POLITEKNIK BANTING SELANGOR

AEROSCOUT THERMOVISION

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DEPARTMENT OF AIRCRAFT MAINTENANCE

SESSION 1: 2025 / 2026

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A REPORT SUBMITTED TO DEPARTMENT OF AIRCRAFT MAINTENANCE IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR A DIPLOMA ENGINEERING IN AIRCRAFT MAINTENANCE.

SUPERVISOR:

MR. MOHAMAD FAIZAL BIN DAUD

REPORT ENDORSEMENT

This report is being submitted, reviewed, and endorsed to fulfill the conditions and requirements of report writing as specified.

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CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP

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"We hereby declare that this report is the result of our own work, except excerpts that we have outlined its sources and this project will be the ownership of polytechnic.

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SUPERVISOR STAMP

Date: 24 November 2025

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Finally, our deepest appreciation goes to all team members for their strong commitment, cooperation, and hard work in implementing this project. The sacrifices of time, effort, and resources, as well as the creative ideas shared by everyone, have made this project possible. We are truly grateful to all individuals and parties, directly or indirectly involved, especially Politeknik Banting Selangor, for their invaluable contribution to the success of this project.

ABSTRACT

The Aeroscout Thermovision was developed to perform automated visual and thermal inspections on aircraft structures, focusing on the empennage section where conventional inspection is difficult and time-consuming. The system was designed by integrating the existing camera on the DJI Phantom 4 Advanced with a thermal imaging module and artificial intelligence analysis software. The visual camera was used to detect surface defects such as cracks, scratches, and corrosion, while the thermal camera was applied to identify possible water ingression within aircraft structures through temperature variations. This project was conducted to enhance inspection accuracy, improve maintenance efficiency, and reduce the reliance on manual visual checks during aircraft maintenance operations. The scope of the project involved modifying the drone platform, installing both visual and thermal cameras, and developing an image-processing system capable of analyzing captured data to identify potential defects. The drone utilized a stable flight control system and obstacle detection sensors to ensure steady and safe operation during inspection. The output of the project showed that the Aeroscout Thermovision was capable of detecting surface damage and thermal anomalies effectively, providing clear data for maintenance evaluation. The analyzed images highlighted defect areas, enabling maintenance personnel to identify early signs of structural degradation more efficiently. As a result, the inspection process became faster, safer, and more reliable compared to conventional methods. Overall, the Aeroscout Thermovision demonstrated significant potential in improving the accuracy of aircraft structural inspections, reducing human error, and supporting the advancement of smart maintenance practices in the aviation industry.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
UAV	Unmanned Aerial Vehicle
FLIR	Forward-Looking Infrared
NDT	Non-destructive Testing
GPS	Global Positioning System

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

In the aircraft maintenance industry, safety, precision, and time efficiency are crucial during every inspection process. One of the most critical areas requiring thorough inspection is the fuselage section, which forms the main body of the aircraft and houses passengers, cargo, and essential systems. This area is challenging to inspect due to its large surface area, curved structure, and limited accessibility, especially in the upper and lower sections. Any water ingression within the fuselage can compromise structural integrity and flight safety if not detected and addressed promptly.

Currently, technicians rely on manual inspection methods, which involve the use of ladders, scaffolding, cherry pickers, or maintenance stands to reach these elevated areas. While this method is widely practiced, it is time-consuming, physically demanding, and poses safety risks to maintenance personnel. In addition, the possibility of missing internal or heat-related damage such as overheating components, hidden cracks, corrosion, or delamination remains high due to limited visual accessibility.

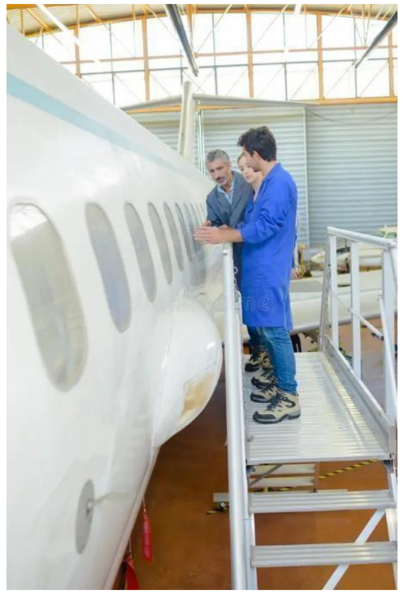


Figure 1.1 : Current inspection method using ladders on a fuselage section.

To address these limitations, this study proposes the development of a drone-based thermal vision system integrated with Artificial Intelligence (AI) named AEROSCOUT THERMOVISION. This innovative technology is designed to replace or support conventional manual inspection processes for the empennage section. It allows technicians to remotely inspect aircraft surfaces using thermal imaging and real-time data analysis powered by AI algorithms.

This system is strictly designated for operation within hangar areas and will only be flown by authorized maintenance personnel who meet the requirements outlined in Regulation 140 of the Civil Aviation Regulations 2016. This ensures that all operational procedures comply with aviation standards and safety regulations.

The drone will be used to detect water ingression on the aircraft structure, such as:

- Trapped moisture within composite or metallic panels
- Water accumulation beneath paint or surface coatings
- Moisture presence around rivets, joints, and seams
- Water trapped inside honeycomb or sealed fuselage areas
- Detection of water ingression through thermal imaging based on temperature variations

The integration of this drone system aims to improve safety, minimize inspection time, and enhance defect detection accuracy, aligning with the industry's move towards smart maintenance and predictive analytics in the era of digital aviation.

1.2 PROBLEM STATEMENTS

Aircraft maintenance inspections play a vital role in ensuring the safety and airworthiness of an aircraft. Among the most challenging and critical areas to inspect is the fuselage section, which forms the main body of the aircraft. This area is essential for maintaining the aircraft’s structural integrity and protecting internal systems. However, it is prone to water ingression, especially in joints, seams, and composite panels. Undetected water ingression can lead to increased structural weight and potential deterioration over time if not identified and rectified promptly.

Conventional inspection methods typically require the use of scaffolding, ladders, maintenance stands, or aerial lifts. These manual practices not only expose technicians to elevated fall hazards, but also limit access to intricate areas such as the rear joints or uppermost surfaces of the vertical stabilizer. This limitation can cause incomplete inspections, potentially allowing defects to go unnoticed.

Several real-world incidents underscore the dangers posed by traditional inspection methods and inadequate detection techniques. For example:

- In 2005, Senior Airman James Harris of the 660th Aircraft Maintenance Squadron suffered fatal injuries after falling 13 feet through an open railing of a maintenance stand during inspection work. Despite receiving immediate medical attention, he succumbed to his injuries.
- In 2016, a regional turboprop aircraft experienced extensive corrosion and electrical malfunctions after undetected water ingression was found inside the fuselage panels during routine maintenance. The trapped moisture had seeped into wiring channels and joints, compromising both structural integrity and system reliability.
- In 2020, maintenance crews discovered severe water accumulation within the fuselage skin and insulation layers of a commercial airliner. The water ingression had gone

unnoticed during previous visual inspections, leading to increased aircraft weight and potential long-term structural deterioration.

This incident emphasized the limitations of traditional inspection methods and the need for more advanced non-destructive techniques such as thermal imaging. These events illustrate the critical importance of effective, safe, and accurate inspection technologies, particularly for areas like the fuselage which are difficult to access and inspect thoroughly through manual means.

In support of these observations, a survey conducted among aviation maintenance personnel and students as part of this study further reinforced the existence of these challenges. The data showed that:

- 50% of respondents cited safety risks as the primary concern during inspection tasks.
- 30% identified limited accessibility to certain aircraft sections as a significant obstacle.
- 30% also reported time inefficiency, and 20% noted inaccuracies in defect detection due to reliance on visual judgment and human limitations.

These findings affirm that traditional inspection methods are no longer adequate in meeting the safety and operational efficiency standards expected in modern aviation maintenance.

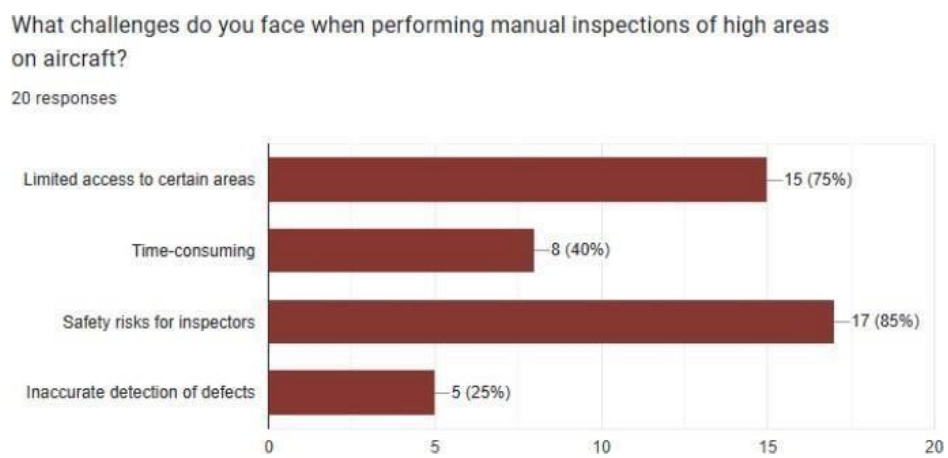


Figure 1.2 : Chart for Challenges Faces When Performing Manual Inspection

Thus, there is a clear and compelling need for an automated, intelligent, and non-invasive inspection system capable of addressing these issues. The development of an AI-integrated drone system equipped with thermal imaging AEROSCOUT THERMOVISION is proposed as a viable solution. This system is designed to:

- Conduct high-altitude inspections remotely and safely within designated hangar environments.
- Detect hidden structural defects such as cracks, corrosion, overheating components, delamination, and loose fasteners using thermal imaging.
- Minimize human involvement, reduce inspection time, and improve accuracy through AI- driven data analysis.

1.3 PROJECT OBJECTIVES

1.3.1 General Project Objectives

The project objectives are:

- To design a drone-based inspection system that provides safe access to high and hard-to-reach areas of an aircraft, such as the fuselage section for maintenance personnel.
- To develop an AI-integrated drone capable of performing accurate and detailed inspections, thereby minimizing human error and enhancing water ingression detection.
- To demonstrate the capabilities of thermal cameras and LiDAR systems in detecting cracks and structural anomalies during aircraft inspections.
- To evaluate the effectiveness of drone-assisted inspections in improving safety, accuracy, and reliability, while reducing the risks and limitations associated with manual inspection methods.

1.3.2 Specific Individual Project Objectives

1.3.2.1 Product Structure

The specific project objectives are:

- To design a lightweight and secure mounting structure that can hold the thermal inspection system firmly beneath the drone without affecting its balance or flight performance.
- To implement a non-intrusive attachment method using high-strength nylon zip ties, avoiding any permanent modification to the drone's frame or sensors.
- To ensure the overall structure maintains aerodynamic stability and minimal vibration, allowing stable thermal image capture during hovering and movement.
- To achieve a low-cost and efficient mounting solution that is easy to install, remove, and maintain while preserving flight safety and operational efficiency.

1.3.2.2 Product Mechanism

The specific project objectives are:

- To design the AeroScout Thermovision drone with a moveable camera that can be adjusted to different angles and positions to inspect various areas of the aircraft.
- To develop the mechanism for extending and retracting the camera to allow for flexibility in positioning and to ensure ease of access to all parts of the aircraft during inspection.
- To demonstrate the functionality of the drone and camera, enabling the inspection of hard
- To-reach areas, ensuring maximum coverage and safety during the inspection process.

