TEAM JUPITER

DESIGN REPORT

SAEISS Autonomous Drone Development Challenge 2025

TEAMID:ADDC2025013

University College of Engineering(A), Osmania University, Hyderabad,500007

Team captain:
G.Suchit

Faculty Advisor:
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STATEMENTS OF COMPLIANCE

Certification of Qualification

Team Name	JUPITER	Team Number: **ADDC2025013**
School	UNIVERSITY COLLEGE OF ENGINEERING OSMANIA UNIVERSITY	
Faculty Advisor	DR.E MADHUSUDHAN RAJU	
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Statement of Compliance

As faculty Adviser:

I certify that the registered team members are enrolled in collegiate courses.

I certify that this team has designed and constructed the radio-controlled multirotor with the intention to use this model in the SAEISS Autonomous drone Development Challenge 2025, without direct assistance from professional engineers, R/C model experts, and/or related professionals.

I certify that this year's Design Report has original content written by members of this year's team.

I certify that all reused content have been properly referenced and is in compliance with the University's plagiarism and reuse policies.

I certify that the team has used the Aero Design inspection checklist to inspect their aircraft before arrival at Technical Inspection and that the team will present this completed checklist, signed by the Faculty Advisor or Team Captain, to the inspectors before Technical Inspection begins.

Signature of Faculty Advisor

Date 20/02/2025

Signature of Team Captain

Date 20/02/2025

Note : A copy of this statement needs to be included in your Design Report as page 2

TheTeam JUPITER

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L. Rahul	[*Design*]
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Executive Summary

The Autonomous Drone Design Competition 2025 posed a series of complex challenges, demanding the creation of a high-performance drone capable of autonomous navigation and QR code scanning. This report details the design, analysis, and testing strategies implemented by Team Jupiter to meet these challenges, resulting in a reliable, high-performing drone.

1.1 System Overview

The drone’s design focuses on functionality, efficiency, and modularity. Key features include a sophisticated navigation system, lightweight ABS for the frame, and polycarbonate for the propeller, ensuring structural integrity. The modular design allows easy integration of sensors, cameras, motors, and control systems. Optimized for smooth flight performance and energy efficiency, the drone is tailored to meet competition requirements, ensuring successful mission completion

1.2 Competition Projections and Conclusions

Based on comprehensive testing and analysis, the drone is projected to excel in speed, stability, and precision. Advanced control algorithms and high-performance hardware will enable accurate navigation from point A to point B, ensuring precise positioning for QR code scanning at the final destination.

1.3 Key Differentiators

Team Jupiter’s drone design is distinguished by its innovative modular architecture, allowing for easy customization and scalability. Sensor fusion algorithms enhance navigation accuracy, while robust structural analysis guarantees durability under all anticipated load conditions. These features collectively provide a significant competitive advantage, ensuring a reliable and high-performing solution for the competition.

CONTENTS

Introduction

The Autonomous Drone Design Competition 2025 challenges participants to design and develop a high-performance, autonomous drone capable of traveling a predefined path and scanning a QR code at its final destination. Team Jupiter from the University College of Engineering, Osmania University, Hyderabad, has undertaken this challenge to create an innovative and reliable drone that excels in navigation, scanning accuracy, and overall flight stability.

Drones, or Unmanned Aerial Vehicles (UAVs), have become integral to numerous industries due to their versatility, lightweight construction, and ease of control. Autonomous drones, in particular, incorporate advanced technology and sensor integration to enable independent flight and real-time decision-making capabilities. Our design incorporates state-of-the-art flight control systems and navigation sensors to address the complex tasks required in this competition.

Project Objectives and Design Philosophy

Our primary objective is to develop a lightweight, energy-efficient drone capable of delivering exceptional precision in both navigation and scanning tasks. The design prioritizes stability and maneuverability through optimized structural integrity and advanced control algorithms. The drone will also feature robust payload delivery and return-to-base capabilities, ensuring mission success in competitive environments.

The fixed-wing design is driven by an electric motor with servo motors used to control flight surfaces, ensuring smooth and reliable flight control. We thoroughly analyzed aerodynamic principles and reviewed relevant literature to ensure optimal performance across all mission scenarios.

Approach to Design and Innovation

Team Jupiter adopted a systematic approach to design, focusing on addressing key challenges such as power consumption, sensor integration, and environmental adaptability. The drone’s structural design and propulsion system were optimized to minimize weight without compromising durability or performance. Extensive reference to the competition rulebook and aerodynamic textbooks guided our design decisions, ensuring compliance with all requirements and industry best practices.

By applying rigorous engineering principles, thorough research, and multiple precautionary measures, we aimed to eliminate potential failure points and deliver a reliable, high-performing drone capable of excelling in all competition tasks.

Mission requirements

Problem Statement

The mission requires an autonomous drone capable of delivering a fragile payload, scanning a QR code, and returning to the launch base within 5 minutes. The challenge involves operating within a competitive arena where multiple teams are functioning simultaneously, and RF network interference is a potential issue. The drone must autonomously navigate to the designated spot, complete the payload delivery, scan the QR code, and return to the base without manual control.

Mission Objectives

- Deliver the payload safely to the designated area within the time limit.
- Scan the QR code accurately before payload delivery, with proof for verification.
- Drop the payload only after successful QR code scanning.
- Start the mission immediately after the 2-minute prep time and complete it within 5 minutes.
- Follow the designated flight path and return to the launch base without deviation.

Functional Requirements

- The drone must operate autonomously, with no pilot control during the mission.
- The drone must remain within the designated flight boundaries.
- In the event of an emergency, manual control may be activated, but the mission will be considered aborted if this occurs.
- The QR code must be scanned and recorded for verification by the judges before payload release.
- The drone must be able to operate in a multi-team environment with potential RF network interference.

Performance Criteria

- Complete the mission within the 5-minute time limit.
- Ensure minimal deviation from the return-to-home point for accurate scoring.
- Perform payload delivery and QR code scanning in a controlled and precise manner.

List of components

Name of the component	Quantity	Weight	Cost (INR)	Model
Flight Controller	1	60gm	6000	Pixhawk 2.4.8
BLDC Motor	4	99gm*4	1480 x 4 = 5950	DYS D3536-8 1000KV
Quadcopter Frame	1	400gm	1000	ABS (Acrylonitrile Butadiene Styrene)
Propellers	4	10gm*4	125x2 = 250	Polycarbonate
Electronic Speed Controller (ESC)	4	34gm*4	4000	Readytosky 40A
Lipo Battery	1	360gm	3000	3s 11.1v
Radiolink M10N GPS SE100	2	100gm	6200	
Camera	1	48gm	6000	AKASO EK7000
Video Transmitter	1	16gm	3000 to 4000	AKK Race Ranger 1.6W VTX 5Ghz
Telemetry	1	25gm	8700	915Mhz 5000MW
Receiver	1	15gm	2000 to 3000	2.4Ghz
Raspberry pi 4 + heatsink	1	90gm	6000	N/A
HDMI to RCA converter	1	20gm	1500	N/A
Raspberry pi Camera module +case	1	10gm	2900	N/A
Servo motor	2	9gm*2	240	SG90
ESC pdb	1	8gm	100	100A
Step down module	1	8gm	70	12V to 5v
Total		1750gm	56,850 to 59,160	

Budget Considerations:

By reusing previously selected components, the overall cost is reduced while maintaining performance. The **Pixhawk 2.4.8 controller** and **DYS 1000KV motors** ensure reliability at a reasonable price. **Polycarbonate propellers** and **Readytosky 40A ESCs** offer durability without added expense. Key components like the **AKASO EK7000 camera** and **Radiolink GPS** keep functionality intact, lowering costs within the **₹56,850 to ₹59,160** range.

Description and Integration of Components

Flight Controller

The flight controller is the brain of the drone, responsible for interpreting data from the various sensors (IMU, GPS, ultrasonic sensors) and managing flight dynamics. It ensures stability and smooth operation during autonomous navigation. The flight controller communicates with all other components, adjusting the drone's behavior in real-time for optimal performance.

BLDC Motor

Brushless DC motors (BLDC) are chosen for their efficiency, durability, and superior performance in drones. These motors provide high thrust-to-weight ratios, allowing for precise control over the drone’s movement. BLDC motors are coupled with the ESCs for smooth and responsive propulsion.

Electronic Speed Controller (ESC)

ESCs control the speed of the BLDC motors by regulating the power supply. The ESCs ensure that the motors receive the correct amount of power to maintain flight stability, accelerate, decelerate, and respond to commands from the flight controller.

LiPo Battery

The LiPo (Lithium Polymer) battery provides the necessary power to the drone. Known for its high energy density, LiPo batteries ensure long flight times and reliable power delivery. The battery is connected to the ESCs, flight controller, and other components to supply energy throughout the drone’s operation.

Camera

The camera is integrated into the drone to provide real-time video feedback, essential for visual data collection. It aids in capturing images for navigation and QR code scanning. The camera is mounted securely on the drone, with its feed transmitted via the video transmitter.

Video Transmitter

The video transmitter (VTx) sends the live video feed from the camera to the ground station or remote receiver. It is crucial for real-time monitoring and operation, providing the pilot or autonomous system with a clear view of the drone’s environment during flight.

