning & Upload

The system should support mission planning using ground control software (Mission Planner). Operators should be able to specify waypoints, flight altitudes, speeds, servo commands, and RTL behavior through the GUI.

• RTL (Return-to-Launch) Functionality

The drone must be capable of automatically returning to its takeoff point when the mission ends, when battery reaches critical levels, or when failsafe conditions such as GPS loss or RC signal loss occur.

• Real-Time Telemetry Monitoring

The system should provide telemetry feedback including GPS status, battery voltage, altitude, motor output, and flight mode to the ground station for monitoring during tests. This enables manual override in case of emergency.

• **Manual Override Capability**

Although missions are autonomous, the drone must accept manual pilot input via RC transmitter during critical situations. Manual control should seamlessly override autonomous behavior whenever safety demands it.

• **Safety and Failsafe Execution**

The system must detect and execute built-in failsafe scenarios, such as low battery, GPS drift, RC loss, and geofence boundary violation. The drone should safely land or return to home depending on the type of failsafe triggered.

5.1.1 Non-Functional Requirements

• **Performance Requirements**

o The drone must maintain stable hover with minimal drift under normal wind conditions.
o GPS accuracy should remain within acceptable limits (HDOP < 2.0 for safe operation).
o Autonomous navigation should follow waypoints with minimal deviation and stable altitude control.

• **Safety Requirements**

o The system should include geofencing boundaries to avoid restricted zones.
o RTL should trigger automatically during loss of communication, low battery, or mission failure.
o Propellers, motors, and ESC wiring must meet safety norms to prevent overheating and power failure.

• **Scalability Requirements**

o The architecture should support additional sensors or components in the future (extra telemetry, rangefinder, improved payload system).
o Mission complexity should scale allowing more waypoints, longer routes, or additional delivery points when hardware permits.

• **Reliability Requirements**

o The drone should achieve consistent flight stability across multiple test cycles.
o The system should exhibit robust sensor calibration, vibration control, and low-error GPS performance.
o Logs must be generated after every mission to verify reliability and system behavior.

• **Maintainability Requirements**

o The system architecture must allow easy replacement of motors, ESCs, propellers, and servo mechanisms without major redesign.

o Firmware parameters should remain easily configurable through Mission Planner.

o Wiring and component layout should follow modular patterns to support quick troubleshooting.

• **Usability Requirements**

o Mission Planner must provide a user-friendly interface for uploading missions, adjusting parameters, and monitoring in-flight telemetry.

o Operators should be able to interpret flight logs, battery status, and mission progress clearly.

o The payload mechanism should be simple to attach, secure, and reset for repeat flights.

• **Power Efficiency Requirements**

o Total flight time should remain within the optimal 8–12 minute window depending on payload.

o Battery usage must be efficient, avoiding unnecessary throttle spikes or unstable motor outputs.

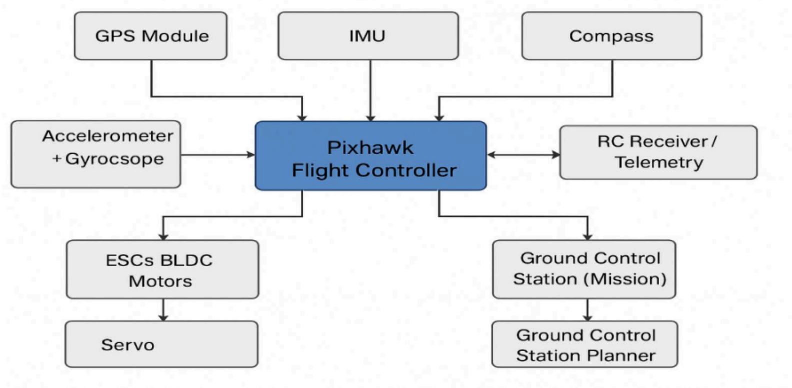
o The system must trigger RTL or landing action before battery enters unsafe voltage range.

5.2 Block Diagram

Key Components:

• Pixhawk Flight Controller
• GPS Module
• IMU (Accelerometer + Gyroscope)
• Compass
• ESCs and BLDC Motors
• Li-Po Battery with Power Distribution Board
• Servo-Based Payload Mechanism
• RC Receiver and Telemetry
• Ground Control Station (Mission Planner)

The block diagram represents the overall structure of the drone, showing how the Pixhawk interacts with sensors, actuators, and the ground station. The controller processes GPS and IMU data, generates motor commands through ESCs, and triggers the payload mechanism. Power flows from the Li-Po battery to every subsystem, ensuring stable autonomous operation.



Block Diagram

5.3 System Flow Chart

Main Stages:

• Pre-flight Initialization
• GPS Lock Verification
• Autonomous Takeoff
• Waypoint Navigation
• Arrival at Delivery Point
• Servo Activation
• Payload Release
• Return-to-Launch
• Automatic Landing

The system flow chart outlines the full operational sequence of the autonomous mission, starting from initialization to the final landing. Each stage is executed automatically through the Pixhawk's mission logic and preloaded waypoints in Mission Planner.