1.3.2.3 Software / Programming

The specific project objectives are:

- To design and integrate the software for AI-based defect detection, enabling the drone to analyze thermal images in real-time.
- To develop AI programming using Python and machine learning models, ensuring that the system can detect various defects such as cracks or overheating components during inspections.
- To design and implement the cloud-based data storage system that securely stores inspection data, providing easy access for analysis and maintenance records.

1.3.2.4 Accessories and Finishing

The specific project objectives are:

- To design and integrate the accessories required for the drone's operation, such as the battery and propellers, ensuring sufficient flight time and stability.
- To develop protective housing for the camera and other sensitive components to ensure they are shielded from environmental factors during operation.
- To ensure the finishing and aesthetics of the drone are both practical and visually appealing, with clear markings and simple controls to enhance usability for operators during inspections.

1.4 PURPOSE OF PRODUCT

The AeroScout Thermovision system has the potential to make a big difference in how aircraft maintenance is done, benefiting both the industry and passengers. By using drones equipped with thermal cameras and AI, it simplifies and speeds up the inspection process, especially in hard-to reach areas like the fuselage. This means maintenance crews can identify issues faster, leading to safer flights for passengers.

One of the key impacts of this system is how it helps improve safety. Traditional inspections can be time-consuming and sometimes miss small but important defects. With AI-powered thermal imaging, the AeroScout Thermovision ensures that issues like cracks, corrosion, or overheating components are detected early. This not only reduces the risk of hidden damage but also prevents potential in-flight problems, making air travel safer for everyone.

On top of that, the system helps streamline the entire inspection process. With real-time data analysis and cloud storage for inspection results, it makes it easier for maintenance teams to stay organized, track aircraft conditions, and keep accurate records. This efficiency can lead to lower costs and more frequent safety checks, keeping planes in top shape.

1.5 SCOPE OF PROJECT

1.5.1 General Project Scope

The AeroScout Thermovision project aims to create a drone-based inspection system using thermal imaging and AI to improve aircraft maintenance. The goal is to make inspections faster, safer, and more accurate, especially in hard-to-reach areas like the empennage. The system will help maintenance crews find potential defects such as cracks, corrosion, and water ingression that might be missed in regular checks.

The project will involve building the entire inspection system, including the drone, thermal camera, AI software for analyzing the images, and a cloud-based storage system for the inspection results. It will also focus on making sure the system can be integrated smoothly into existing aircraft maintenance procedures.

1.5.2 Specific Individual Scope

1.5.2.1 Product Structure

The AeroScout ThermoVision system will have three key parts. First, the drone body, which will be lightweight but sturdy enough to carry the thermal camera and the AI unit. It will ensure stable flight and hold all the components in place. Second, the thermal camera will be the FLIR Lepton 3.5, responsible for capturing thermal images of the aircraft. This will help detect temperature changes that indicate potential defects. Lastly, the AI processing unit will be powered by a Raspberry Pi 5, which will analyze the thermal images and detect any issues. This unit will process the data quickly to provide results in real-time, helping with faster decision- making during inspections.

1.5.2.2 Product Mechanisms

The system will work through several mechanisms. The flight mechanism will be provided by the DJI Phantom 4 Advanced drone, which will be stable and have obstacle sensing for safe and precise flights. The camera mechanism will involve the FLIR Lepton 3.5 camera, which will be mounted on the drone and can be adjusted to capture the right angles. The AI mechanism will use the Raspberry Pi 5 to process thermal images and detect defects, such as cracks or overheating, in real time. Finally, the data storage mechanism will store the results in the cloud, allowing easy access to past inspections for analysis and reporting.

1.5.2.3 Software / Programming

The software will focus on AI algorithms that analyze thermal images and detect defects. The AI software will be developed using Python and machine learning libraries like TensorFlow and OpenCV. The real-time data processing will be done by the Raspberry Pi 5, ensuring that the inspection results are available quickly. The system will also have cloud integration, allowing inspection results to be stored and accessed online. A simple user interface will be developed, so maintenance teams can easily control the drone, view live data, and receive alerts when defects are found. The software will be designed to ensure the system is easy to use and reliable.

1.5.2.4 Accessories & Finishing

The accessories and finishing will ensure the system is functional, durable, and easy to use. The battery and power system will be designed to provide up to 30 minutes of flight time, with fast recharging capabilities. The propellers will be strong and efficient, ensuring stable flight. The camera housing will protect the FLIR Lepton 3.5 camera from dust and moisture, while also reducing vibrations to keep the thermal images clear. The system's finishing will make the drone lightweight, durable, and sleek in appearance. Finally, safety features like anti-collision sensors and emergency return-to-home functions will be included to ensure safe flights during inspections.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

This chapter reviews past research and technological advancements relevant to the development of the AeroScout Thermovision system. It focuses on three primary areas: aircraft inspection methods, the use of drones in maintenance, and thermal imaging with AI-based defect detection for identifying water ingress in composite and honeycomb structures.

Previous studies have shown that conventional aircraft inspection methods such as tap testing, ultrasonic testing, and visual inspection remain the most commonly used techniques for detecting water ingress or delamination in composite materials. However, these traditional approaches present significant challenges. They typically require aircraft to be grounded for extended periods, resulting in increased maintenance downtime and operational disruptions. Furthermore, manual inspections are labor-intensive and depend heavily on operator experience, which may lead to inconsistent results. Detecting subsurface moisture within honeycomb cores is particularly difficult, as water can become trapped without any visible external indications.

Recent research has explored the integration of unmanned aerial vehicles (UAVs) with non-destructive testing (NDT) technologies to improve the efficiency and accessibility of aircraft inspections. Drones equipped with high-resolution cameras, have been used to identify any surface damage on fuselage structure. However, limited studies have focused on detecting water ingress within honeycomb structures, which remains a significant challenge in composite aircraft maintenance.

To address this gap, the AeroScout ThermoVision system introduces a novel approach that utilizes drone-mounted thermal imaging and AI-driven analysis to detect water ingress in aircraft honeycomb panels. By analyzing thermal variations that indicate trapped moisture, the system aims to provide a rapid, non-destructive, and accurate method of inspection without requiring long aircraft grounding periods. This integration of drone technology, thermal sensing, and artificial intelligence represents a new advancement in autonomous aircraft structural health monitoring.

2.1.1 Conventional Aircraft Inspection Method

Aircraft maintenance heavily relies on visual and manual inspections to identify structural damage like water ingress in honeycomb structure. Traditionally, this inspection is performed using ladders, scaffolding, or maintenance stands, especially when examining the upper fuselage or empennage sections of an aircraft. While effective for detecting visible surface defects, these conventional methods are time-consuming, labor-intensive, and expose maintenance personnel to safety risks when working at height or in confined areas.

In cases of water ingress, conventional inspection techniques such as tap testing, ultrasonic testing, or moisture meters are often used. However, these methods have several limitations. Tap testing depends heavily on the technician’s experience and may fail to identify moisture trapped deep within the honeycomb core. Ultrasonic testing, while more accurate, requires physical contact with the surface and is limited to small inspection areas at a time, making it inefficient for large-scale aircraft structures. Moreover, aircraft must be grounded for extended periods during these inspections, resulting in operational downtime and maintenance delays.

Figure 2.1.1 Stepping up ladder in aviation industry

2.1.2 Integration of Drones In Aircraft Maintenance

Unmanned Aerial Vehicles (UAVs), commonly known as drones, have gained traction in industrial inspections due to their flexibility and accessibility. Several studies have explored drone applications in aircraft surface inspection, showing promising results in detecting surface cracks, dents, and missing fasteners. Drones like the DJI Phantom 4 have been tested for their stability, image capture capabilities, and ability to maneuver in constrained spaces. However, most drone-based systems still rely on visual cameras, limiting their capability to detect subsurface defects or water ingress within composite and honeycomb structures, which often present no visible external indications.

2.1.3 Thermal Imaging Technology in Defect Detection

Thermal imaging is widely used in non-destructive testing (NDT) to detect subsurface anomalies, delamination, and moisture intrusion in composite and honeycomb materials. Cameras such as the FLIR Lepton 3.5 provide compact and cost-effective thermal solutions suitable for drone integration. In aircraft maintenance, this technique enables the detection of water ingress, as trapped moisture alters the thermal conductivity of honeycomb panels, producing measurable temperature differences. Thermal inspection therefore offers a non-contact, efficient method for identifying hidden defects in critical areas such as the fuselage and empennage.

2.1.4 Artificial Intelligence In Maintenance And Inspection

The incorporation of artificial intelligence (AI) and machine learning in aircraft maintenance has greatly enhanced the ability to interpret inspection data and detect structural anomalies. Algorithms trained with large datasets can identify thermal or visual patterns that indicate water ingress, delamination, corrosion, or cracks more accurately than manual inspection alone. AI systems, particularly those using convolutional neural networks (CNNs), have demonstrated high success rates in image-based fault detection and classification, making them ideal for analyzing thermal images captured by UAVs. By automating the interpretation of thermal data, AI enables faster, more consistent, and more reliable detection of hidden defects within aircraft honeycomb structures.

2.1.5 Existing Drone Based Inspection Solutions

Several institutions and companies have piloted drone-based solutions for aircraft inspections. For instance, Airbus developed an autonomous drone inspection system capable of capturing high-resolution images of an aircraft's fuselage to detect surface defects such as dents, paint deterioration, and missing fasteners. While effective for external visual inspections, these systems are primarily designed for large commercial aircraft and lack thermal imaging or AI capabilities for identifying subsurface issues such as water ingress within honeycomb structures.

This limitation highlights a gap in current maintenance technology and underscores the need for a compact, AI-powered drone system capable of performing both visual and thermal inspections. The AeroScout Thermovision system aims to address this gap by enabling autonomous detection of water ingress and hidden structural anomalies, providing a faster, safer, and more efficient solution for aircraft maintenance operations.

2.2 SPECIFIC LITERATURE REVIEW

2.2.1 Product Structure

The structure of the AeroScout Thermovision system is built to support safe, lightweight, and stable drone operation for aircraft inspections. The selected drone platform, such as the DJI Phantom 4 Advanced, is engineered using robust yet lightweight composite materials, ensuring maneuverability within aircraft hangars. To accommodate the integrated inspection hardware, the drone body is customized to mount critical components including the FLIR Lepton 3.5 thermal camera and Raspberry Pi 5 for AI Detecting Processing Software.

The drone's main body houses the flight controller, voltage regulation system, and computing board (Raspberry Pi 5), all positioned to maintain weight distribution and flight balance. The modular design enables ease of access for repairs or upgrades. The LiPo battery (11.1V 5200mAh) is secured in a protected compartment and voltage is stepped down to 5V to supply stable power to onboard electronics. Structural features also incorporate shock absorption to protect sensitive equipment during minor impacts or landings. This architecture ensures the drone is physically optimized for precision maintenance inspections.

Figure 2.2 : DJI Phantom 4 Advanced

2.2.2 Product Mechanisms

The mechanical mechanism of the AeroScout ThermoVision drone integrates propulsion, navigation, and sensor systems that are tailored for inspection tasks in constrained environments. Obstacle avoidance is achieved through the use of a LiDAR system (e.g., Intel RealSense D435i), which provides real-time spatial awareness and distance measurement to prevent collisions with aircraft structures.

The drone operates on a quadcopter design, utilizing brushless motors to maintain high stability during vertical and horizontal flight. These motors are powered by the high-capacity LiPo battery, regulated to avoid voltage fluctuations. The drone's mounting framework ensures all sensors and payload components are securely fixed and vibration-isolated to preserve data accuracy during flight.