Telemetry

Telemetry modules enable real-time communication between the drone and the ground station, transmitting important flight data such as battery status, GPS coordinates, altitude, and system health. This data is essential for tracking the drone’s performance and ensuring mission success.

Transmitter

The transmitter allows the operator to manually control the drone if necessary. It communicates wirelessly with the drone, sending commands for throttle, pitch, roll, and yaw. While the drone is designed for autonomous flight, manual control via the transmitter serves as a backup in case of system failure.

Receiver

The receiver on the drone receives the signals from the transmitter, allowing manual control of the drone. It ensures that the drone can be guided by the operator when necessary.

Raspberry Pi 4 + Heatsink
The Raspberry Pi 4 serves as the onboard computer, processing high-level tasks such as image recognition and mission planning. It is equipped with a heatsink to prevent overheating during prolonged operation, ensuring reliable performance throughout the flight.

HDMI to RCA Converter
The HDMI to RCA converter is used to interface the Raspberry Pi with the video transmitter. It converts the HDMI output from the Raspberry Pi's camera module into a signal that can be transmitted through the video transmitter, allowing for live video streaming during flight.

Raspberry Pi Camera Module + Case
The Raspberry Pi Camera Module captures high-quality images and video for real-time navigation and QR code scanning. It is securely housed in a protective case, ensuring durability and preventing damage during flight.

Servo Motor
The servo motor is responsible for actuating the payload release mechanism. It enables precise control over the deployment of the fragile item, ensuring that it is released accurately at the designated location.

ESC PDB (Power Distribution Board)
The ESC PDB is responsible for distributing power from the battery to the ESCs and flight controller. It ensures stable power delivery, minimizing voltage fluctuations and optimizing the drone's power efficiency during flight.

Step-Down Module
The step-down module is used to regulate the voltage for specific components that require lower power, such as the Raspberry Pi and camera. It ensures that the voltage provided to each component is stable and within the required range.

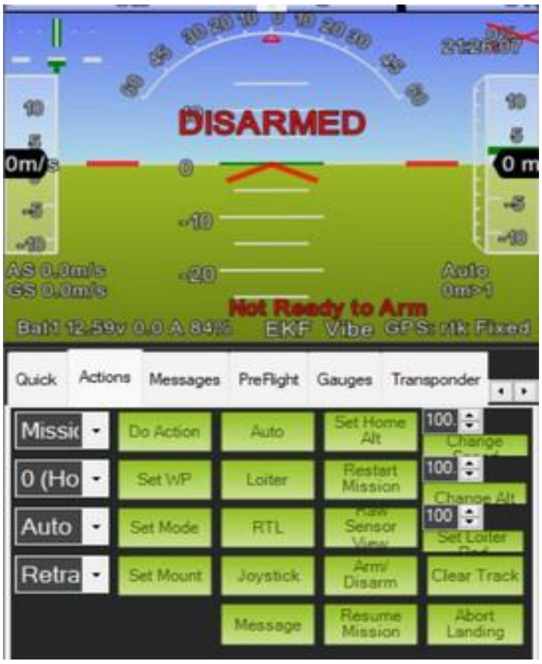
Integration

All components are integrated into a cohesive system, ensuring smooth operation and efficient communication between the various parts. The flight controller manages the interactions between the BLDC motors, ESCs, and telemetry system, while the camera, video transmitter, and Raspberry Pi work together to provide real-time navigation and mission data. The power distribution system ensures that each component receives the correct power supply, while the servo motor precisely releases the payload. The modular design of the drone facilitates future upgrades and customization.

MISSION PLANNING

Hardware and Setup Conditions

Access the Setup tab at the top left, then select Mandatory Hardware. Here, find options like Optional Hardware, Install Firmware, and Advanced. Within Mandatory Hardware, access a list of available calibrations.



Accerelation Calibration: Calibrates the accelerometer level.

Compass Calibration: Sets the priority of compasses.

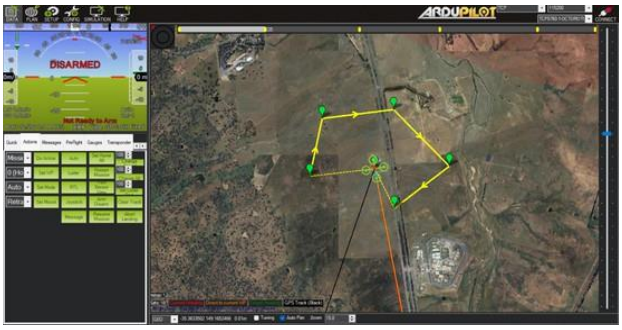
Radio Calibration: Configures transmitter operation.

Servo Output : Calibrates servo ,essential for payload mechanisms.

Failsafe : Initiates UAV landing in case of signal loss or critical failure.

1.

Command					Lat	Long	Alt
TAKEOFF	0	0	0	0	-35.3633512	149.16524...	20
WAYPOINT	0	0	0	0	-35.3633693	149.16498...	20
LAND	0	0	0	0	-35.3629832	149.16495...	0
DO_AUX_FUNCTION	153	0	0	0	-35.3629569	149.16516...	0
DELAY	10	0	0	0	0	0	0
DO_SET_SERVO	2	1250	0	0	0	0	0
DELAY	5	0	0	0	0	0	0
DO_AUX_FUNCTION	153	2	0	0	0	0	0
TAKEOFF	0	0	0	0	0	0	20
WAYPOINT	0	0	0	0	-35.3629548	149.16520...	20
LAND	0	0	0	0	-35.3633419	149.16524...	0



Access the 'data' tab in the top left corner for real-time altitude and speed data. Once accessed, the drone navigates through waypoints automatically. Below the data display, find the line of tabs, then select 'actions' and choose 'set mode' to 'auto' to start the mission. Execute additional actions as needed by selecting 'do action’ .To proceed, click the arm/disarm button.

Overall Design Layout and Size

This section provides an overview of the drone's layout, overall dimensions, and key design features. The design is tailored to meet system functional requirements, focusing on aerodynamics, structural integrity, payload capacity, and stability. The total size of the drone is optimized for maneuverability and efficient energy use. Each subassembly is integrated with an emphasis on minimizing weight while ensuring structural strength.

The drone follows an **X-configuration layout**, with the arms symmetrically arranged in a cross pattern at 90° angles. This configuration ensures better stability, uniform thrust distribution, and improved agilityideal for the competition's mission that includes autonomous flight and payload delivery.

The CAD model illustrates the following key features:

- **Symmetrical Design**: Ensures equal weight distribution across the four arms.
- **Central Frame Hub**: Houses essential components such as the battery, flight controller, and payload mechanism, ensuring the center of gravity is optimized.
- **Arm-Mounted Propellers**: Propellers are positioned at the ends of the arms to ensure unobstructed airflow and minimize drag.

Key Design Considerations:

1. **Total Drone Dimensions:**
    - **Length:**681.40 mm
    - **Width:**258.72 mm
    - **Height:**150.78 mm
2. **Weight Distribution:**
   The weight is symmetrically distributed to ensure balance. The heaviest components, such as the battery and payload mechanism, are positioned near the center of gravity to maintain flight stability.
3. **Propeller Positioning:**
   The propellers are positioned at the ends of the four arms in an X-configuration. This arrangement maximizes thrust efficiency, reduces drag, and improves responsiveness and stability during flight.
4. **Center of Gravity (CoG):**
   The CoG is located near the central hub, where the heaviest components are positioned. This placement minimizes rotational instability and enhances maneuverability, especially during quick movements or payload drops.

Payload Mechanism

The payload design is a crucial part of the drone, enabling autonomous delivery and release of a fragile item. A rack-and-pinion mechanism ensures smooth, precise control over payload release, meeting mission requirements without affecting flight stability or aerodynamics.

Key Design Features

- **Material:**
  The rack-and-pinion mechanism is constructed from lightweight, durable materials such **ABS**(Acrylonitrile Butadiene Styrene) offering structural strength and wear resistance while keeping the drone's weight minimal.
- **Working Mechanism:**
  The servo motor drives the pinion gear, which moves the rack to release the payload. This system provides precise and controlled movements, avoiding sudden jolts that could damage the fragile item.
- **Mounting and Integration:**
  The mechanism is securely integrated into the drone's central frame, ensuring proper weight distribution, maintaining the center of gravity, and preventing imbalance during the mission.
- **Payload Capacity:**
  The system is designed to handle a payload of up to **500 grams**. The rack's linear motion is calibrated to manage this weight, ensuring the servo motor operates within its capacity without stalling or overloading.
- **Release Mechanism:**
  The servo motor activates at the designated drop location, moving the rack to trigger the release. The smooth operation prevents damage to the payload, and safety stops are included to prevent overextension, protecting both the drone and the item.
- **Shock Absorption:**
  To safeguard the fragile item during handling or flight, shock-absorbing materials, such as foam or rubber padding, are used in the payload bay, reducing the risk of damage from vibrations or sudden movements.
- **Aerodynamic Considerations:**
  The streamlined design of the payload bay minimizes drag, ensuring stable flight even when the payload is onboard. The compact rack-and-pinion system is designed to minimize interference with airflow, optimizing flight performance.
- **Reliability and Redundancy:**
  The system is built with fail-safe mechanisms and redundancies, preventing accidental release or malfunction. This ensures consistent performance, even under challenging conditions, and guarantees the payload is released only when intended.