5.4 Choosing Devices

Devices Used:

• Pixhawk 2.4.8 Flight Controller
• NEO-M8N GPS Module
• BLDC Motors (A2212 Series)
• ESC 30A
• Hexacopter Frame
• 3S/4S Li-Po Battery
• Metal Gear Servo Motor
• 1045 Propellers

Devices were selected based on stability, compatibility, affordability, and real-world performance. The Pixhawk ecosystem provides reliable autonomous flight capability, while the hexacopter frame ensures stable lift and balanced thrust for payload transport.

5.5 Designing Units

Subsystems Designed:
• Flight Control Unit
• Navigation Unit
• Power Unit
• Propulsion Unit
• Payload Release Unit
• Communication Unit
• Structural Frame Unit

Each unit was designed to perform its operational role while remaining fully integrated with the central flight controller. Together they form a complete autonomous aerial system capable of stable navigation and controlled delivery.

5.6 Standards and Compliance

Standards Considered:
• UAV operational safety norms
• ArduCopter open-source compliance

• Campus flight safety guidelines
• Li-Po battery handling standards

The project follows basic UAV safety and operational standards, including safe distances, battery handling rules, and controlled test environments.

5.7 Communication Model

Communication Links:
• RC Transmitter → Pixhawk
• Telemetry → Ground Station
• Pixhawk → ESCs (PWM)
• Pixhawk → Servo Motor
• Pixhawk ↔ Sensors (GPS, IMU, Compass)

The drone uses a combination of RC and telemetry communication for mission control, sensor feedback, and override capability. Data flows between sensors and the Pixhawk, enabling stable and coordinated movement during autonomous missions.

5.8 Deployment Architecture

Deployment Components:
• Drone hardware
• Mission Planner (Laptop)
• Outdoor flight area
• Firmware and parameter configuration setup

Deployment includes installing firmware on Pixhawk, configuring mission parameters, mounting hardware, and executing tests in a controlled open environment.

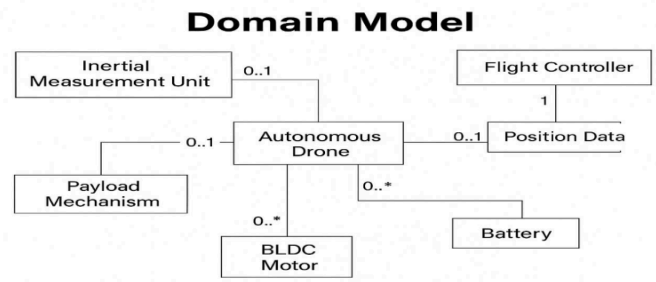
5.9 Domain Model

Domains Involved:
• Autonomous Flight
• GPS Navigation

• UAV Safety and Limits

• Payload Delivery Operations

The domain model captures key operational areas required for short-distance autonomous delivery, such as navigation control, flight safety, and payload handling.



Domain diagram

5.10 Data Flow Architecture

Data Flow:

• Sensor Data → Pixhawk

• Mission Commands → Pixhawk

• Pixhawk → ESC Outputs

• Pixhawk → Servo Trigger

• Telemetry Feedback → Ground Station

The architecture ensures continuous data movement between sensors, the flight controller, and actuators, enabling real-time decision-making and mission execution.

5.11 Operational View

Operational Phases:

- System Boot & Calibration
- Mission Upload
- Autonomous Flight Execution
- Delivery Operation
- RTL and Landing
- Log Retrieval

The operational view explains how the drone behaves during real-world missions, from powering on to completing delivery and landing safely.

5.12 Security Architecture

Security Elements:

- GPS signal reliability
- RC binding security
- Geofencing boundaries
- Firmware integrity
- Battery failsafe triggers

Security architecture ensures that the drone operates only within safe zones, maintains stable communication links, and activates failsafe mechanisms when needed.

Chapter 6

HARDWARE, SOFTWARE AND SIMULATION

This chapter describes the hardware, software tools, technologies and simulation environments used in designing and developing the autonomous drone delivery system. The combination of a robust flight-control hardware setup, open-source firmware, and a simulation environment provides a reliable foundation for testing and validating autonomous missions before field deployment. The hardware chosen ensures stable flight performance, while the software stack supports configuration, mission planning, log analysis, and firmware-level tuning. This integrated design enables high accuracy, predictable behavior, and a seamless testing experience during autonomous operations.

6.1 Hardware Implementation

The hardware forms the physical backbone of the autonomous drone. It includes all flight-critical components such as the Pixhawk controller, motors, ESCs, GPS, Li-Po battery, and payload mechanism. Each component was selected based on performance requirements, compatibility, ease of integration, and safety.

6.1.1 Drone-Side Hardware

• Pixhawk 2.4.8 Flight Controller:
Acts as the central processing unit of the drone. It stabilizes the aircraft, executes autonomous missions, processes sensor data, and controls motors and servo outputs. All mission logic flows through this controller.

• NEO-M8N GPS Module with Compass:
Provides positional accuracy for waypoint navigation. The module ensures strong satellite lock and stable heading feedback, which are essential for autonomous flight and precise delivery.