Figure 2.3 : Micro LiDar Module

2.2.3 Software / Programming

AeroScout Thermovision's software system is developed using Python, enabling real-time data processing, sensor fusion, and AI-based defect recognition. The core programming is executed on a Raspberry Pi 5 board, which integrates inputs from the FLIR Lepton 3.5 thermal sensor.

The software stack includes modules for temperature anomaly detection, visual mapping, and automated obstacle detection. Image data from the thermal camera is processed and overlaid with distance data from the LiDAR, allowing technicians to identify surface cracks, corrosion, or hotspots.

AI algorithms assist in analyzing patterns by comparing real-time images with stored references of aircraft surfaces. The drone's flight path is controlled through GPS input and inertial measurement data, and safety parameters are programmed in accordance with CAAM Regulation 140 to restrict operation altitude and location. The software system also supports future enhancements, such as cloud data syncing and remote operation.

Figure 2.4 : Raspberry Pi 5

2.2.4 Accessories and Finishing

The AeroScout drone includes several accessory components that enhance functionality, safety, and usability. Key accessories include the PureThermal 3 (Figure 2.5) interface board, which facilitates seamless integration of the FLIR Lepton thermal camera, and shock-mounted camera holders to reduce vibration during flight.

The finishing aspects focus on modular assembly, thermal shielding, and weight optimization. Non-reflective matte coatings are applied to minimize interference during inspections, especially when lighting conditions vary.

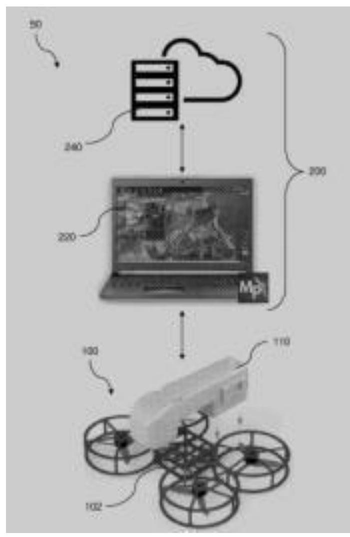
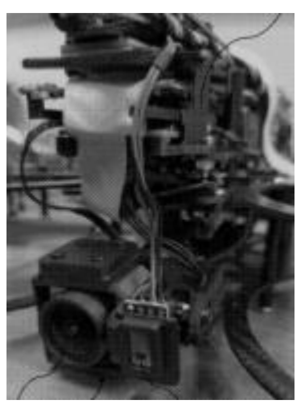
Protective casing around electronics ensures durability, and the drone's structural layout provides passive cooling for heat-sensitive components. All accessories and finishes are selected to ensure regulatory compliance, operational efficiency, and extended service life in a maintenance hangar environment.

Figure 2.5 : Purethermal 3

2.3 REVIEW OF RECENT RESEARCH / RELATED PRODUCT

2.3.1 Related Patented Product

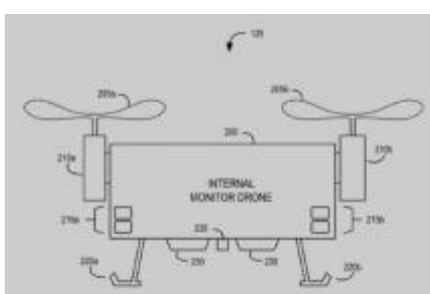
2.3.1.1 Patent Drone for Surface Defects Inspection

No.	Patent Product	Patent Summary
1.	 	**Patent Title**: Drone for Surface Defects Inspection **Patent No.**: WO2020139195A1 **Published Date**: July 2, 2020 **Patent Office Country**: WIPO (PCT)- USA **Inventors**: Wei Jun Jay Ang, Tze Huan Jake Goh, Chien Ming Mervin Hoon, Kok Wee Keith Ng, Yu Da Tan, Wi-Soon Mark Toh **Abstract**: This patent describes a drone system designed for inspecting surface defects in enclosed environments. The drone comprises a body with guard frames, propellers, and a set of sensors including time-of-flight and optical flow sensors for navigation without GPS. An inspection module equipped with optical and thermal cameras captures visual data, which is processed to identify surface defects. The system enhances safety by reducing the need for human inspectors in hazardous areas and improves inspection efficiency through semi-

		autonomous navigation and real-time data processing.

Table 2.3 : Patent Drone for Surface Defects Inspection

2.3.1.2 Patent systems and methods for inspecting a delivery vehicle using a paired inspection drone

No.	Patent Product	Patent Summary
2.		**Patent Title**: Systems and methods for inspecting a delivery vehicle using a paired inspection drone **Patent No.**: US10482418B2 **Published Date**: September 21, 2017

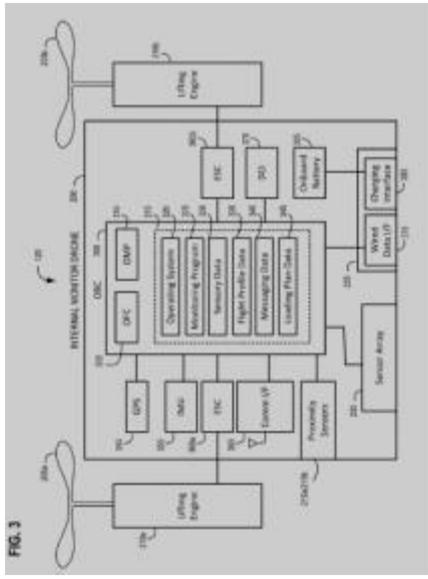
		**Patent Office Country**: USA **Inventors**: V Reuben F. Burch, David A. Doyle, Brian D. Popp **Abstract**: A paired drone-based system is used to inspect a delivery vehicle. The system includes a docking station inside the vehicle and a sensor-equipped drone that is paired with it. When activated, the drone powers on, detaches from the docking station, and identifies specific inspection points on the vehicle. It then flies to each of these points, gathers inspection data using its sensors, and detects if any condition is outside the acceptable range for normal operation. If an issue is found, the drone sends a notification to the vehicle's receiver, identifying the problem area.

Table 2.4 : Patent systems and methods for inspecting a delivery vehicle using a paired inspection drone

2.3.1.3 Patent Drone Inspection Analytics for Asset Defect Detection

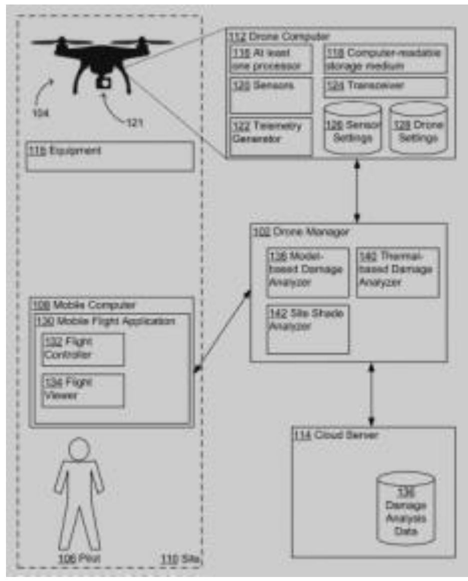
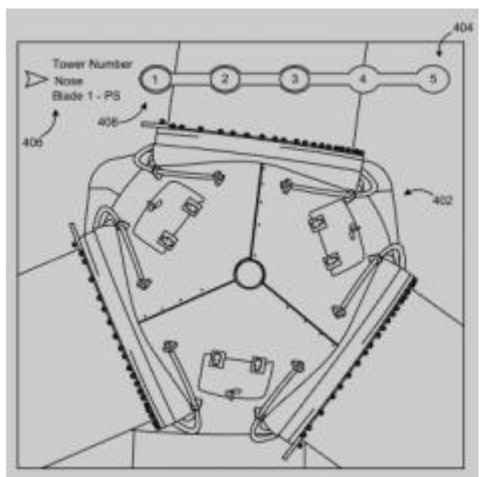
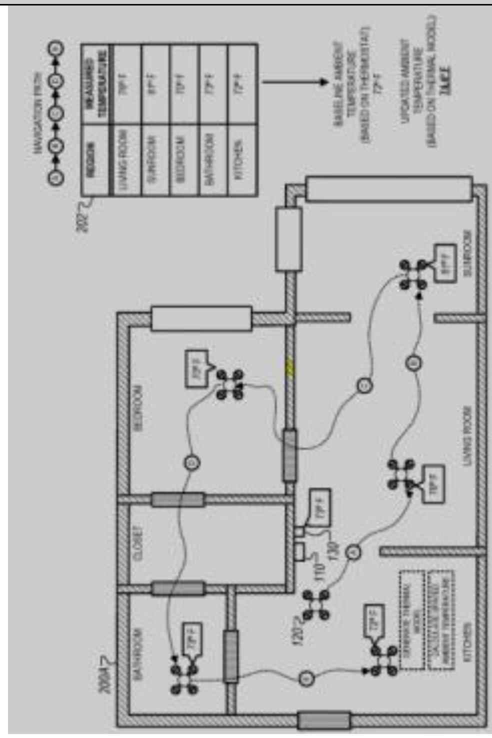
No.	Patent Product	Patent Summary
3.	 	**Patent Title**: Drone Inspection Analytics for Asset Defect Detection **Patent No.**: US20200279367A1 **Published Date**: September 3, 2020 **Patent Office Country**: USA **Inventor**: Preston White **Abstract**: This patent introduces a system where drones collect images and telemetry data during inspections. The data is processed using convolutional neural networks (CNNs) to automatically detect and classify defects. The system maps images to 3D models of the inspected object, identifies areas omitted during initial inspections, and generates optimized flight paths for comprehensive coverage.

Table 2.5 : Patent Drone Inspection Analytics for Asset Defect Detection

2.3.1.4 Patent Drone-assisted Thermal Monitoring Techniques

No.	Patent Product	Patent Summary
4.		**Patent Title**: Drone-assisted Thermal Monitoring Techniques **Patent No.**: US12039774B2 **Published Date**: March 12, 2024 **Patent Office Country**: USA **Inventors**: Babak Rezvani, Ahmad Seyfi, Glenn Tournier, Donald Gerard Madden, Ethan Shayne **Assignee**: Alarm.com Inc. **Abstract**: This patent introduces a drone-assisted thermal monitoring system designed to detect temperature anomalies across various properties. The system employs drones equipped with thermal imaging sensors to capture temperature

		data, which is then analyzed to identify potential issues such as overheating components or insulation failures. The technology emphasizes real-time data processing and can be applied to various structures, including aircraft, to enhance maintenance procedures by providing timely and accurate thermal assessments.

Table 2.6 : Patent Drone-assisted Thermal Monitoring Techniques

2.3.2 Recent Market Product

2.3.2.1 Patent Flyability Elios 2

No.	Market Product	Product Summary
1		**Product Name**: Flyability Elios 2 **Published Date**: 2019 **Inventor**: Flyability SA (Switzerland) **Description**: The Elios 2 is a collision-tolerant inspection drone designed for GPS-denied and confined environments. Equipped with a 4K camera, thermal sensor, and LiDAR, it enables remote visual and thermal inspections in dangerous or hard-to-reach places such as aircraft interiors, fuel tanks, and engine compartments. It significantly enhances inspection safety and data quality while reducing the need for human entry into hazardous zones.

Table 2.7 : Explanation of Market Product and Product Summary of Flyability Elios 2

2.3.2.2. Patent DJI Mavic 2 Enterprise Dual

No.	Market Product	Product Summary
2		**Product Name**: DJI Mavic 2 Enterprise Dual **Published Date**: November 2018 **Inventor**: DJI (Da-Jiang Innovations, China) **Description**: This commercial-grade drone combines a visual camera with a FLIR thermal sensor, offering dual imaging capabilities for industrial inspections. With features like GPS tracking, obstacle sensing, and real-time thermal imaging, it is used across industries, including aircraft maintenance, for identifying thermal anomalies like overheating components or fluid leaks in engines or electrical systems.