Payload Mechanism with QR Detection

Ensuring the secure and efficient delivery of payloads is a critical aspect of drone operations. The drone is equipped with a QR detection system integrated with **OpenCV** and **PiCamera** libraries, allowing precise identification and verification of the payload before release. This mechanism enhances operational accuracy by ensuring that the payload is delivered to the correct location and released only after successful QR code verification.

QR Detection System and Payload Release Mechanism

The drone employs a **computer vision-based QR detection system** to verify the delivery location before payload release. The process involves:

1. The drone navigating to the designated drop site using GPS and real-time obstacle avoidance.
2. The downward-facing **RPi camera** capturing images of the payload area.
3. The **OpenCV library** processing the captured frames to detect and decode the QR code.
4. Payload release being triggered only after successful QR code verification.
5. The drone returning to the launch base using a predefined flight path.

Strategic Camera Selection for Autonomous Drones

The **Raspberry Pi Camera Module** is selected over a conventional webcam due to its advantages in processing speed, efficiency, and integration. Unlike USB webcams, which introduce additional processing overhead, the RPi camera connects directly to the Raspberry Pi via the **Camera Serial Interface (CSI) port**, enabling **faster data transfer and lower latency**. This ensures real-time QR code detection, which is essential for precise payload release.

Other advantages of the RPi camera include:

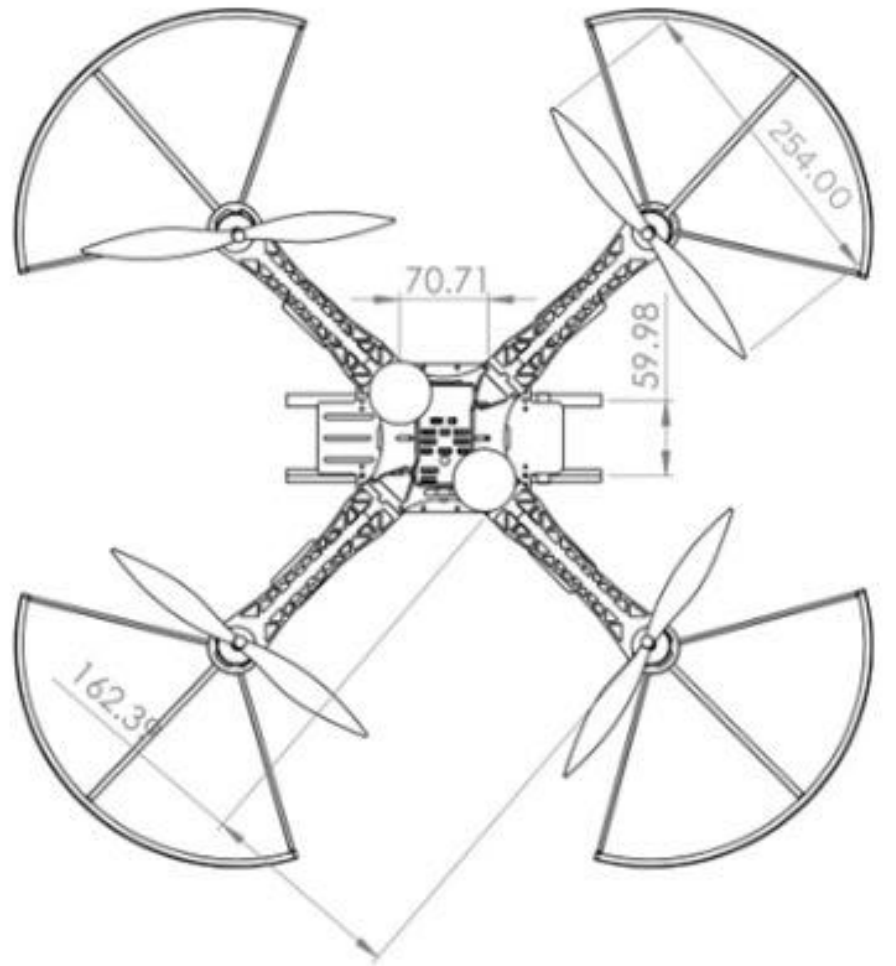
- **Optimized Performance:** Reduces system resource usage, allowing efficient allocation of processing power for image recognition and drone control.
- **Compact and Lightweight Design:** Minimizes additional weight, making it suitable for drone applications.
- **High Frame Rate and Resolution:** Captures clear images for accurate QR detection in various lighting conditions.

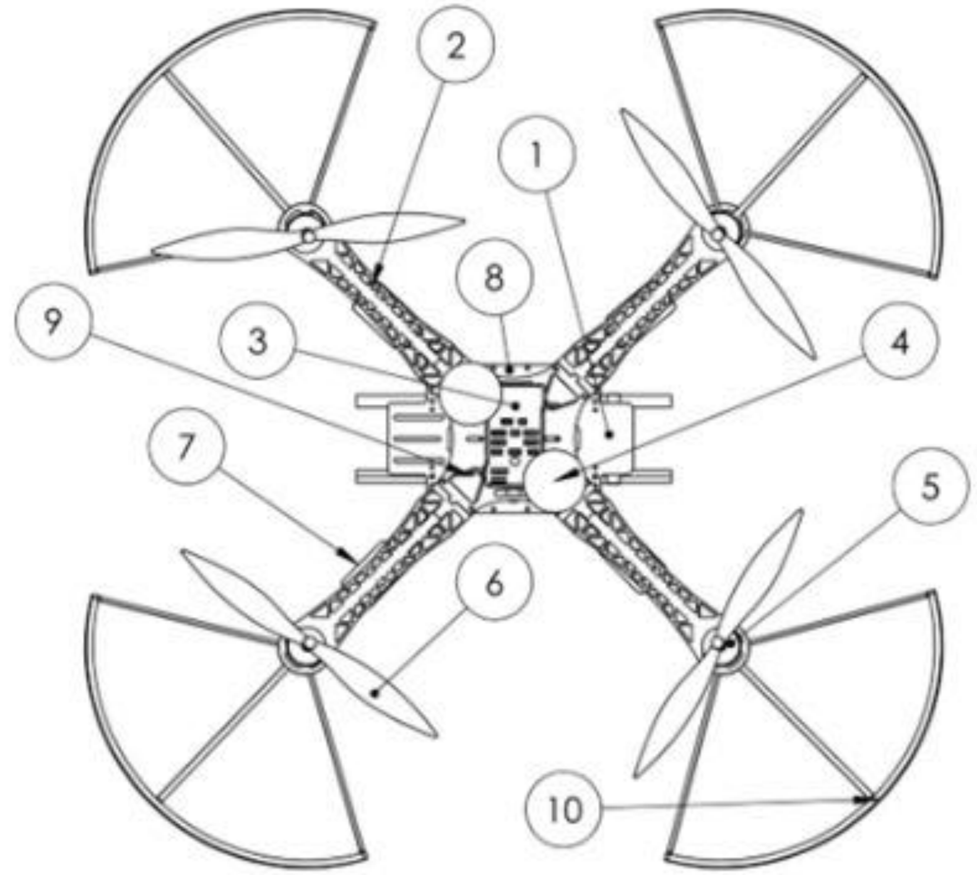
Operational Workflow

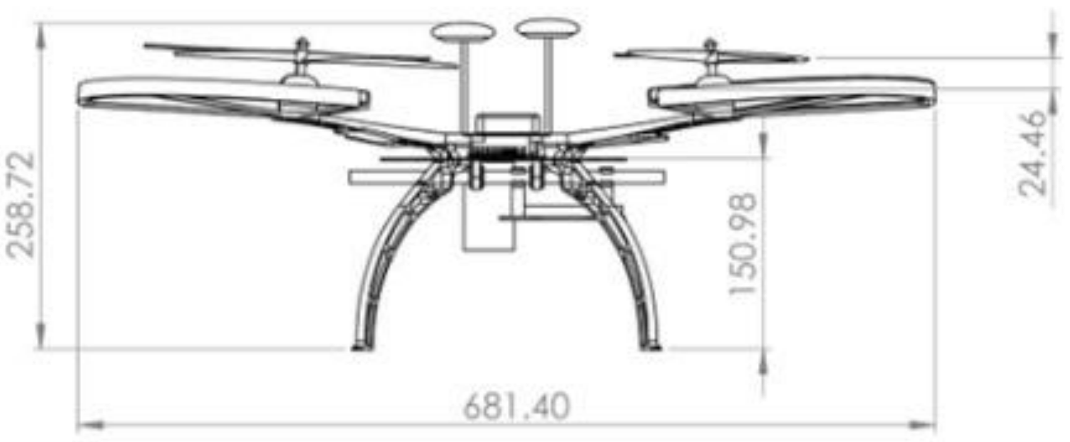
1. The drone reaches the pre-programmed delivery site using GPS navigation.
2. The RPi camera scans for the QR code in the designated area.
3. The onboard processor, using OpenCV, verifies the QR code.
4. If the QR code matches the expected payload ID, the drone releases the payload.
5. After successful delivery, the drone autonomously returns to the launch base.