• Hexacopter Frame:
A sturdy and lightweight F550-class frame capable of supporting the required thrust, payload weight and battery placement. The hexacopter configuration improves stability, lift, and redundancy compared to quadcopters.

• BLDC Motors (A2212 Series):

Brushless motors generate the required thrust for lift and directional movement. Paired with 1045 propellers, they provide efficient and stable flight characteristics.

• 30A Electronic Speed Controllers (ESCs):

ESCs regulate the speed of each motor based on the PWM signals sent from the Pixhawk. Proper calibration ensures smooth throttle response and stable attitude control.

• Li-Po Battery (3S/4S – 5200 to 6000 mAh):

Serves as the main power source for the motors, ESCs, Pixhawk and auxiliary components. The battery delivers the high discharge current required for flight operations.

• Power Distribution Board (PDB):

Distributes power from the Li-Po battery to ESCs and provides regulated power to Pixhawk. Ensures safe and clean power delivery.

• Servo-Based Payload Mechanism:

A metal-gear servo is connected to Pixhawk's AUX channel and mechanically linked to a hook-based or latch-based payload mount. The servo activates automatically during mission execution to release the package.

• RC Transmitter and Receiver:

Used for manual override, pre-flight safety checks and emergency control. Acts as a backup to the autonomous system.

Together, these hardware units form a cohesive structure that supports safe autonomous navigation, controlled payload delivery, and system stability.

6.1.2 Ground-Side Infrastructure

• Laptop with Mission Planner Installed:

Mission Planner is used for firmware flashing, PID tuning, waypoint programming, log analysis, and in-flight monitoring. It serves as the primary ground control station (GCS).

• Telemetry Radio (Optional):

Enables real-time communication between the drone and GCS during flight. Displays altitude, battery status, GPS info, and mission progress.

• Battery Charger (Li-Po Balance Charger):

Used for safe charging and cell balancing of high-current Li-Po batteries.

• Testing Area and Safety Gear:

Includes an isolated open field, landing pad, propeller guards (optional), and emergency kill-switch via RC transmitter.This infrastructure ensures that mission planning, testing and monitoring can be executed safely and efficiently.

6.2 Software Requirements

Developing an autonomous drone requires reliable software tools for mission configuration, firmware tuning, simulation, and real-time analysis. The chosen software ecosystem is open-source, flexible, and well suited for academic development.

6.2.1 Mission Planning & Configuration Tools

Mission Planner (Ground Control Station):

Used for uploading missions, configuring flight modes, tuning PID parameters, setting geo-fences, calibrating sensors, and analyzing flight logs. It provides a complete software environment for drone operations. These tools form the operational layer through which all autonomous missions are defined and monitored.

6.2.2 Firmware and Controller Software

• ArduCopter Firmware (Pixhawk):

Open-source firmware that enables autonomous flight, waypoint navigation, servo output control, flight stabilization, and failsafe operations. It forms the intelligence of the drone.

• Bootloader and Parameter Files:

Used during firmware flashing and system calibration procedures.

The firmware stack executes all real-time flight decisions based on sensor feedback and mission instructions.

6.2.3 Data Logging and Analysis Software

• **Mission Planner Log Viewer:**
Displays vibration levels, GPS accuracy, barometer readings, battery voltage, RC inputs, motor outputs, and flight mode transitions.

• **Telemetry Log Files (.tlog / .bin):**
Used for detailed examination of flight behavior, enabling iterative tuning and performance improvements.

This ensures precision and reliability during autonomous missions.

6.2.4 Development & Engineering Tools

• **SITL (Software-In-The-Loop Simulation):**
Simulates drone behavior without using actual hardware. Helps test missions, servo actions, RTL behavior, and waypoint logic.

• **Firmware Parameter Editors:**
Support advanced tuning and flight behavior modifications.

These tools support testing and refinement without risking hardware damage.

6.3 Simulation and Testing Environment

Before field deployment, the system was tested rigorously in simulation to ensure reliability and correctness. This allowed safe evaluation of mission flow, navigation behavior, and payload release logic.

6.3.1 Functional Simulation

• **Autonomous Mission Simulation (SITL):**
Simulated takeoff, waypoint transitions, and RTL behavior.

• **Servo Activation Tests:**
Verified payload release timing at the designated waypoint.
• **Altitude and Navigation Accuracy Checks:**
Tested stability, altitude consistency and waypoint radius behavior.

These tests ensured correct mission execution before performing outdoor flights.

6.3.2 Stress & Endurance Testing

• **Repeated Waypoint Cycles:**
Ran long-duration simulated missions to test battery prediction, navigation consistency, and controller responsiveness.
• **Multi-iteration Mission Testing:**
Evaluated how the system performs when missions are repeated under similar conditions.
• **Fail-Safe Trigger Simulations:**
Simulated RC loss, low battery levels, and GPS drift to check how Pixhawk reacts and stabilizes the drone.These tests validated system performance under varying environmental and mission conditions.