Table 2.8 : Explanation of Market Product and Product Summary of DJI Mavic 2 Enterprise Dual

2.3.2.3 Patent Parrot Anafi Thermal

No.	Market Product	Product Summary
3		**Product Name**: Parrot Anafi Thermal **Published Date**: May 2019 **Inventor**: Parrot SA (France) **Description**: The Parrot Anafi Thermal is a compact drone equipped with a FLIR Lepton thermal sensor and a 4K HDR camera. Designed for professional inspection tasks, it provides real-time thermal feedback and visual documentation, ideal for detecting heat leaks, insulation faults, and structural issues. Its portability and ease of use make it suitable for on-site aircraft inspections.

Table 2.9 : Explanation of Market Product and Product Summary of Parrot Anafi Thermal

2.3.2.4 Patent DJI Mavic 2 Enterprise Advanced

No.	Market Product	Product Summary
4		**Product Name**: DJI Mavic 2 Enterprise Advanced **Published Date**: 2021 **Inventor**: DJI (Da-Jiang Innovations, China) **Description**: The Mavic 2 Enterprise Advanced features a 48MP visual camera and a high-resolution 640×512 thermal sensor. It supports up to 32× digital zoom and offers centimeter-level positioning accuracy with the RTK module. The drone's dual-vision capabilities allow for real-time switching between visual, thermal, or split-view feeds, enhancing situational awareness during inspections. Its compact design and advanced imaging features make it ideal for detailed aircraft inspections, facilitating the identification of overheating components and structural defects.

Table 2.10 : Explanation of Market Product and Product Summary of DJI Mavic 2 Enterprise Advanced

2.4 COMPARISON BETWEEN RECENT RESEARCH AND CURRENT PROJECT

2.4.1 Patent Drone for Surface Defects Inspection vs. Product Flyability Elios 2 vs. AeroScout ThermoVision

Feature	Drone for Surface Defects Inspection	Flyability Elios 2	AeroScout ThermoVision
Design Structure	Guarded drone body with sensors	Spherical cage with internal camera	Quadcopter with thermal module
Mobility Mechanism	Semi-autonomous, GPS-free indoor navigation	GPS-free, stable flight in confined spaces	Manual/auto flight modes
Primary Function / Purpose	Surface defect detection in enclosed areas	Industrial inspections (indoor/confined)	Aircraft inspection in hard-to-reach zones
Physical Dimensions (inches)	Not specified	15.7 x 15.7 x 10.2	Approx. 12 x 12 x 8
Locking / Folding Mechanism	Fixed body	Fixed internal cage	Fixed body with detachable propeller
Integrated Technologies	Time-of-Flight, Optical Flow, Thermal camera	4K Camera, Thermal Imaging, Distance Lock	AI, FLIR thermal, real-time processing

Operational Environment	Indoor, GPS-denied spaces	Indoor, confined or dangerous spaces	Outdoor & indoor, aircraft zones

Table 2.11 : Patent Drone for Surface Defects Inspection vs. Product Flyability Elios 2 vs. AeroScout ThermoVision

2.4.2 Patent Systems and methods for inspecting a delivery vehicle using a paired inspection drone vs. Product DJI Mavic 2 Enterprise Dual vs. AeroScout ThermoVision

Feature	Systems and methods for inspecting a delivery vehicle using a paired inspection drone	DJI Mavic 2 Enterprise Dual	AeroScout ThermoVision
Design Structure	Dockable sensor drone	Compact quadcopter	Quadcopter with thermal module
Mobility Mechanism	Auto-docks, GPS-based flight	GPS + Obstacle avoidance	GPS/optical nav
Primary Function / Purpose	Vehicle pre-check and anomaly alerts	Thermal inspection, emergency use	Aircraft surface thermal inspection
Physical Dimensions (inches)	Not disclosed	8.4 x 3.3 x 3.6	Approx. 12 x 12 x 8

Locking / Folding Mechanism	Docking station-based lock	Foldable arms	Fixed Body with detachable propeller
Integrated Technologies	Sensors, automated alerts	4K + FLIR, modular attachments	AI vision, FLIR thermal, anomaly detection
Operational Environment	On-road, vehicle-based	Industrial, public safety	Aircraft zones, outdoor inspections

Table 2.12 : Patent Systems and methods for inspecting a delivery vehicle using a paired inspection drone vs. Product DJI Mavic 2 Enterprise Dual vs. AeroScout ThermoVision

2.4.3 Patent Drone Inspection Analytics for Asset Defect Detection vs. Product Parrot Anafi Thermal vs. AeroScout ThermoVision

Feature	Drone Inspection Analytics for Asset Defect Detection	Parrot Anafi Thermal	AeroScout ThermoVision
Design Structure	Standard quadcopter, AI camera payload	Foldable drone with thermal camera	Quadcopter with thermal module
Mobility Mechanism	Auto-routing with optimized AI flight paths	Manual GPS flight, 3x zoom gimbal	Semi-auto flight

Primary Function / Purpose	Detect and classify defects via CNN	Thermal mapping & visual inspection	Aircraft structural/thermal anomaly detection
Physical Dimensions (inches)	Not stated	9.6 x 2.6 x 2.5	Approx. 12 x 12 x 8
Locking / Folding Mechanism	Fixed frame	Foldable arms	Fixed body with detachable propeller
Integrated Technologies	CNN AI, 3D model mapping, thermal camera	FLIR Lepton, HDR camera	AI processing, FLIR, GPS-free flight
Operational Environment	Outdoor/industrial	Outdoor	High altitude aircraft zones, GPS-denied areas

Table 2.13 : Patent Drone Inspection Analytics for Asset Defect Detection vs. Product Parrot Anafi Thermal vs. AeroScout ThermoVision

2.4.4 Patent Drone-assisted Thermal Monitoring Techniques vs. Product DJI Mavic 2 Enterprise Advanced vs. AeroScout ThermoVision

Feature	Drone-assisted Thermal Monitoring Techniques	DJI Mavic 2 Enterprise Advanced	AeroScout ThermoVision
Design Structure	Drone with telemetry & imaging systems	Compact dual-sensor quadcopter	Quadcopter with thermal module
Mobility Mechanism	AI-driven inspection with optimized paths	RTK + 32x zoom + obstacle sensors	Semi-auto flight
Primary Function / Purpose	Asset inspection and data mapping	Detailed inspection and search & rescue	Aircraft AI inspection (structure + thermal)
Physical Dimensions (inches)	Not specified	8.4 x 3.3 x 3.6	Approx. 12 x 12 x 8
Locking / Folding Mechanism	Not mentioned	Foldable arms	Fixed body with detachable propeller
Integrated Technologies	CNNs, 3D mapping, telemetry	48MP + 640x512 thermal, RTK positioning	FLIR thermal, real-time AI, aircraft-safe

Operational Environment	Outdoor/industrial assets	Outdoor, industrial, emergency	High/complex aircraft surfaces

Table 2.14 : Patent Drone-assisted Thermal Monitoring Techniques vs. Product DJI Mavic 2 Enterprise Advanced vs. AeroScout ThermoVision

2.5 RESEARCH GAP

Year / Study	Focus / Contribution	Key Findings or Technology Used	Identified Limitation / Research Gap
2012 – Ibarra-Castanedo et al.	Infrared thermography for detecting water ingress in honeycomb structures	Proved that both active and passive thermography can detect trapped moisture in composite honeycomb panels	Laboratory-based only; not suitable for large aircraft surfaces or drone integration
2016 – Donecle (Industry)	Autonomous visual UAV inspection for aircraft fuselage	Reduced inspection time and improved safety through automation	Limited to surface crack/dent detection; no subsurface or moisture detection
2018 – Airbus Indoor Drone	Automated drone inspection within hangars	Demonstrated feasibility of UAVs for visual aircraft inspection	Still visual only; no integration with NDT or AI-based thermal analysis
2022 – Wang et al.	CNN-based thermal image analysis for moisture/seepage detection in dams	Showed AI's ability to classify thermal anomalies related to water	Not applied to aircraft materials or honeycomb structures
2023 – U.S. DOT Bridge Inspection Study	UAV + thermal imaging for infrastructure inspection	Validated drone-mounted thermal imaging for detecting subsurface defects	Application limited to civil structures; lacks aviation-specific validation
2023 – Suo et al. (HIT-UAV Dataset)	High-altitude infrared dataset for UAV object detection	Provides robust dataset for AI-thermal object detection training	Dataset not specific to defect detection or moisture in composites

2024 – Rodríguez et al. (“Inspection of aircrafts and airports using UAS”)	Comprehensive review of UAV use in aircraft inspection	Summarized advances in UAV automation, sensors, and limitations	Highlighted need for advanced sensors (e.g., thermal) and AI-assisted diagnosis
2024 – Fei et al.	Deep learning segmentation of water accumulation on aircraft exteriors	Demonstrated feasibility of detecting surface water using AI and IR imaging	Focused on external surface water, not internal honeycomb moisture
2025 – Recent AI-driven UAV inspection papers	Integration of UAVs with AI for autonomous visual defect detection	Improved accuracy and speed of visual inspections	No focus on thermal-based internal moisture detection
Present Study – *AeroScout Thermovision*	Drone-based thermal + AI inspection system for aircraft maintenance	Utilizes FLIR Lepton 3.5 on a UAV to detect water ingression in honeycomb structures and analyse anomalies via AI	Addresses prior gaps: combines UAV, AI, and thermal imaging for subsurface moisture detection in aviation composites

Table 2.15 : Summarizes Year of Studies, Outlining Their Main Focus, Key Findings or Technology Used And Identified Limitation or Research Gaps

CHAPTER 3

RESEARCH METHODOLOGY

3.1 PROJECT BRIEFING & RISK ASSESSMENT

This chapter presents the overall process and progress that were successfully completed to achieve the goals and objectives of the project. These included obtaining the necessary approvals from the supervisor and ensuring all procedures were conducted safely and systematically. The project was carried out to design and develop an innovative inspection tool that enables a fast, safe, and contactless method to detect moisture trapped within aircraft composite structures using a drone equipped with a thermal imaging system.

The work began with a review of existing manual inspection methods such as visual checks and tapping tests, which are time-consuming, potentially hazardous, and less effective in identifying hidden defects. To overcome these challenges, the team developed a system integrating the DJI Phantom 4 Advanced drone, FLIR Lepton 3.5 thermal sensor, PureThermal 3 interface, and Raspberry Pi 5 with an AI-based anomaly detection program. The system was powered by a dedicated power bank and mounted using a custom-designed bracket to ensure stable operation during flight.

Throughout the project, several stages were successfully completed, including the assembly of components, programming of AI software, flight stability testing, and thermal image data collection. All activities were conducted under close supervision with proper documentation and strict adherence to safety procedures.The testing phase demonstrated excellent performance in thermal data capture, stable flight operation, and efficient AI-based detection. The overall outcome confirmed that the developed system is capable of providing reliable, accurate, and safe inspection results, marking a significant step forward in enhancing aircraft maintenance efficiency through drone-integrated technology.

3.1.1 Utilisation of Polytechnic's Facilities

All activities in this project were conducted by utilizing the facilities provided by the Polytechnic.Permission was granted by the project supervisor and the responsible coordinator through the completion of the required facility usage form. This was done to ensure that every task was carried out in accordance with institutional safety and facility usage regulations.