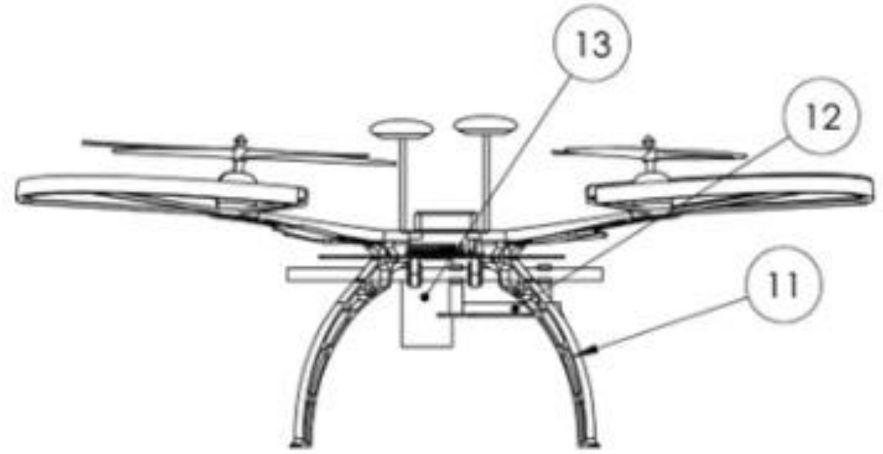
Conclusion

The integration of a QR-based payload mechanism ensures **safe, efficient, and automated** delivery. By utilizing the **RPi camera** for **fast and accurate QR detection**, the system minimizes the risk of incorrect payload drops while optimizing overall mission success. The combination of real-time image processing and autonomous navigation allows the drone to complete deliveries with precision and reliability.



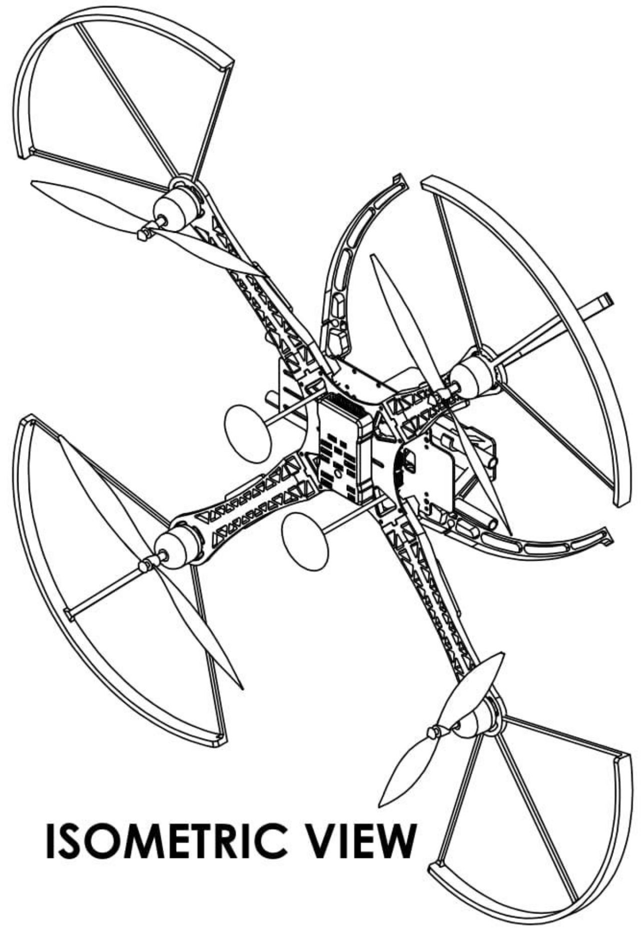




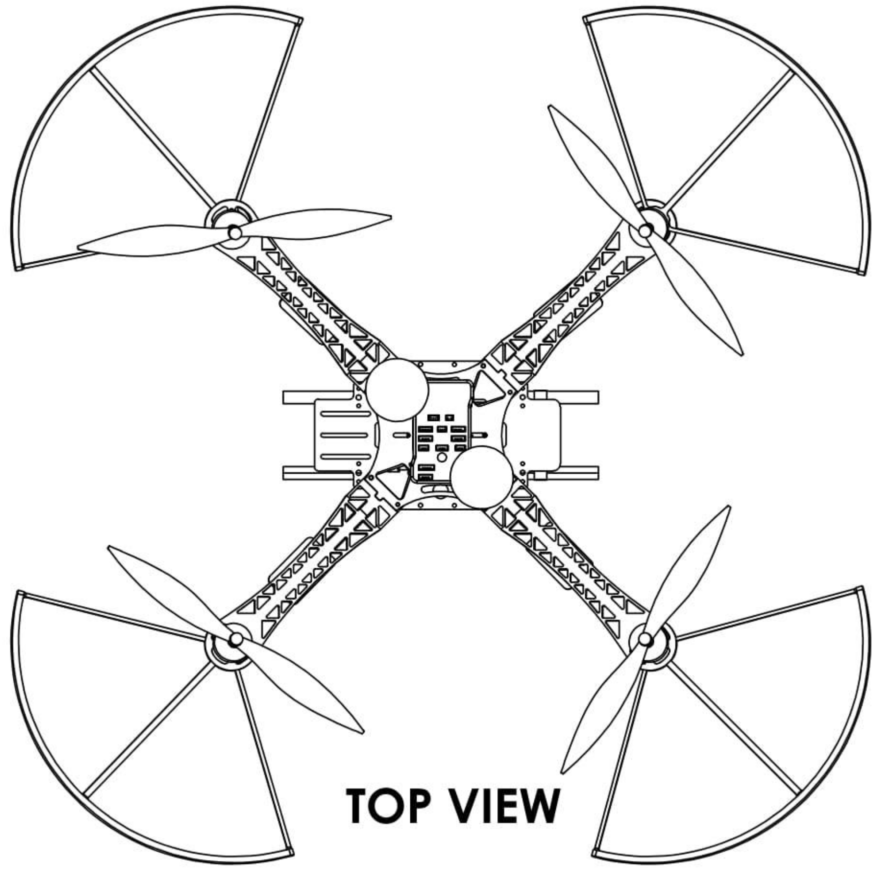


ITEM NO.	PART NUMBER	QTY.
1	PCB BOARD	1
2	ARM	1
3	FLIGHT CONTROLLER	1
4	GPS	2
5	BLDC MOTOR	4
6	PROPELLER	4
7	ESC	4
8	BASE TOP	1
9	RASPBERRY PI 4	1
10	PROPELLER GUARD	4
11	LANDING GEAR	4
12	BATTERY	1
13	PAYLOAD MECHANISM	1

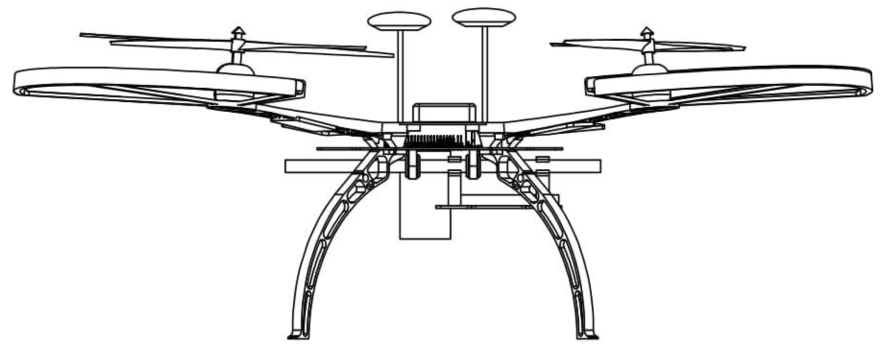
TEAM ID **ADDC2025013**	TEAM NAME **TEAM JUPITER**	ALL DIMENSIONS IN MM COLLEGE **UNIVERSITY COLLEGE OF ENGINEERING, OSMANIA UNIVERSITY**
SIGNATURE	SIZE:A3 SCALE 1:6 SHEET 1 OF 2	TITLE **QUADCOPTER DIMENSIONS**