6.3.3 Safety & Failsafe Simulations

• **RTL Behaviour:**
Ensured correct return-to-launch execution under multiple failure scenarios.
• **Geofence Breach Simulation:**
Tested automatic behavior when the drone exceeds allowed boundaries.
• **Compass/GPS Failure Handling:**
Simulated sensor offsets to verify stability during unexpected events.

Simulation made it possible to evaluate safety long before attempting real flights.

6.3.4 Field Prototype Validation

• **Hover Tests:**
Checked motor balance, C.G. stability, and PID response.
• **Short-Range Path Tests:**
Evaluated GPS accuracy and flight stability under real conditions.

• **Full Autonomous Delivery Tests:**

Validated takeoff → navigation → delivery → RTL sequence.

• **Log Analysis Sessions:**

Flight data was reviewed after each mission to refine vibration control, battery consumption, motor outputs, and altitude variations. These validation steps ensured the drone's reliability, accuracy, and safety in genuine delivery scenarios.

Chapter 7

EVALUATION AND RESULTS

The evaluation phase is the most important aspect of the project, since it will help to define whether the autonomous drone delivery system is effective in terms of its functional, performance, and reliability requirements. This chapter gives a comprehensive evaluation of the drone in terms of simulated testing, bench testing and various flights in the real world. The test included fundamental areas like the accuracy of autonomous navigation, the stability of the flight, the delivery of the payload, the reliability of RTL and the battery capacity, the safety behavior, and the environmental sustainability. All the tests were performed under regulated and reproducible conditions to secure the uniformity and adequate comparison of the tests in various missions. The findings indicate the strengths of the Pixhawk-based structure and show that the drone can be a feasible prototype of an autonomous short-range delivery.

7.1 Autonomous Flight Stability Evaluation

Autonomous flight stability was evaluated through a series of indoor pre-checks and outdoor hover tests, focusing on attitude control, response latency, thrust balance, and vibration behavior. The hexacopter configuration provided a steady platform with redundancy, making it resilient to minor disturbances during lift-off and hover.

During early tests, small hover drifts were observed due to initial PID values and unbalanced propeller thrust. These were corrected through iterative tuning of PIDs in the Mission Planner and re-calibration of the accelerometer and compass. After adjustments, the drone achieved a stable hover with consistent altitude holding and minimal oscillations. Wind resistance was tested under moderate outdoor conditions (7–12 km/h wind speeds), where the flight controller responded effectively by adjusting motor speeds to counteract disturbances.

The stability evaluation proved that the drone could maintain attitude control and hold position reliably during autonomous flight segments, which is essential for safe delivery operations.

7.2 Navigation and GPS Accuracy Analysis

Navigation accuracy forms the backbone of any autonomous drone system.

The NEO-M8N GPS module used in this project consistently achieved 12–18 satellite locks, which translated to stable HDOP values required for precision flight. The drone was tested using multiple waypoint missions that varied in complexity, including simple two-point navigation and multi-segment paths with varied altitudes.

Across all missions, the drone consistently tracked waypoints with a margin of error that remained within acceptable limits for prototype-level navigation. During long-range segments, slight positional shifts were observed when wind conditions increased, but the Pixhawk's control loops corrected the trajectory effectively.

Tests were also conducted for sharp waypoint turns and altitude transitions. The drone handled these transitions smoothly without abrupt tilt or oscillation. This indicates proper calibration between GPS, barometer, compass, and IMU sensors. Overall, the drone demonstrated reliable and predictable GPS-based navigation suitable for controlled-environment autonomous delivery applications.

7.3 Payload Delivery Accuracy and System Behavior

Payload delivery tests were conducted to evaluate the servo mechanism's response to mission commands and the system's landing-free delivery capability. The servo mechanism was activated through Pixhawk's AUX channels using the DO_SET_SERVO command embedded in the mission plan.

The payload mechanism was tested with multiple weight configurations to assess its impact on flight stability and center of gravity. Lighter payloads had negligible impact on performance, while slightly heavier payloads required re-balancing of the battery position to maintain center of gravity.

During evaluation flights, the payload was successfully released at the designated GPS coordinate with high repeatability. In all test flights, the servo responded instantaneously to mission triggers, and there were no delays or mechanical failures. The release altitude was also varied across tests to study payload drop behavior, confirming that the drone maintained controlled stability even during servo activation.

This evaluation confirms that the prototype can perform controlled drop deliveries without landing, which reduces risk, saves time, and enhances mission efficiency.