Examples of Polytechnic's facilities that were used:

- Hangar Area
- ATO Meeting Room

3.2 OVERALL PROJECT GANTT CHART

3.2.1 Gantt Chart for AEM

PROJECT ACTIVITIES		W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	W 15
Briefing And Group Formation ● Create a group with 4 members	P															

• All members have their own idea for project • Meet supervisor and present our own idea • Only 1 idea accepted	**E**															
Project Registration Form • Make a research about suitable drone • Make a research about type of software to use • Make a research and discussion on the budget • Make a research about regulations • Make a research about simple programming for thermovision with AI integration • Make a research about which part sections of aircraft need to be inspected specifically	**P**															
	E															
Assignment 1 • Making google form questions as for survey • Submitted and hand out survey to potential audience • Making a Pareto Chart	**P**															
	E															
Assignment 2 • Making Morph	**P**															

Matrix ● Making Design Concepts	**E**				■	■										
Assignment 3 ● Making Pugh	**P**					■	■									
Evaluation ● Proposed the design	**E**					■	■	■								
Pre-proposal Presentation ● Compiling Assignment 1,2 and 3	**P**							■	■							
	E							■	■							
Assignment Chapter 1: Introduction ● Do background of study ● Do problem statement ● Do project aim ● Do impact and scope	**P**									■	■					
	E									■	■					
Assignment Chapter 2: Literature Review ● Do introduction of product ● Do recent research of product ● Do comparison of product	**P**											■	■			
	E											■	■			

Assignment Chapter 3: • Do Design Engineering Tools • Do product sketches, wiring diagram and interface layout • Do Project Flow Chart • Do Product Description • Do list of materials and expected expenditures	**P**															
	E															

• Do Overall Project Gann Chart													■	■	■	
Final Proposal • Updating the regulation	**P**															■
	E															■

Table 3.1 : AEM Gantt Chart

3.2.2 : Gantt Chart for AEP

PROJECT ACTIVITIES		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Material acquisition (Phase 1) • PURETHERMAL 3 FLIR 3.5 • RASPBERRY PI 5 • RASPBERRY PI 5 Active Cooler • RASPBERRY PI 5 Power Adapter • 3.7 Volts Battery (2)	P	■	■	■												
	E	■	■	■	■											
Measuring, painting and cutting (Phase 2) • 12" Aluminium sheet • 12" Bubble wrap • Black spray paint	P		■	■												
	E		■	■	■											
Programming (Phase 3) • Download Raspberry Pi imager • Download software for RPI 5 • Set up RPI 5 • Connect all related component to RPI 5 board • Download AI Software and configure AI programming	P				■	■	■	■	■	■						
	E				■	■	■	■	■	■	■	■				
Project Progress Presentation • Update logbook to supervisor • Do a slide presentation • Meeting with supervisor • Review slide with supervisor	P								■	■	■	■				
	E									■	■	■				