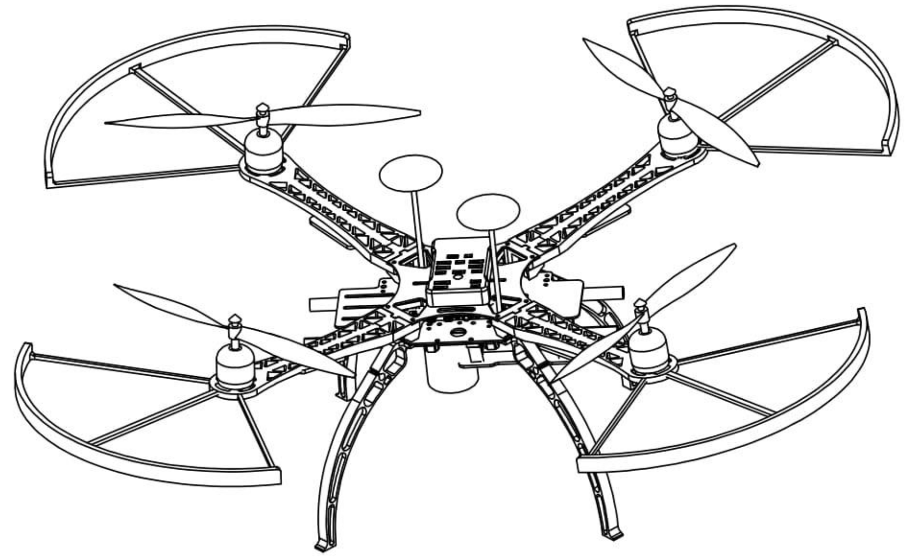
ISOMETRIC VIEW



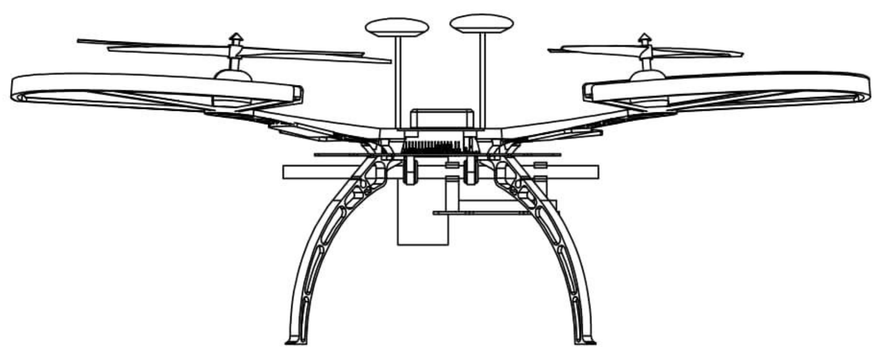
TOP VIEW



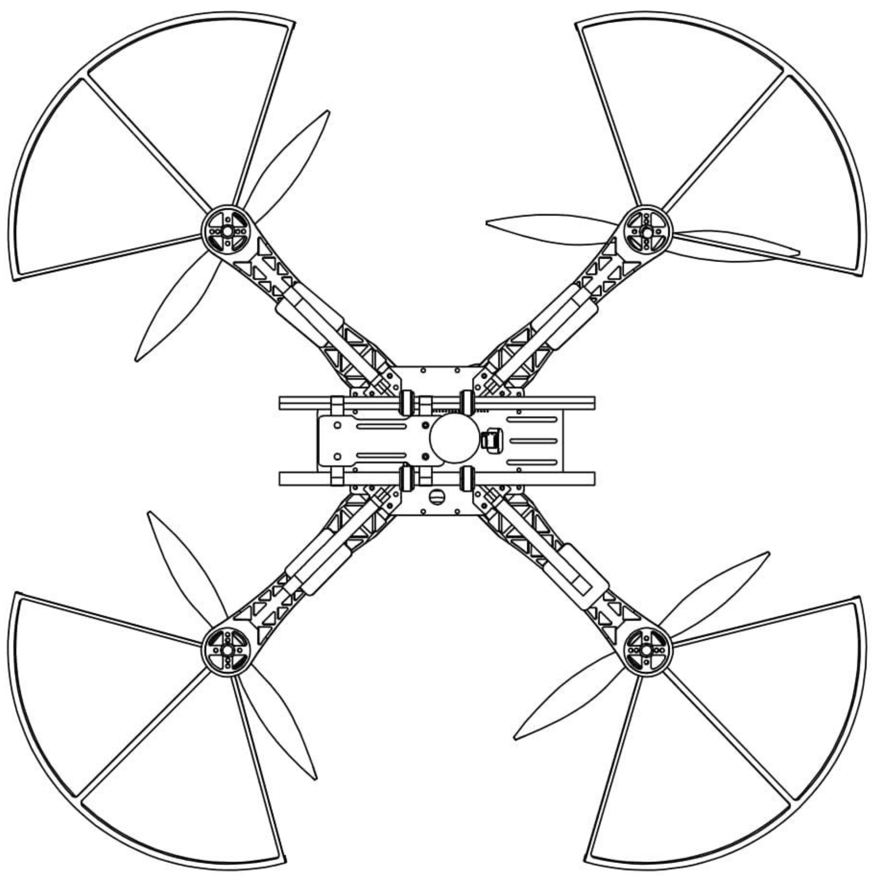
BOTTOM VIEW



CURRENT VIEW

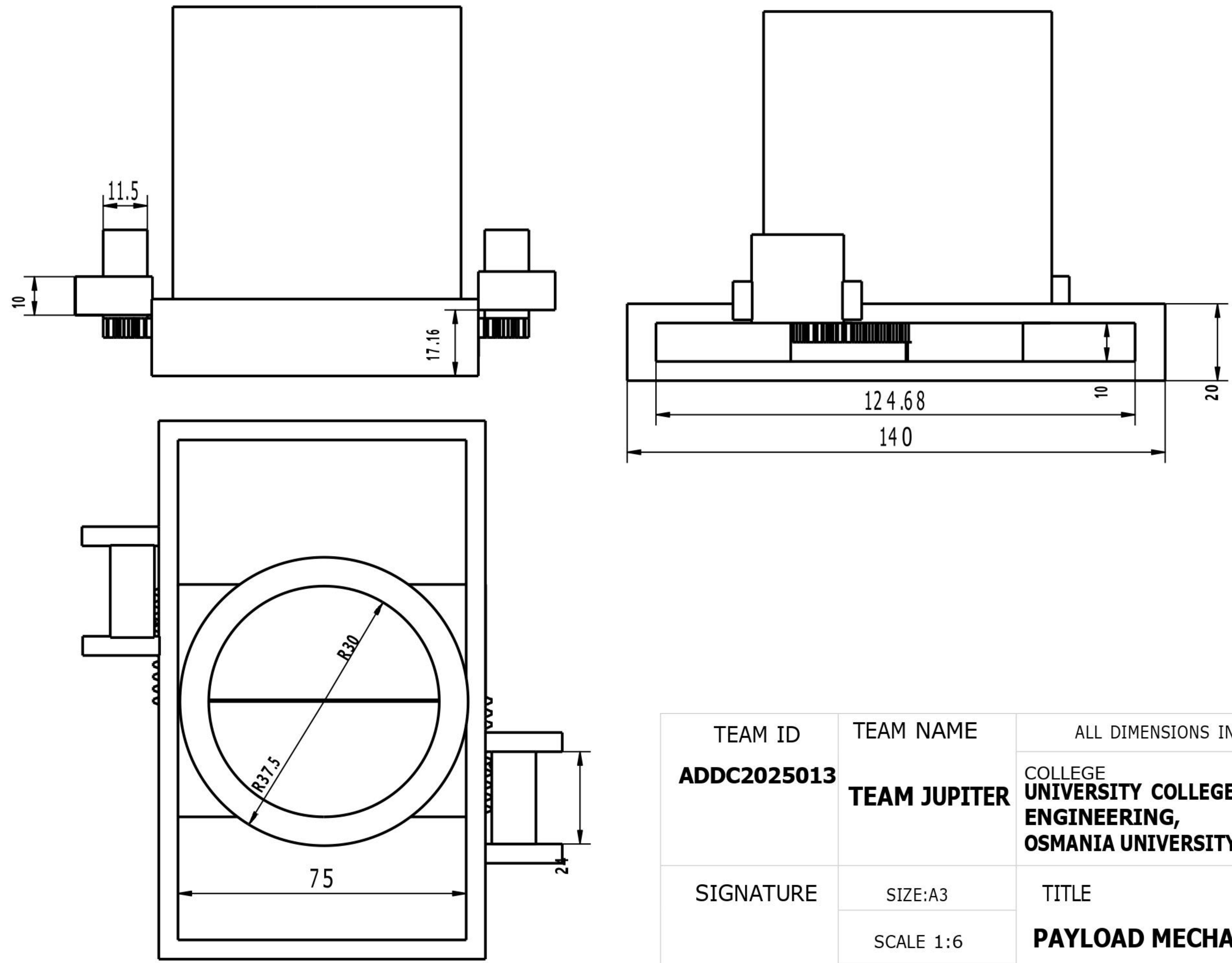


FRONT VIEW



BACK VIEW

TEAM ID	TEAM NAME	ALL DIMENSIONS IN MM
ADDC2025013	TEAM JUPITER	COLLEGE **UNIVERSITY COLLEGE OF ENGINEERING, OSMANIA UNIVERSITY**
SIGNATURE	SIZE:A3 SCALE 1:6 SHEET 2 OF 2	TITLE **QUADCOPTER VIEWS**



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ADDC2025013	**TEAM JUPITER**	COLLEGE **UNIVERSITY COLLEGE OF ENGINEERING, OSMANIA UNIVERSITY**
SIGNATURE	SIZE:A3 SCALE 1:6 SHEET 2 OF 2	TITLE **PAYLOAD MECHANISM DIMENSIONS**

Innovation

To enhance the drone's performance and operational success, several innovations have been proposed across different functional areas:

1. Sensor Integration for Obstacle Avoidance

The following sensor technologies will be integrated to improve the drone's obstacle-avoidance capabilities:

1. **LiDAR (Light Detection and Ranging):**
    - Uses laser pulses to measure distances and generate a 3D map of the surroundings.
    - Highly accurate but expensive.
    - Performs well in low-light conditions.
2. **Infrared (IR) Sensors:**
    - Detects thermal signatures, such as human body heat.
    - Effective in darkness but has a limited range.
    - Commonly used in rescue operations.
3. **Ultrasonic Sensors:**
    - Uses sound waves to detect obstacles.
    - Affordable but limited by short range.
    - Less effective in noisy environments.