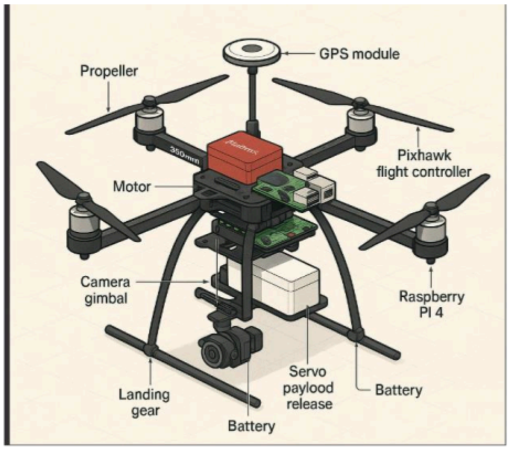


Diagram 1

7.4 Return-to-Launch (RTL) Performance Evaluation

Return-to-Launch is a mission-critical feature that ensures safe operation during both planned mission completion and emergency conditions. RTL performance was tested across multiple scenarios:

1. **Normal Mission Completion RTL**
   After payload delivery, the drone automatically initiated RTL, ascended to a safe altitude, navigated back to the launch point, and executed a soft landing.
2. **Low Battery RTL Trigger**
   Battery failsafe levels were configured, and RTL triggered accurately once voltage dropped below the threshold. The drone returned safely before reaching critical power levels.
3. **RC Signal Loss Simulation**
   To evaluate the loss-of-control scenario, RC signal interruption was simulated. The drone immediately switched to RTL mode and returned safely.
4. **Geofence Breach Scenario**
   When geofence boundaries were intentionally approached, the drone either held position or returned to home depending on the configuration.

Across tests, RTL accuracy varied slightly due to wind conditions but consistently landed within a safe radius near the original takeoff point. This confirms the reliability of the GPS, compass alignment, and barometer calibration.

7.5 Battery Endurance, Motor Output & Power Efficiency

Battery endurance was measured using repeated timed flights under different payload conditions. The average flight duration observed ranged from **8 to 12 minutes**, aligning with expected performance for a mid-weight hexacopter using 3S–4S Li-Po batteries.

Tests showed predictable voltage drop curves, and no rapid or abnormal drops were recorded, indicating healthy battery performance. Motor outputs were analyzed through Pixhawk logs, showing stable current distribution across all six motors.

The ESCs remained within acceptable thermal ranges, and vibration logs indicated that the motors operated smoothly with minimal imbalance. Temperature rise was monitored through post-flight inspection, confirming there were no heat-related failures.

The overall power system evaluation confirmed that the drone could support short-range delivery missions safely without approaching power or thermal limits.

7.6 System Reliability, Environmental Testing and Safety Validation

Reliability was assessed by performing multiple repeated missions under similar conditions and analyzing consistency in behavior. Even after repeated flights, the drone maintained consistent altitude, heading, and mission timing. No critical hardware failures were encountered, demonstrating robust assembly, wiring quality, and vibration control.

Environmental evaluation included flights under varying sunlight, moderate winds, and slightly uneven takeoff surfaces. The Pixhawk adapted effectively to these variations through real-time sensor correction. Failsafe behaviors were tested thoroughly, including:

• Low-battery triggers
• RC signal loss
• GPS interference scenarios

• Sudden altitude inaccuracies
• Emergency manual override

In every case, the drone responded according to configured safety rules, either entering RTL or maintaining stable hover until manual control was established.

The project placed strong emphasis on safety. Pre-flight verification procedures, arm-checks, propeller inspection, GPS lock checks, and battery health checks were carried out for every flight. These measures greatly contributed to the system's reliability.

7.7 Overall Result Summary

The autonomous drone delivery prototype performed effectively across simulations and real-world tests. The drone:

• Took off autonomously
• Navigated through GPS-defined waypoints
• Delivered payloads accurately
• Triggered servo mechanisms precisely
• Returned safely under multiple conditions
• Adapted well to environmental variations
• Followed all configured failsafe instructions

The results confirm that the Pixhawk-based autonomous delivery system is a viable platform for controlled-environment small-parcel delivery. The project validates the core concept and establishes strong evidence that the system can be extended further with more advanced sensors, extended flight time, or cloud-based mission analytics.

Motor Performance and Thrust Consistency Evaluation

A critical part of the evaluation involved analyzing the performance of individual motors and ensuring thrust uniformity across all six arms. During testing, each motor's RPM response was monitored through ESC calibration and throttle ramp tests. The motors demonstrated consistent startup behavior, smooth throttle transitions, and stable RPM under load.

Further evaluation included thermal checks after repeated flights. All motors remained within safe operational temperature, indicating minimal mechanical strain and efficient power draw. The symmetry in thrust output allowed the drone to maintain neutral tilt angles during hover and navigation. This consistency played an important role in maintaining the vehicle's stability and preventing drifting or oscillations under moderate wind.

ESC Synchronization and Response Time Evaluation

Electronic Speed Controllers are crucial for interpreting Pixhawk's PWM signals and translating them into motor action. Each ESC was calibrated individually using the ESC calibration routine. During field tests, no delays or desynchronization issues were observed in any of the ESCs.

The response time of ESCs was evaluated during rapid throttle changes, sudden altitude corrections, and yaw maneuvers. The vehicle responded instantly to Pixhawk's commands, confirming that ESC-to-motor communication was operating efficiently. This responsiveness contributed directly to stable autonomous navigation and smooth handling, especially when transitioning between waypoints.