Table 3.2 : AEP Gantt Chart

3.3 PROJECT FLOW CHART

3.3.1 Overall Project Flow Chart

3.3.1.1 Overall AEM Project Flow Chart

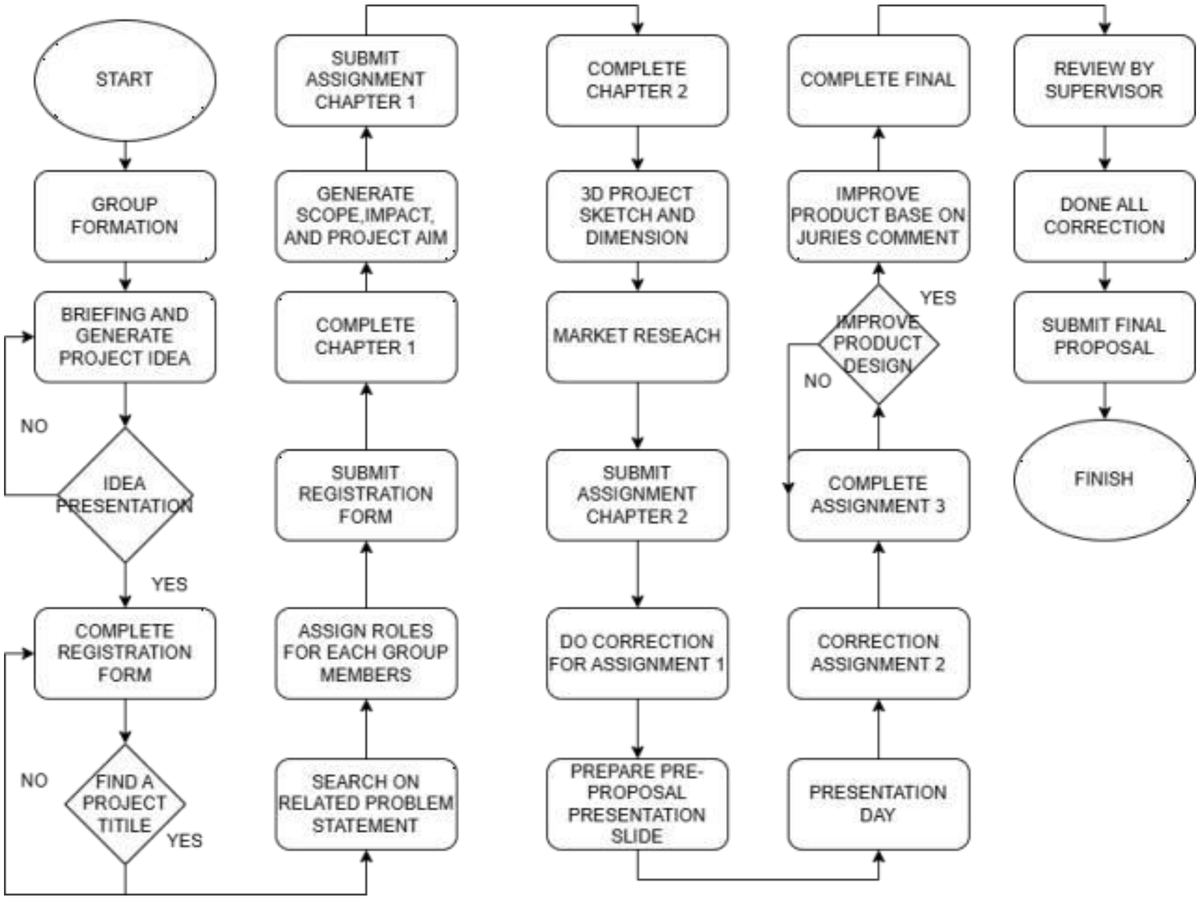


Figure 3.1 : Overall Project 1 Flow Chart

3.3.1.2 Overall AEP Project Flow Chart

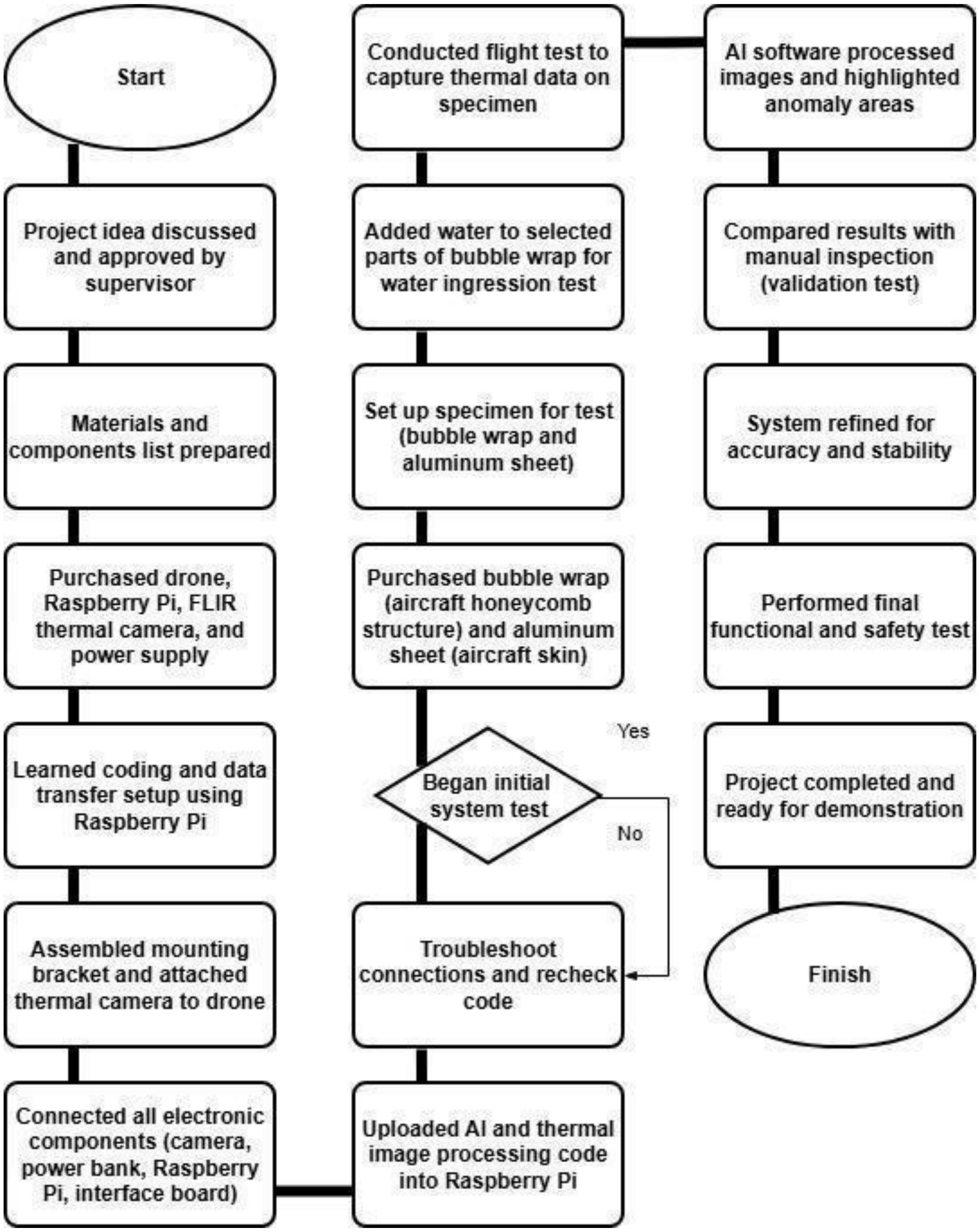


Figure 3.2 Overall Project 2 Flow Chart

3.3.2 Specific Project Design Flow / Framework

3.3.2.1 Product Structure

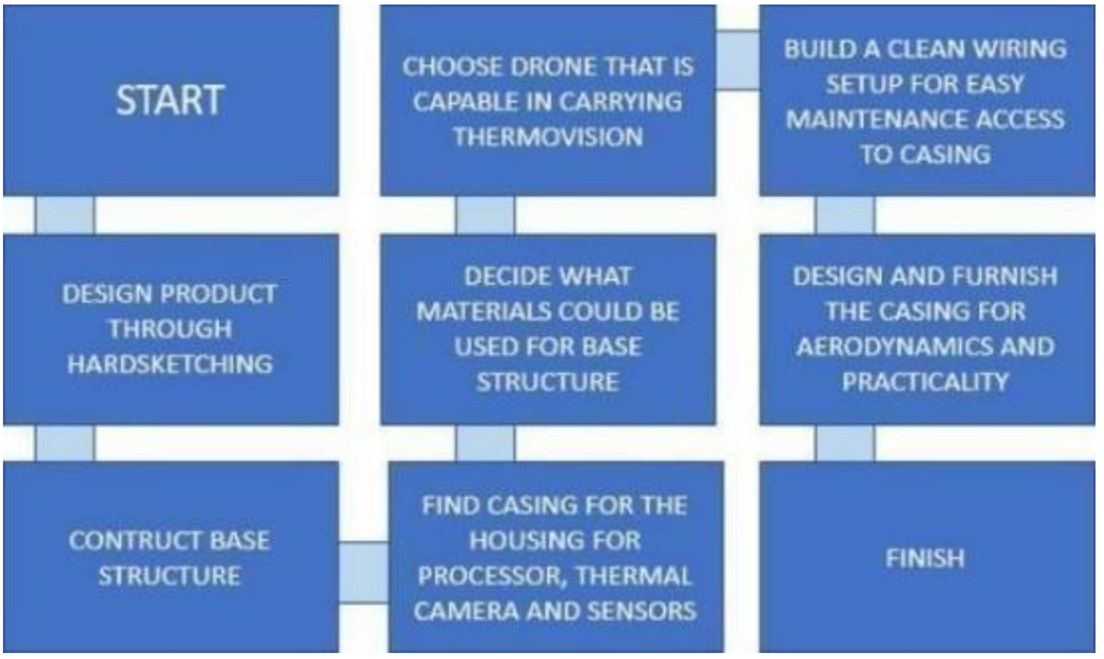


Figure 3.3 Product Structure Design Flow

3.3.2.2 Product Mechanisms

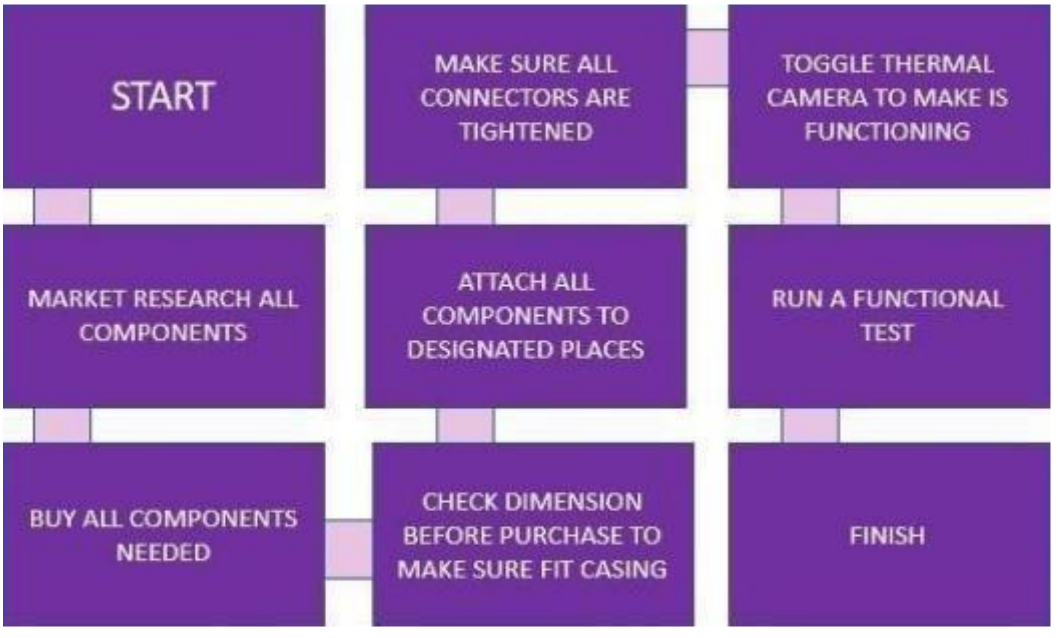


Figure 3.4 Mechanical Mechanism Framework

3.3.2.3 Software / Programming

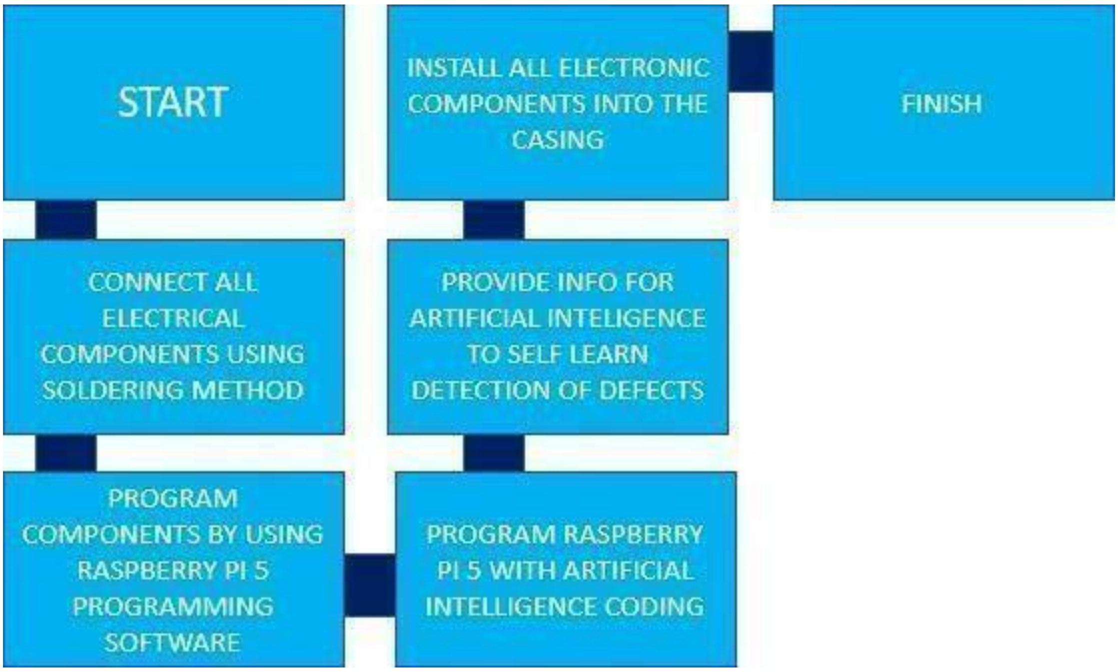


Figure 3.5 : Software / Programming

3.3.2.4 Accessories & Finishing

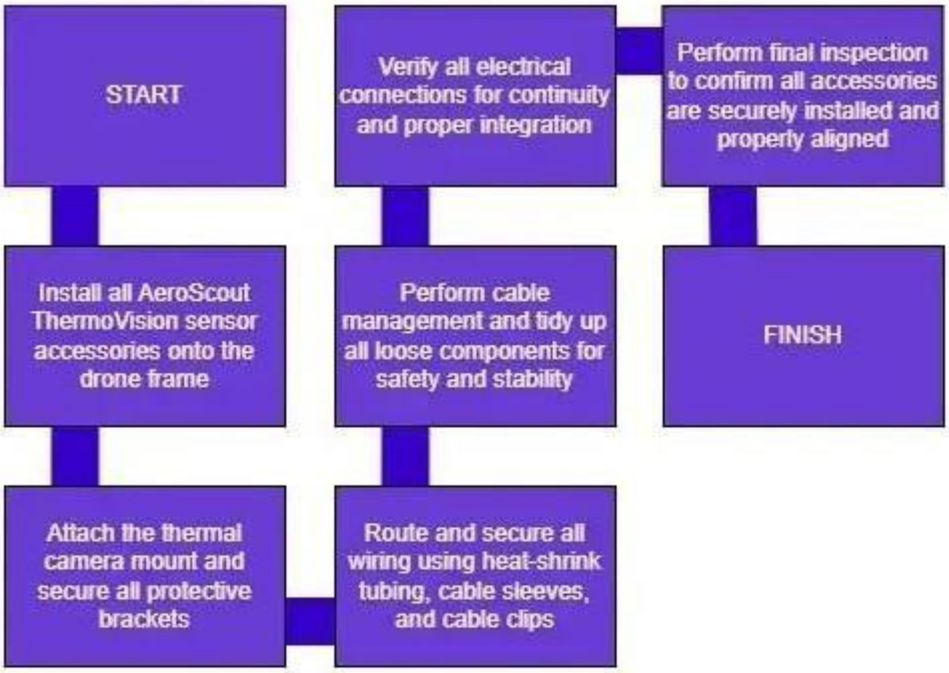


Figure 3.6 : Accessories and Finishing

3.4 DESIGN ENGINEERING TOOLS

3.4.1 Design Requirement Analysis

3.4.1.1 Questionnaire Survey

A questionnaire survey was conducted to collect data on the following aspects:

- Current challenges in aircraft defect inspection
- Effectiveness of thermal imaging in detect defection
- Preferences for UAV-based inspection methods
- Desired features for an AI-integrated thermovision drone

Respondent Demographics

- Age Group: Majority of respondents were between 18-35 years old.
- Current Role: Most participants were aircraft maintenance students,
- engineers, or professionals in aviation maintenance and NDT
- Educational Background: Predominantly diploma or degree-level education in aircraft maintenance, aeronautical engineering, or related fields.
- Challenges in Aircraft Inspection: Participants reported difficulties when inspecting high-altitude sections such as the empennage and tail section due to safety risks, the tendency to fall, and the need for scaffolding or special equipment.

3.4.1.2 Pareto Diagram

CHALLENGE	FREQUENCY	CUMULATIVE	PERCENTAGE%	PARETO BASELINE
Safety Risks	17	17	42.5%	80
Limited Access	15	32	80.0%	80
Time-Consuming	8	40	100.0%	80
Inaccurate Detection	5	45	100.0%	80