Integrating these sensors will significantly enhance the drone's ability to avoid obstacles, improving the mission's success rate and fulfilling key operational objectives.

2. Specific Use Case: Temperature-Sensitive Payload Transportation

For transporting temperature-sensitive items like vaccines, blood samples, and medicines, we propose using a **Peltier Module (Thermoelectric Cooler, TEC)** within the payload module. Its advantages include:

- **Compact & Lightweight:** Minimal weight addition to the drone.
- **Precise Temperature Control:** Ensures accurate temperature maintenance.
- **No Refrigerants:** Environmentally friendly, eliminating the need for chemical coolants.
- **Vibration Resistant:** Performs well despite vibrations during flight, ensuring consistent cooling.

3. Payload Handling Mechanism

To safely handle fragile payloads (e.g., eggs), we plan to incorporate:

- **Suction-Type Mechanism:**
    - Secures the payload and allows safe deployment on rigid surfaces without damage.
- **Gripper Claw:**
    - Provides controlled handling and versatility for different types of payloads.

These mechanisms will enhance the safe delivery of sensitive items, increasing mission success and payload safety.

Originality & Unique Technology Development

Introduction

Drones have transformed modern logistics, but conventional designs primarily focus on general package delivery. Our drone, however, is specifically engineered for **fragile payload transportation**, incorporating advanced handling mechanisms, multi-sensor navigation, and efficient thermal management. This section highlights the originality of our approach and the unique technological advancements that set our drone apart.

Originality

1. **Innovative Hybrid Payload Handling System**

    - Traditional drones use **either** a gripper or a suction mechanism for payload handling. Our drone uniquely combines both to ensure secure, damage-free transport.
    - The **adaptive system** dynamically selects the optimal handling technique based on payload material and shape.
    - This design minimizes the risk of impact forces and ensures **gentle release**, making it ideal for handling fragile items such as medical vials or delicate electronics.

2. **Multi-Sensor Fusion for Obstacle Avoidance**

    - While most drones rely on a **single sensor type**, our drone integrates **LiDAR, Infrared (IR), and Ultrasonic sensors** to enhance navigation safety.
    - The **sensor fusion algorithm** processes real-time data to detect obstacles in **varied environments**, including low-light conditions or complex terrains.
    - This **multi-layered approach** provides enhanced reliability compared to single-sensor drones, improving mission success rates in challenging environments.

3. **Compact and Efficient Temperature Regulation**

    - Standard refrigerated payload compartments add **bulk and weight** to drones, limiting efficiency.
    - Our design incorporates a **Thermoelectric Cooling (TEC) module**, which maintains **precise temperature control** for medical payloads like **vaccines, blood samples, and biological materials**.
    - Unlike conventional refrigeration systems, our solution is **lighter, energy-efficient, and eco-friendly**, ensuring extended flight times and optimized energy consumption.

Unique Technology Development

1. **Custom-Engineered Suction-Gripper Payload Mechanism**

    - The payload system integrates **a hybrid suction and mechanical gripper**, allowing for **secure and controlled handling** of delicate cargo.
    - A **shock-absorption system** ensures that payloads experience minimal vibration during flight and landing.
    - The release mechanism is designed to function on **both soft and hard surfaces**, expanding potential use cases in medical, commercial, and research applications.

2. **Intelligent Multi-Sensor Navigation System**

    - The drone's custom **sensor fusion algorithm** processes data from **LiDAR, IR, and Ultrasonic sensors** for **adaptive flight control**.
    - The system provides **real-time environmental mapping**, enabling precise obstacle avoidance and stable flight paths.
    - Unlike conventional drones that rely on vision-based sensors, our solution is **resilient to environmental factors such as darkness, fog, or confined spaces**.

3. **Advanced Thermal Management for Sensitive Cargo**

    - The **Peltier-based Thermoelectric Cooling (TEC) system** maintains **precise temperature levels without refrigerants**.
    - Our drone uses **automated temperature monitoring**, alerting operators if fluctuations exceed acceptable limits.
    - This solution ensures medical payloads remain **uncompromised**, making it suitable for **pharmaceutical logistics and emergency medical supply transport**.

4. **GPS Blending for Enhanced Positioning Accuracy**

    - The drone employs **GPS blending**, which merges data from multiple satellite constellations (e.g., GPS, GLONASS, Galileo) for **high-precision navigation**.
    - This approach reduces signal loss and improves **location accuracy**, even in environments with weak GPS signals, such as urban canyons or dense forests.
    - GPS blending enhances **flight stability and waypoint precision**, making the drone more reliable for long-distance and autonomous operations.

Conclusion

Our drone's **originality** lies in its **hybrid payload handling, multi-sensor navigation, GPS blending, and lightweight thermal regulation**, setting it apart from traditional delivery drones. Meanwhile, our **unique technology development** focuses on custom engineering solutions that **enhance safety, efficiency, and reliability** in fragile payload transportation. This integrated approach offers a groundbreaking advancement in drone logistics, making it highly suitable for **medical, research, and precision cargo transport**.

Safety Measures in Drone Operations

Ensuring the safety of a drone during operation is crucial for protecting both the drone itself and its surroundings. Unmanned Aerial Vehicles (UAVs) operate in diverse environments and are exposed to risks such as collisions, equipment failure, and uncontrolled landings. To enhance operational reliability and reduce hazards, several safety measures have been incorporated into the drone design.

1. Multi-Sensor Fusion for Obstacle Avoidance To prevent mid-air collisions and ensure smooth navigation, the drone is equipped with a multi-sensor fusion system combining LiDAR, infrared sensors, and ultrasonic sensors. These sensors work together to:

- Detect obstacles in real time and adjust the flight path accordingly.
- Enhance navigation in low-visibility conditions, such as fog, darkness, or complex terrains.
- Prevent crashes, reducing damage to both the drone and its surroundings.

By integrating multiple sensors, the drone achieves a higher level of safety and reliability in flight.

2. Shock-Absorbing Landing Gear A key safety concern for drones is the impact sustained during landing, especially in rough terrains or emergency situations. To address this, the drone features shock-absorbing landing gear, which:

- Minimizes impact forces during touchdown.
- Protects sensitive payloads, such as medical supplies or fragile cargo.
- Reduces structural damage to the drone, prolonging its lifespan.

This system ensures that even in cases of unexpected rough landings, the drone and its payload remain safe.

3. Propeller Guards for Damage Prevention The drone is equipped with propeller guards to enhance operational safety. Propeller damage is a common cause of drone failures, and exposed propellers can pose a hazard to operators and bystanders. The guards:

- Prevent direct contact with propellers, reducing injury risks.
- Shield the propellers from external impacts, such as trees, walls, or other obstacles.
- Extend the operational lifespan of the drone by minimizing mechanical failures.

By including this safety feature, the drone ensures safer operation in various environments and minimizes risks associated with unintended collisions.

4. Emergency Landing Mechanism To handle unexpected failures such as power loss, signal disruptions, or severe weather conditions, the drone is equipped with an emergency landing mechanism. This system:

- Automatically detects malfunctions and initiates a controlled descent.
- Uses pre-programmed safe landing zones to prevent damage to property and bystanders.
- Reduces the likelihood of uncontrolled crashes, enhancing safety and reliability.

5. Flight Restrictions and Safety Compliance To prevent operational hazards, the drone is programmed with geofencing and no-fly zone restrictions, preventing it from entering restricted or high-risk areas. Additionally, compliance with aviation safety standards such as those set by the Federal Aviation Administration (FAA) and the Directorate General of Civil Aviation (DGCA) is maintained to ensure responsible and lawful operation.

6. Thermal Management for Safe Operation Overheating of electronic components can lead to system failures, especially during extended operations. The drone incorporates thermal management systems to:

- Prevent overheating of motors and battery packs, ensuring consistent performance.
- Enhance battery efficiency, reducing the risk of thermal runaway.
- Improve overall system durability, increasing the drone's reliability.

This system ensures that all components remain within safe temperature limits, even under demanding conditions.

7. Redundant Power Supply

A backup power system helps prevent sudden power failures and ensures a safe return in emergencies:

- Dual battery configuration provides extended operational time and redundancy.
- Intelligent battery management system monitors charge levels and prevents over-discharge.
- Emergency reserve power allows the drone to land safely if the main power source fails.

8. Pre-Flight Safety Checks

Before every flight, a thorough inspection is conducted to ensure all components are in working condition:

- Checking battery levels and ensuring a full charge.
- Inspecting propellers for cracks or damage.
- Ensuring sensors and cameras are clean and functioning properly.