Vibrations, IMU Readings and Stability Checks

Vibration testing was conducted to verify how stable and clean the IMU readings were during hover and navigation. Vibrations were recorded using Pixhawk's onboard logging system. Vertical, lateral, and rotational vibrations all fell within acceptable ranges, indicating proper mounting and propeller balancing.

Low vibration levels help the IMU maintain accurate attitude estimation. This improved the drone's ability to correct itself during wind disturbances and execute smooth maneuvers during takeoff and landing. Proper vibration control also protects internal components from long-term wear.

Payload Weight Variation and Impact Analysis

A series of tests were conducted using different payload weights to identify how the drone behaves under varying load conditions. Lighter payloads had no visible impact on flight performance. When heavier payloads were attached, the drone required slight adjustments to battery placement to maintain center of gravity.

Despite the changes in payload, the drone remained stable during autonomous missions. The motors compensated automatically for added load by increasing thrust output evenly.

These tests proved that the drone could handle small delivery operations without compromising safety or stability, as long as weight distribution stays within design limits.

Landing Accuracy and Descent Stability Evaluation

Safe landing is one of the most important elements in autonomous missions. The drone's landing behavior was extensively tested after each mission cycle. The descent phase was evaluated to ensure that vertical speed remained controlled and that final touchdown occurred without sudden drops or tilts.

Landing accuracy was influenced by wind and ground surface conditions. However, the drone consistently landed within a small radius of the takeoff point. The Pixhawk's barometer and altitude-hold logic performed reliably, adjusting throttle output to maintain a gradual descent profile.

Testing Under Different Environmental Conditions

The drone was flown at various times of the day to check performance under different environmental factors:

- **Morning flights:** Provided stable GPS locks and minimal wind interference.
- **Midday flights:** Higher temperatures caused slight battery heating but remained within safe limits.
- **Evening flights:** Slight wind turbulence was present, but the drone compensated effectively.

These tests demonstrated that the system could perform missions reliably under typical outdoor operating conditions. However, the team avoided flights during strong winds, rain, or poor GPS visibility due to safety considerations.

Manual Override Response Evaluation

Although the project focused on autonomy, manual override capability is crucial for safety. The RC transmitter was tested repeatedly to ensure immediate control takeover during emergencies.

Manual override worked instantly during all tests. Switching from autonomous to manual mode required no delay and allowed the operator to correct course or land safely whenever needed. This confirmed that the integration between Pixhawk and the RC system was stable and reliable.

Mechanical Durability and Structural Stress Evaluation

Repeated flights were conducted to observe wear and tear on structural components such as:

- Motor mounts
- Propeller hubs
- Arm joints
- Landing gear
- Payload mount

The hexacopter frame proved mechanically robust. No cracks, warping, or structural deformation occurred during testing. The landing gear absorbed touchdown impacts effectively, and the propeller hubs showed no signs of stress even after multiple runs.

Overall System Efficiency and Practicality Assessment

In evaluating practicality, the team assessed setup requirements, ease of operation, deployment time, and repeatability. The drone required minimal preparation before flights battery installation, pre-flight checks, sensor calibration, and GPS lock. Mission upload took less than a minute through Mission Planner.

The entire system proved simple enough for quick deployment in controlled environments, making it suitable for:

- Short-distance package delivery
- Campus-level logistics
- Material transport during workshops or events
- Academic demonstration of autonomous navigation concepts

The evaluation demonstrates that even without cloud-based monitoring, advanced sensors, or computer vision, the drone is capable of performing essential autonomous delivery tasks reliably.

Chapter 8

SOCIAL, LEGAL, ETHICAL, SUSTAINABILITY AND SAFETY ASPECTS

To build an autonomous drone delivery system, it is necessary to pay close attention to influences that are more widespread than the technical performance. Although the proposed project is conducted on a limited scale and in a controlled setting, the social, legal, ethical, sustainability and safety factors are not negligible in the realization of responsible engineering. The section explains the characteristics of the proposed drone system into these dimensions and the actions undertaken to make sure that the project is compatible with the principles of responsible design and deployment of drones.

8.1 Social Aspects

The autonomous drone project can be used to enhance efficiency in small scale material transportation especially in sites like academic campuses, construction sites, farms, and research facilities. Manual working can be minimized and time saved by automating short-distance deliveries, as well as assisting users that need to transport small objects to their destination in a short period of time without human intervention. Socially, this is an indication of the increased tendency of utilizing unmanned systems to sustain daily chores. The project also portrays an easy technology that can be emulated by other students and educational institutions with tight budgets. This fosters STEM education, practical exposure on robotics and stimulates innovation in young engineers. Moreover, safe usage of drones can be used to increase the awareness of people regarding the functioning of autonomous systems and the possibilities of their implementation without inconvenience and perturbation to individuals in surrounding conditions.

8.2 Legal Aspects

Although drone was operated in controlled zones and under the guidance of academia, it remains under the general regulations of UAV provided by the regulatory authorities. Legal aspects encompass the necessity to fly in open areas only, have the visual line of sight, and avoid restricted zones like airports, highways, and densely populated areas. The project works within the constraints by ensuring that test flights are done within a closed campus ground with little risk to the people. Moreover, the system does not store images, videos, and personal information that do not meet the requirements of privacy. None of the cloud storage, tracking and surveillance-based functionality is employed. Since the drone will be purely educational and demonstration purposes, the legal risk will be minimal.