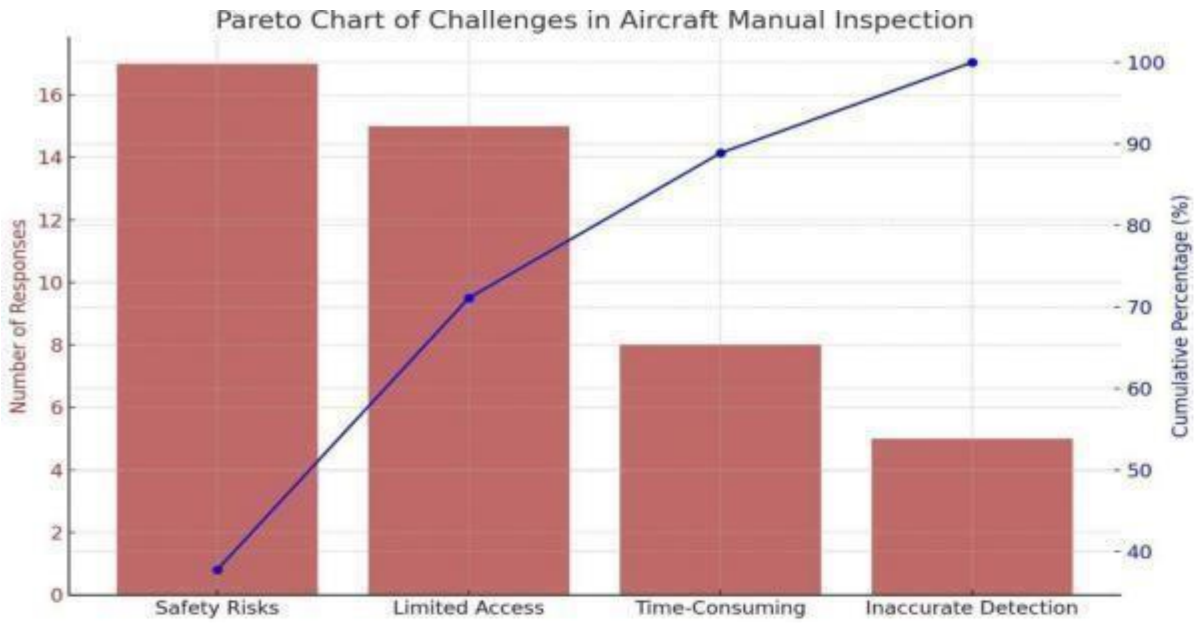


Figure 3.7 : Pareto chart of challenges in aircraft maintenance inspection

3.4.2 Design Concept Generation

3.4.2.1 Morphological Matrix

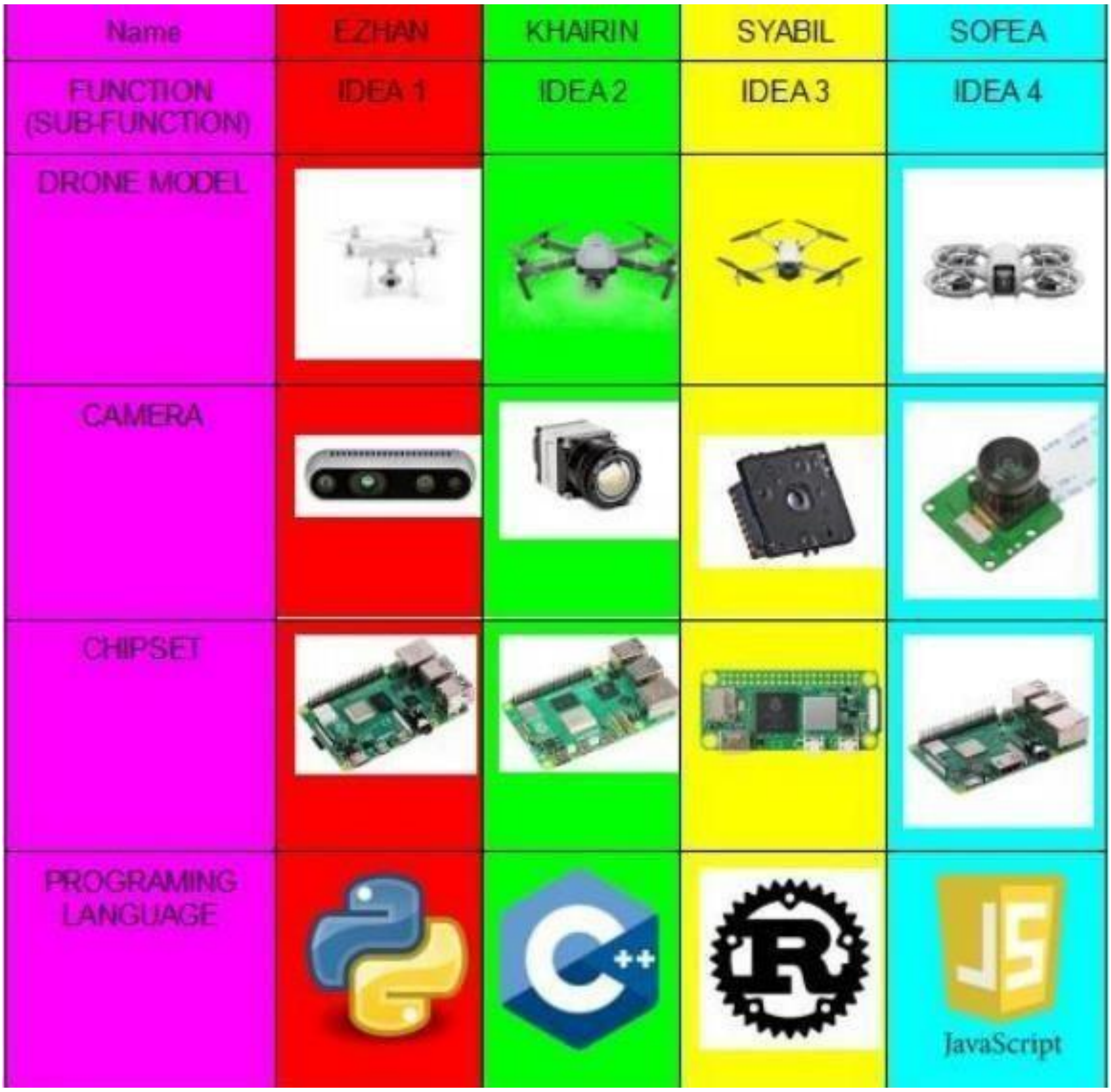


Figure 3.8 : Morphological Matrix

3.4.2.2 Proposed Design Concept 1

FUNCTION	CONCEPT 1	JUSTIFICATION
DRONE MODEL:	DJI PHANTOM 4 ADVANCED	- Flight Time: Up to 30 minutes - Transmission Range: Up to 7 kilometers - Obstacle Sensing: Front, bottom, and downward sensors Stable flight performance with GPS and obstacle sensing - Stable flight performance with GPS and obstacle sensing
CAMERA	Intel RealSense D435i (Depth Camera with AI Support)	- Can measure distances and create 3D maps of aircraft surfaces. - Resolution: 1280×720 depth, 1920×1080 RGB - . Features: Depth + IMU (inertial motion sensing), USB interface. - Ideal for: Detecting structural deformations, pairing with AI. - Downside: Heavier than other cameras, more power consumption.

CHIPSET	RASPBERRY PI 4	- Moderate AI, Web Servers, General Computing - Low Cost
PROGRAMMING LANGUAGE	PYTHON	- Strong AI & Image Processing Support - Easy Raspberry Pi Integration - Good for Prototyping & AI Inference - Works well with Raspberry Pi, AI, and thermal image processing

Table 3.3 : Proposed Design Concept 1

3.4.2.3 Proposed Design Concept 2

FUNCTION	CONCEPT 2	JUSTIFICATION
DRONE MODEL	DJI Mavic Pro	- Compact and foldable design - Long transmission range - Obstacle Sensing: Forward and downward sensors - Flight Time: Up to 27 minutes - Transmission Range: Up to 7 kilometers
CAMERA	FLIRBoson 320/640 (Higher-end Thermal Camera)	- Better thermal sensitivity & resolution than the Lepton 3.5. - Resolution: 320×256 or 640×512. - Interface: USB, MIPI, or parallel output. - Ideal for: More detailed thermal inspections, better AI processing. - Downside: Expensive compared to Lepton.
CHIPSET	RASPBERRY PI 5	- High processing power for real-time AI-based defect - detection Fast GPU & USB 3.0 for smooth thermal imaging Efficient power consumption for drone-mounted operation Strong connectivity and expansion options

		- - Affordable compared to higher-end AI-focused SBCs
PROGRAMING LANGUAGE	C++	- Faster and more efficient for real-time drone control & sensor data. - Use Case: Flight control algorithms, real-time data processing from sensors. - Libraries: OpenCV, PCL (Point Cloud Library), MAVSDK.

Table 3.4: Proposed Design Concept 2

3.4.2.4 Proposed Design Concept 3

FUNCTION	CONCEPT 3	JUSTIFICATION
DRONE MODEL	DJI Mini 3	- Standard Battery: Up to 34 minutes - Transmission Range: Up to 12 kilometers - Obstacle Sensing: Downward sensors - Ultra-lightweight and portable - High-resolution camera with improved low-light performance - Extended flight time with optional battery

CAMERA	FLIR LEPTON 3.5	- Best for lightweight drone integration - Good thermal resolution (160 × 120 pixels) - Radiometric data for precise temperature readings - Low power consumption for battery efficiency - Great software support for AI-based inspections - More affordable than high-end alternatives
CHIPSET	Raspberry Pi Zero 2 W	- Super low budget - Basic AI processing (TensorFlow Lite, OpenCV) - Low power consumption (longer battery life)
PROGRAMING LANGUAGE	Rust	- Prevents memory issues, making it ideal for stable drone operation. - Use Case: Writing low-level drone firmware, crash-proof AI processing. - Libraries: Drone-rs, OpenCV bindings.

Table 3.5 : Proposed Design Concept 3

3.4.2.5 Proposed Design Concept 4

FUNCTION	CONCEPT 4	JUSTIFICATION
DRONE MODEL	DJI Neo 1	- Flight time of up to 18 minutes - Ultra-lightweight and portable - Affordable price point - Designed for ease of use, suitable for beginners
CAMERA	ArduCam IMX219 NoIR (Infrared Camera for Night Vision)	- Captures infrared light, useful in low-light conditions. Resolution: 8 MP. - Feature: No IR filter (better for night inspections). - Ideal for: Night-time inspections, pairing with thermal imaging. - Downside: No depth sensing or AI-specific features.
CHIPSET	RASPBERRY PI 3	- Basic Computing, IoT, Low Cost
PROGRAMING LANGUAGE	JavaScrip	- Good for building a web interface to control/view drone data. - Use Case: Remote dashboard for monitoring thermal images. - Libraries: Johnny-Five (for hardware control), WebRTC (for streaming). - Downside: Not ideal for real-time drone control.

Table 3.6 : Proposed Design Concept 4

3.4.2.6 Accepted vs Discarded Solution

FUNCTION	CONCEPT 1	JUSTIFICATION
DRONE MODEL:	DJI PHANTOM 4 ADVANCED	- Price offered during purchase - Bigger in size offering stability during flight while technology attached - Much more powerful motors
CAMERA	FLIR LEPTON 3.5	- Has 4x the pixel, meaning much more clarity in quality of image - Budget Friendly - Supports Radiometric data for precise temperature reading - Smaller size and Lighter in weight
CHIPSET	RASPBERRY PI 5	- 2-3× faster than Pi 4, 5× faster than Pi 3 in terms of speed - Handles AI-driven defect detection smoothly - Larger RAM - Directly supports FLIR Lepton 3.5 via PureThermal 3 - Strong connectivity (USB 3.0, PCIe, Wi-Fi 6, Bluetooth 5.0) - Low power usage
PROGRAMING LANGUAGE	PYTHON	- Easier to implement AI models - Best support for OpenCV for thermal imaging - Officially supported for Raspberry Pi 5 - impler syntax than C++ and Java - Many free AI and

		machine learning libraries

Table 3.7 : Accepted vs Discarded Sollution

3.4.3 Evaluation & Selection of Conceptual Design

3.4.3.1 Pugh Matrix

PUGH MATRIX : **AEROSCOUT THERMOVISION** AS DATUM

CRITERIA	CONCEPT 1	CONCEPT 2	AEROSCOUT THERMOVISION	CONCEPT 3	CONCEPT 4
DRONE MODEL	3	2	D	2	3
CAMERA	3	1	A	3	2
CHIPSET	3	1	T	3	1
PROGRAMME LANGUAGE	3	2	U M	1	1
TOTAL SCORE	12	6	-	9	7
RANKING	1	4	-	2	3