Conclusion

The integration of advanced safety measures in drone operations ensures both reliability and security in various applications. By incorporating multi-sensor fusion for obstacle avoidance, shock-absorbing landing gear, propeller guards, and an emergency landing mechanism, the drone is designed to handle unforeseen challenges effectively. Additional measures such as flight restrictions, thermal management, redundant power supply, and pre-flight safety checks further enhance operational efficiency and minimize risks.

These safety features not only protect the drone and its payload but also ensure compliance with aviation regulations and safeguard people and property. As drone technology continues to evolve, prioritizing safety will remain essential for expanding their use in critical fields such as medical deliveries, surveillance, and disaster response.

DESIGN ANALYSIS

The design analysis of the drone was conducted to validate its structural and performance capabilities under anticipated operational conditions. This analysis serves as a critical step in ensuring that all components meet the required design criteria for strength, durability, stability, and aerodynamic efficiency. By leveraging advanced simulation tools, the analysis evaluated the drone's behavior under varying load cases, including flight maneuvers, payload loads, aerodynamic forces, and landing impacts.

A primary focus of this analysis was to assess the structural integrity of key load-bearing components, particularly the frame and arms. Understanding the stress distribution, deformation characteristics, and safety margins of these components ensures that the design is robust enough to handle real-world conditions without compromising performance. The subsequent sections detail the findings of the structural analysis for both the frame and propeller, followed by an evaluation of the aerodynamic performance of the propeller through Computational Fluid Dynamics (CFD).

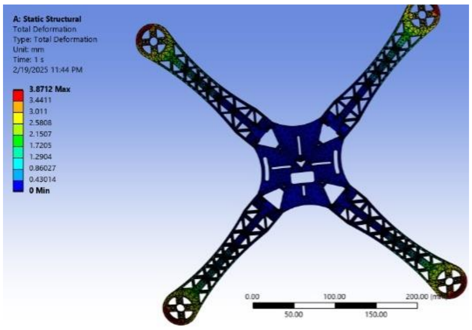
STRUCTURAL ANALYSIS

Structural analysis of a frame

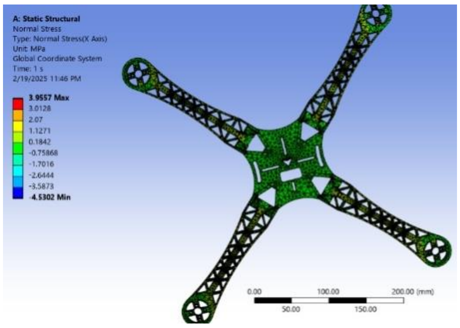
The structural analysis of the drone frame was conducted to evaluate its load-bearing capacity and overall mechanical integrity under expected operational conditions. The primary objective was to ensure that the frame could withstand static and dynamic loads without failure or excessive deformation.

Methodology

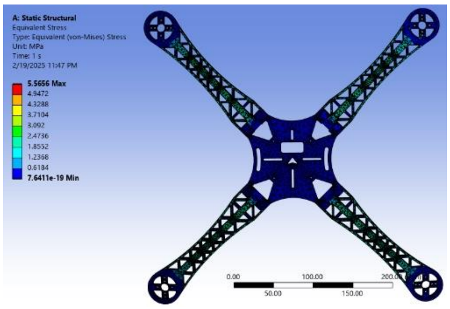
The analysis was performed using ANSYS, with the frame modeled using ABS (Acrylonitrile Butadiene Styrene) material due to its favorable mechanical properties, including high impact resistance and durability. Boundary conditions were applied to simulate fixed supports at motor mount locations. Load cases included the weight of the payload, aerodynamic forces, and landing impacts to assess the frame's structural integrityunder typical operational conditions.



TOTAL DEFORMATION



EQUIVALENT STRESS



NORMAL STRESS

Result

The structural analysis confirmed that the frame can withstand all anticipated operational loads with minimal deformation. The thrust force of each propeller, measured at 11.56 N, results in a total combined thrust of 46.24 N. The total weight acting on the frame, calculated as 17.16 N, was also considered in the analysis, along with the effects of gravity.

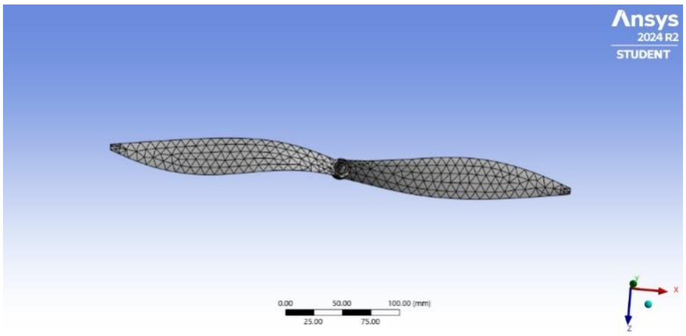
Structural Analysis of a Propeller

The structural analysis of the drone propeller was conducted to evaluate its ability to withstand various operational load conditions, including thrust generation, rotational forces, and gravitational effects. The primary objective was to ensure that the propeller maintains structural integrity under all expected loading scenarios without failure or excessive deformation.

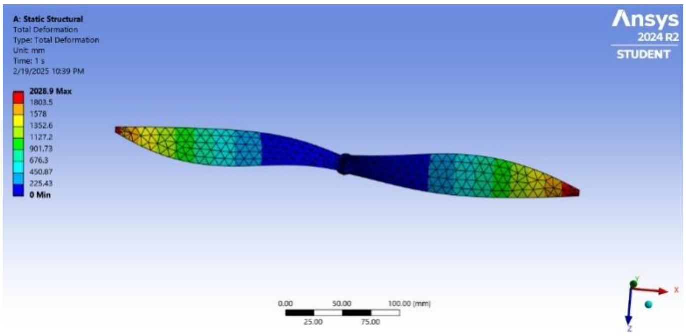
Methodology

The analysis was performed using ANSYS with the propeller modeled from polycarbonate material, known for its high impact resistance and toughness. The propeller geometry consisted of two blades with a diameter of 254 mm. Boundary conditions and load cases were applied as follows:

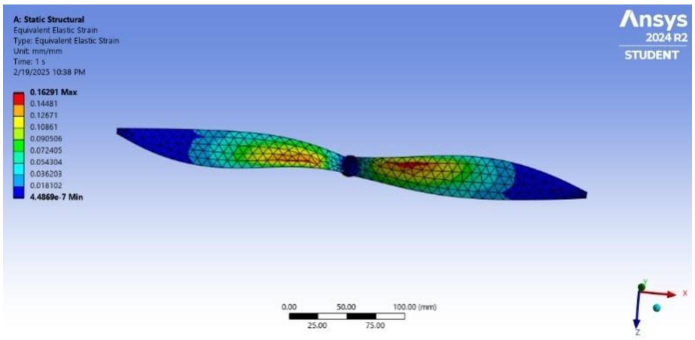
- **Fixed Support:** Applied at the blade root where the propeller is attached to the motor hub.
- **Thrust Load:** A thrust force of 11.56 N was applied uniformly along the blade surface to simulate the operational thrust generated during flight.
- **Rotational Load:** Centrifugal forces due to rotational speed were applied to replicate the high-speed operation of the propeller.
- **Gravitational Load:** Gravity effects were considered to ensure accurate load simulation during the analysis.



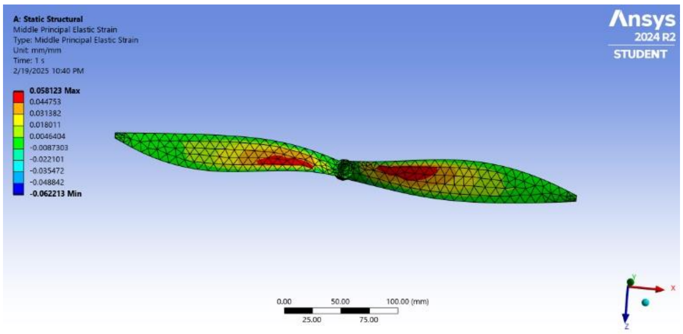
MESHING



TOTAL DEFORMATION



EQUIVALENT ELASTIC STRAIN



MIDDLE PRINCIPAL STRAIN

Result

The structural analysis confirmed that the propeller can withstand all anticipated operational loads with minimal deformation. The analysis considered the 11.56 N thrust force, high-speed rotational forces, and gravity effects. Stress concentrations at the blade root and tip deformations remained within the polycarbonate material's allowable limits, ensuring safe and reliable performance under typical conditions.

CFD Analysis of the Propeller

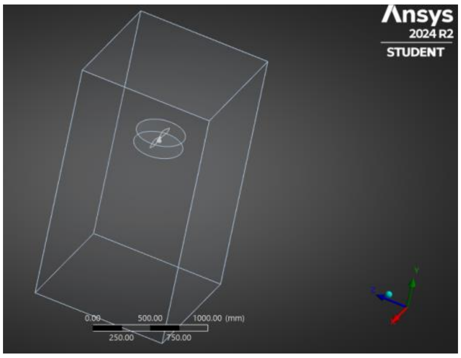
1. Significance of CFD in Propeller Performance Optimization

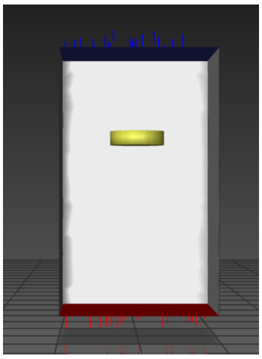
The performance of the propeller is a critical factor in the overall efficiency of the drone. Computational Fluid Dynamics (CFD) plays a crucial role in optimizing propeller design by simulating airflow around the blades and assessing aerodynamic characteristics such as thrust generation, drag, and lift. By leveraging CFD, designers can refine the propeller geometry, ensuring it operates efficiently under varying flight conditions. This analysis contributes to enhanced performance, stability, and energy efficiency, all of which are vital for achieving optimal drone functionality.