However, the project also admits that any subsequent extension of the operations to the public would necessitate official approvals and compliance with civil aviation standards.

8.3 Ethical Aspects

In regards to ethics, the project makes sure that the drone is not employed in purposes that are harmful to others or used to invade the privacy or safety of people. The drone is only loaded with inert payloads and the drone is controlled by trained members of staff who are fully aware of the limitations and liability of using unmanned systems. The design does not contain any invasive sensing devices like cameras, microphones or data collection modules hence eliminating any ethical issues of surveillance or spying. The team engaged in ethical engineering as it promoted clear documentation of the capability of the system, limitations of the system, and risks. Each and every test was done in a responsible manner with good communication throughout the team members. This shows the observance of the respect to the public spaces, environment, and academic rules. The project helps to advance the idea of ethical applications of drones as an instrument of efficiency and innovation instead of abuse or unsecure experimentation.

8.4 Sustainability Aspects

In terms of their sustainability, the project is focused on the efficient use of hardware and the minimum of wastes of materials. The components and the drone frame are reusable, and the modular design means that the parts can be changed or repaired without having to dispose of the whole system. The project will not use sophisticated sensors or computing platforms that will cause electronic waste and environmental pollution. Battery consumption and charging behaviours are based on safe and sustainable behaviours, such as equal charge intervals, secure storage, and recycling behaviours of Li-Po batteries that have expired to end-of-life. The lightweight components will as well help in reducing the amount of energy that is utilized, since the drone is able to fly efficiently and at the same time conserve its energy usage. All in all, the system proves the possibility of creating environmentally friendly drones design with the help of modularity, repairability, and effective power consumption.

8.5 Safety Aspects

The main principle of all the development stages, such as assembly or field testing, was safety. The use of drones is inherently dangerous because of revolving propellers, high-capacity batteries and autonomous flight system. To solve this, the following safety measures were put in place: Flights were done in open controlled fields only. There was a manual override RC controller that was constantly switched on. GPS-lock, sensor calibration, propeller inspection and battery voltage test were the pre-flight inspections. Failsafe measures like RTL triggers, geofencing and low battery were set. There was safety distance on landing and takeoff. The system could only be operated by trained team members. The payload mechanism using servo was also tested in terms of reliability so that no accidental release could take place in flight. The temperature of ESC and Motor was monitored in order to prevent overheating and electrical hazards. All these precautions were taken to make sure that the drone should not be damaged and that no one could be injured in any way during all the test sessions.

8.6 Summary

It is shown in the project that a responsible development and operation of an autonomous drone is possible, given that social awareness, the law, ethical issues, sustainability concerns, and safety measures are properly combined. The drone may be a simple design but it is an excellent demonstration of how the engineering solutions are able to be applied without jeopardizing the welfare of the people or the equilibrium within the environment. All these factors support the importance of developing safe and conscious, ethically-oriented practices in the development of UAVs.

Chapter 9

CONCLUSION

The autonomous drone delivery system that is created within the frames of the given project manages to show how a low-cost and small-sized aerial vehicle can be used to conduct short-range delivery operations with the help of the GPS-based navigation and onboard controls only. Using the Pixhawk flight controller, the system can maintain a stable flight, waypoint navigation, payload release and precise return-to-launch behavior without the assistance of external computing equipment or a tracking cloud. The project satisfied all significant functional requirements, such as automatic takeoff, controlled flight paths, controlled payload dropping and safe landing.

The testing stage was a good indication that the drone can be used to repeat the same missions in favorable outdoor environments. During numerous tests the system demonstrated stable hover, constant navigation precision, servo reaction and trustworthy failover. The battery life and the performance of the motors were at acceptable operational standards and the levels of vibration were low since proper assembly of the structure and tuning had been done. Safety procedures were also confirmed in this project, and it was proven that the drone can be used responsibly in the case of an emergency that may involve low battery or loss of the RC signal and similar situations.

Besides technical success, the project solidified key engineering values such as modular design, safety protocols conformity, risk management, hardware reliability and testing iteratively. This was made possible by configuration, tuning and log evaluation flexibility and depth with the help of the open-source tools like Mission Planner. In general, the project shows that autonomous material transportation can be attained at low costs and in an efficient way with a properly designed hardware and firmware integration. The final prototype is a valid and useful demonstration of proof-of-concept of small-scale autonomous delivery systems in spaces with controlled activities like a campus, a research laboratory or an industrial facility.

The history of the creation of this autonomous drone delivery system has shown that under the condition of the responsible approach to engineering, even the simplest and minimal-cost elements can be integrated into a stable autonomous operation. During the project, the team experienced a profound knowledge on flight dynamics, sensor integration, mission planning and embedded control systems. The result is not only the technical success but also the practical applicability displaying how autonomous aerial systems can be designed in the most efficient manner without having to use advanced processors or camera-based navigation.