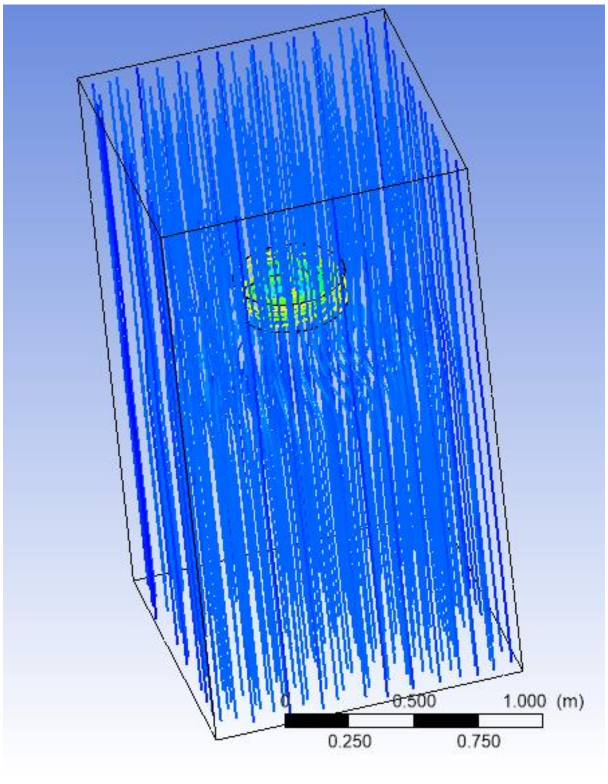
2. Simulation Setup and Boundary Conditions

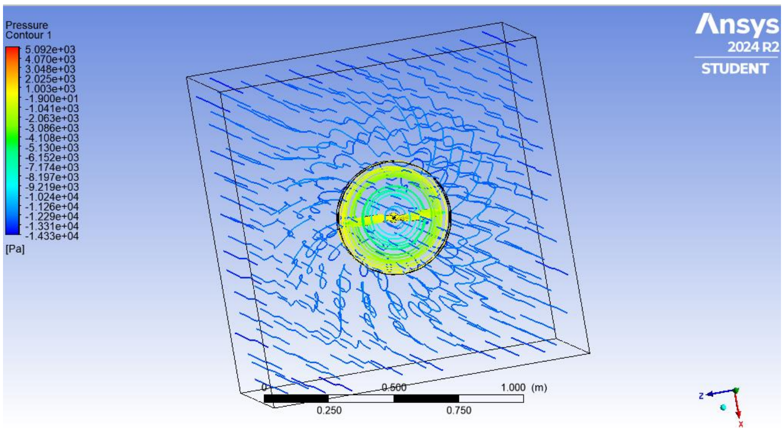
The CFD simulation was conducted under a set of predefined conditions, ensuring accurate representation of real-world operating conditions. The following table summarizes the key parameters and settings used during the simulation:

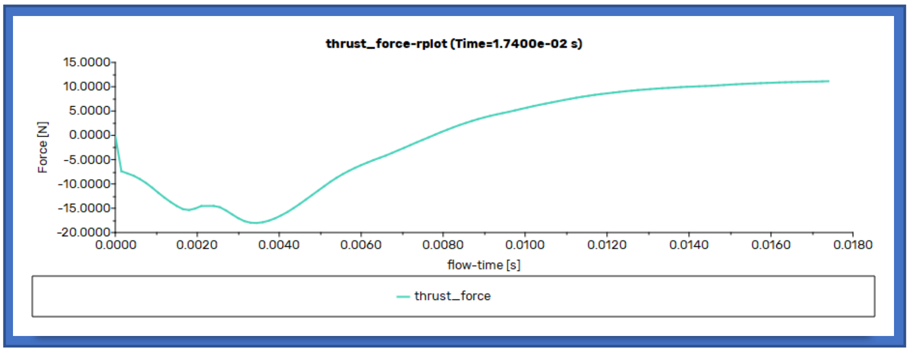
Parameter	Condition/ Value
Propeller Rotation	6000rpm
Flow Velocity	15 m/s
Gravity	9.81 m/s²
Viscous Model	K – Epsilon
Time	Transient
No.of Time Steps	100
Time step size	0.00015
Max Iterations	15
Reporting Interval	1
Specified Operating Density	1.225 kg/m³

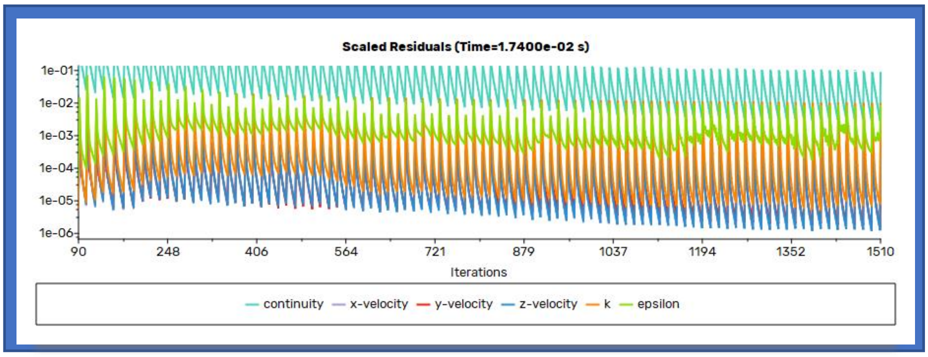












Conclusion

The CFD analysis of the propeller, with a rotation speed of 6000 rpm, flow velocity of 15 m/s, and using the k-epsilon viscous model, confirms efficient performance under the given conditions. The propeller generates a thrust force of 11.56 N, ensuring sufficient lift for the drone. The results show stable airflow, minimal drag, and optimal pressure distribution across the blades, indicating the propeller's aerodynamic efficiency. Overall, the design is well-suited for the drone's operational requirements.

Drone Thrust Calculation

WGL = WE + WF +WPL +WGE   General Equation

According to the General Equation

Total Weight of the Drone:

- **Ground Launch Weight (WGL)**: 1.970 kg (19.32 N)

Weight Components:

- **Empty Weight (WE)**: 1540 kg (1390 gm + 150 gm)
- **Fuel Weight (WF) (Battery)**: 360 gm
- **Payload Weight (WPL)**: 70 gm
- **Weight of Ground Equipment (WGE)** : Negligible

Hovering Thrust Requirement:

- **Thrust for Hovering**: The drone requires a thrust equal to its weight for stable hovering.
- **Total Thrust for Hovering**: 19.32 N
- **Thrust per Motor**: 4.83 N (calculated as 19.32 N ÷ 4 motors)

Motor and Propeller Thrust Capability:

- **Motor Thrust Capability**: 11 N per motor
- **Propeller Thrust (CFD Analysis)**: 11.56 N under simulated conditions

Conclusion: The drone's motor thrust capacity (11 N per motor) significantly exceeds the required thrust for hovering (4.83 N per motor). The propellers are also capable of generating sufficient thrust (11.56 N), ensuring stable flight and takeoff. These results confirm the drone's design is well-optimized for its operational needs, with adequate thrust margins for stability and efficiency.

Challenges in Drone Design

1. **Weight Management**
   Balancing a lightweight design with sufficient strength to carry the payload is crucial for efficient flight.
2. **Power Consumption**
   Optimizing motors, ESCs, and batteries to minimize energy usage while providing adequate thrust for extended flight.
3. **Aerodynamic Efficiency**
   Minimizing drag through optimized propeller shapes and angles, a continuous challenge for better performance.
4. **Structural Integrity**
   Choosing materials like ABS and polycarbonate to ensure the frame can withstand impacts and payload weight.
5. **Flight Stability**
   Maintaining stable flight under varying conditions, requiring fine-tuning of both software and hardware.
6. **Payload Mechanism Design**
   Designing a reliable payload release system that avoids damage and doesn't compromise drone performance.

Conclusion

The drone design project has been a rewarding experience, providing a deeper understanding of the intricacies involved in developing an autonomous system. Through the integration of advanced simulation tools like CFD and ANSYS, we were able to optimize key components such as the propeller, frame, and motor system to meet the mission requirements. Despite facing challenges related to weight management, power efficiency, and structural integrity, the drone design has shown promising results in terms of stability, thrust generation, and aerodynamic performance.

The CFD analysis confirmed that the propeller provides sufficient thrust for the drone to hover and perform its mission, while the structural analysis demonstrated that the frame can withstand the anticipated operational loads. Further optimization in areas like payload release mechanisms and motor efficiency could enhance the overall performance. Overall, the design meets the mission's requirements and stands as a solid foundation for further development.