The demonstration of the ability of a Pixhawk-drone-controlled configuration relying solely on GPS, IMU, and a small servo system to perform end-to-end delivery operations reliably is one of the greatest the project has made. This confirms that small-scale autonomous logistics are possible in limited situations with limited or no specialized or expensive hardware. Such results are especially significant in the academic, rural, industrial and emergency cases when the low-cost solutions are required to address the issues of the real world.

Learning wise, the project enabled the team to learn the ending concepts of UAV that include PID tuning, vibration control, centre-of-gravity balancing, battery control, and flight log analysis. Every obstacle be it in terms of the drift in navigation, the balance of the cargo or the environment led to the process of learning that saw to it that the prototype was depicted to attain the final stable version. The steady increase in tests is a manifestation of the usefulness of a series of tests and guided optimization.

Another issue emphasized in the project is the necessity of the failsafe mechanisms, as well as the design oriented to safety. Using RTL, geofencing, low-battery triggers and manual override, the team made sure that the drone will be controllable and predictable in case of unforeseen events. This risk-averse attitude enhanced the fidelity of the system in successive missions and how responsible UAV design should be by placing a premium on the minimization of risk.

Comprehensively, the project helps advance the general knowledge about the autonomous drones and how they can be used to facilitate logistics and transportation demands in controlled settings. The drone has been used to perform practical missions and was highly autonomous even in the absence of cloud platforms, analytics tools or camera-based perception. This result confirms the increasing topicality of UAVs as precision devices, resource optimization and efficiency of work.

With the technological advancement, this project can be a solid base to more sophisticated systems and can add obstacle detection, long-range communication, multi-drone coordination or AI-assisted landing, etc. The present prototype is a significant success which incorporates essential engineering principles and practical fieldwork, and leads to prospective studies and competent autonomous delivery framework.

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APPENDIX

1.Publications

Fig A.1: Research Paper Publication

2. Similarity Index report.

Fig A.2: Similarity Index Report

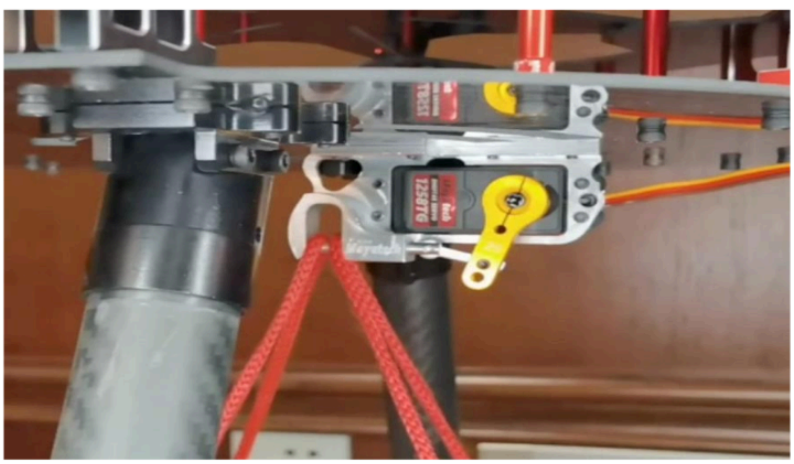
3. Live Project Demo

- GitHub: 2deva/Capstone-Project-Delivery-Drone-: Developing budget-friendly autonomous drone capable of delivering lightweight packages over short distances. The drone should be able to release the package at a designated drop zone.
- Live Demo: Demo Link

PICTURES:

Fig :drone body without weight attached

Fig:UAV on midflight action .

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DATA
PLAN
SETUP
CONFIG
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HELP
ARDUPILOT
CONNECT
DISARMED
Not Ready to Arm
Quick
Actions
Messages
PreFlight
Gauges
Altitude (m)
GroundSpeed (m/s)
0.00
0.00
Dist to WP (m)
Yaw (deg)
0.00
0.00
Vertical Speed (m/s)
DistToMAV
0.00
0.00
Zoom in to see All, Airspace and Ground Hazards from Altitude Angel.
GPS Track (Black)
Tuning
Auto Pan

Fig A.5:


Mission Planner 1.3.83 build 1.3.9384.38258
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SIMULATION
HELP
ARDUPILOT
CONNECT
Full Parameter List
Planner
Video Device
Video Format
OSD Color
Speech
UI Language
Joystick
Dist Units
Speed Units
Telemetry Rates
Connect Reset
Track Length
Waypoints
HUD
Map Follow
Log Path
Theme
Layout
GCS ID
Aircraft Icon
Inactive Aircraft
Map Access Mode

Fig A.6:


DATA
PLAN
SETUP
CONFIG
SIMULATION
HELP
DISCONNECT
DISARMED
Not Ready to Arm
Quick
Actions
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PreFlight
Gauges
Altitude (m)
GroundSpeed (m/s)
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Zoom in to see All, Airspace and Ground Hazards from Altitude Angel.
GPS Track (Black)

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