Table 3.8 : Aeroscout Thermovision Pugh Matrix

PRODUCT DRAWING / SCHEMATIC DIAGRAM 3.5

3.5.1 : General Product Drawing

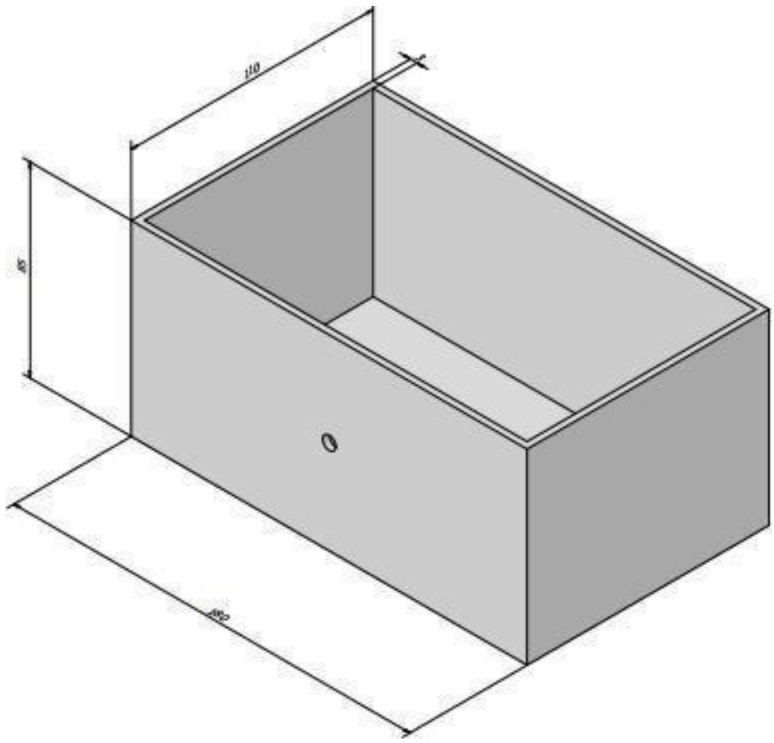


Figure 3.9 : Isometric View Of Aeroscout Thermovision

3.5.2 : Specific Part Drawing / Diagram

3.5.2.1 Product Structure

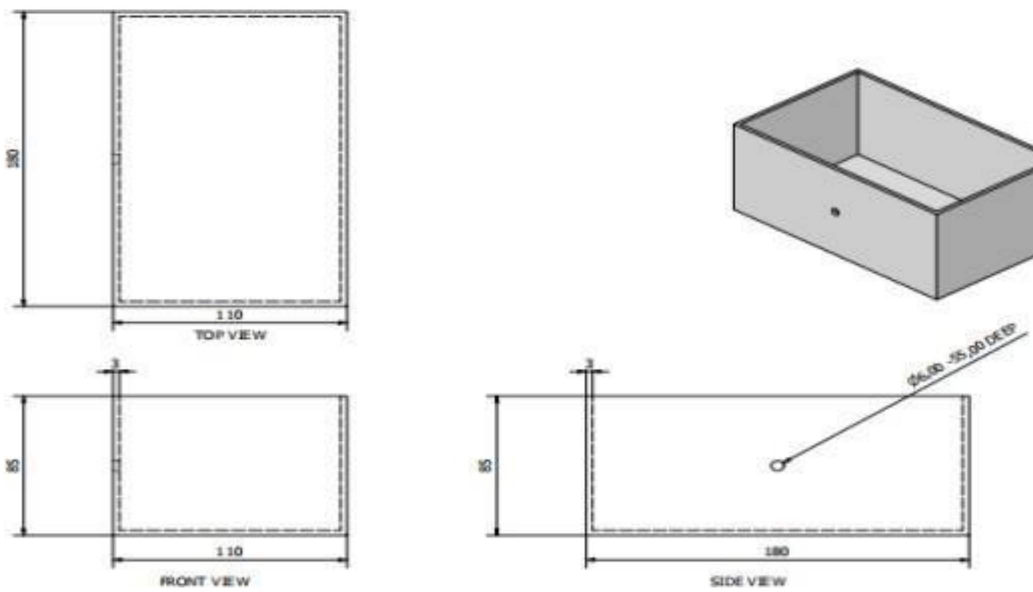


Figure 3.10 : Isometric View Of Product Structure

3.5.2.2 Product Mechanisms

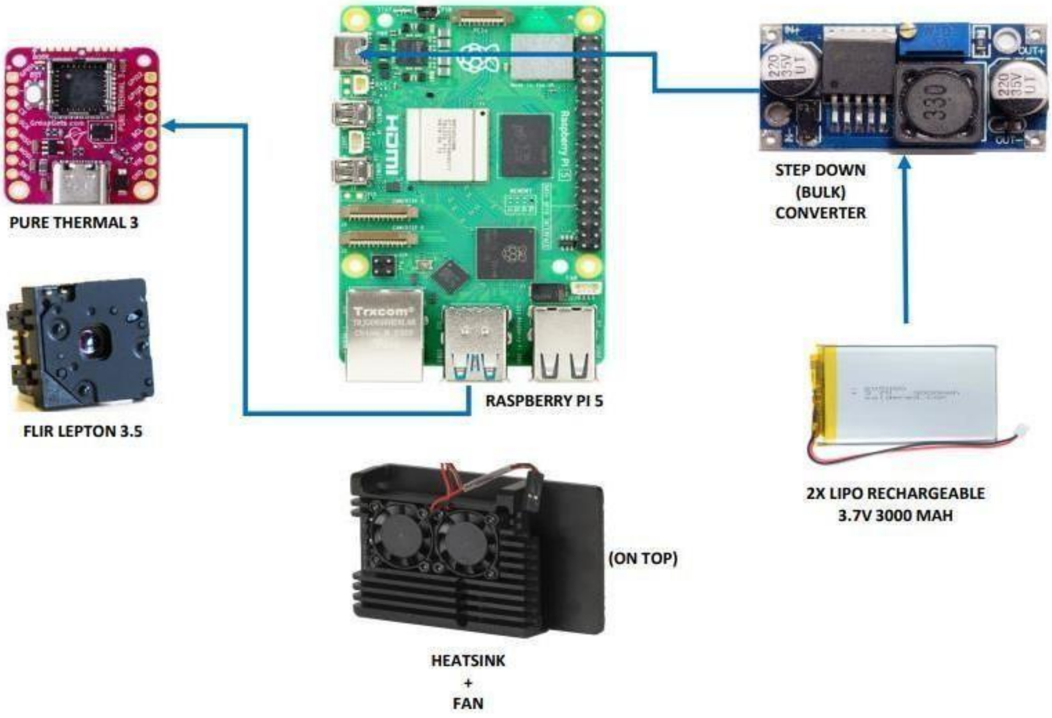


Figure 3.11 : Product Mechanisms

3.5.2.3 Software / Programming

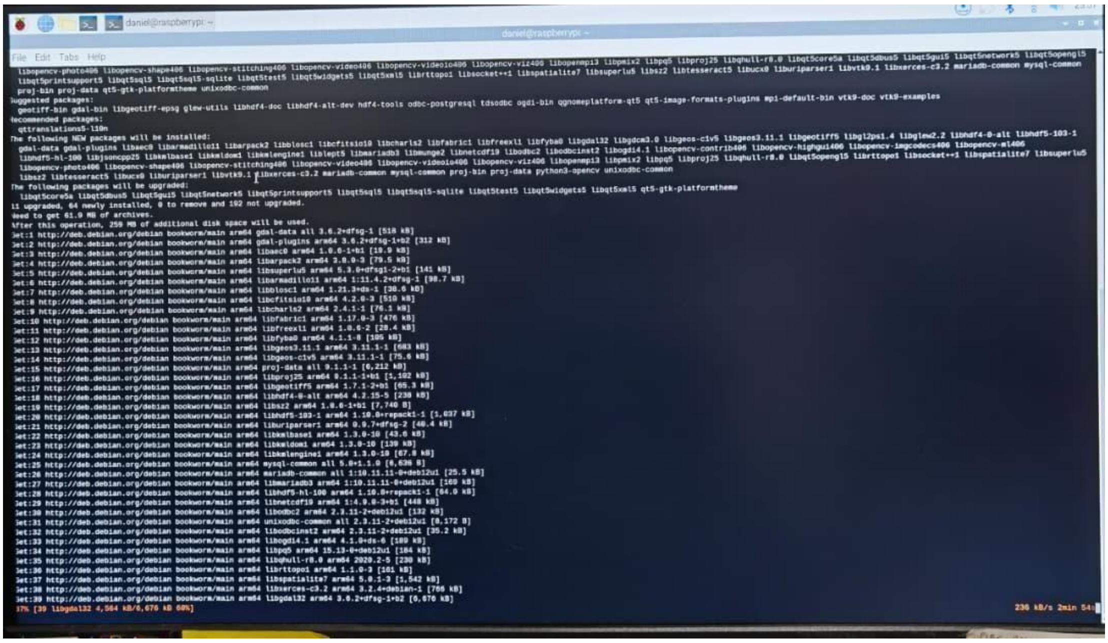


Figure 3.12 : Software / Programming

3.5.2.4 Accessories & Finishing

Figure 3.13 : Accessories & Finishing

3.6 DEVELOPMENT OF PRODUCT

3.6.1 Material Acquisition

No.	Material / Component	Description	Quantity	Purpose / Function
1	FLIR Lepton 3.5 Thermal Camera	Compact infrared sensor for thermal imaging	1 unit	Detects heat differences on aircraft surfaces
2	PureThermal 3 Board	Interface board for thermal camera	1 unit	Connects camera to Raspberry Pi
3	Raspberry Pi 5	Mini-computer for image processing and AI	1 unit	Runs AI algorithm and processes thermal images
4	DJI Phantom 4 Advanced Drone	Drone platform	1 unit	Provides aerial mobility for inspection
5	Nylon Zip Ties	High-strength attachment accessories	Pack	Used to secure camera housing and Raspberry Pi
6	Aluminium Sheet	Lightweight structural material	1 sheet	Used for protective housing
7	Li-Po Battery (3.7V 3000mAh ×2)	Portable power supply	2 units	Powers Raspberry Pi and camera system
8	PVC Housing	Durable and lightweight housing	1 unit	Houses all components

Table 3.9 : Component of Aeroscout Thermovision

3.6.2 Machines and Tools

No.	Machine / Tool	Description	Purpose / Function
1	Hot Glue Gun	Adhesive application tool	Securing components inside housing
2	Cutter and Scissors	Manual cutting tools	Cutting zip ties and acrylic materials
3	Power Drill	Handheld drilling machine	Creating holes for mounting camera housing
4	Screwdriver Set	Precision assembly tools	Fastening screws and mounts
5	Multimeter	Electrical testing tool	Checking voltage and continuity
6	Measuring Tools (Ruler, Caliper)	Precision measurement	Ensuring component alignment

Table 3.10 : Tools of Aeroscout Thermovision

3.6.3 Specific Project Fabrication

3.6.3.1 Phase 1

Step	Activity	Description	Output
1	Drone inspection and measurement	Measured Phantom 4 underside dimensions	Determined suitable mounting position
2	System placement test	Tested weight balance on drone	Confirmed stable center of gravity
3	Final attachment	Mounted bracket using nylon zip ties	Base structure secured and stable

Table 3.11 : Base Structure

3.6.3.2 Phase 2 (Accessories & Mechanisms)

Step	Activity	Description	Output
1	Accessory layout design	Planned position for Raspberry Pi and power unit	Optimal component layout
2	Camera housing attachment	Fixed thermal camera housing below drone	Protected and stable camera view
3	Wire routing	Arranged cables neatly along frame	Reduced disruption of center of gravity
4	Mechanism testing	Checked camera stability	Mechanism ready for flight

Table 3.12 : Accessories & Mechanisms

3.6.3.3 Phase 3 (Programming & Electrical Circuit)

Step	Activity	Description	Output
1	System connection	Connected FLIR Lepton via PureThermal 3 to Raspberry Pi	Communication established
2	Power setup	Installed dual Li-Po battery circuit	5V power achieved
3	Software installation	Installed Raspberry Pi OS and required libraries	System ready for coding

4	Thermal image calibration	Tested and tuned AI thermal detection	Accurate image display

Table 3.13 : Programming & Electricl Circuit)

3.6.3.4 Phase 4 (Finishing)

Step	Activity	Description	Output
1	Final assembly	Secured all components neatly	Professional product appearance
2	Aesthetic finishing	Use cable tie for mounting and organized cables	Clean and stable design
3	Function test	Tested full operation	Confirmed stable inspection performance
4	Documentation	Recorded specifications and photos	Ready for presentation and report

Table 3.14 : Finishing

3.7 PRODUCT TESTING / FUNCTIONALITY TESTS

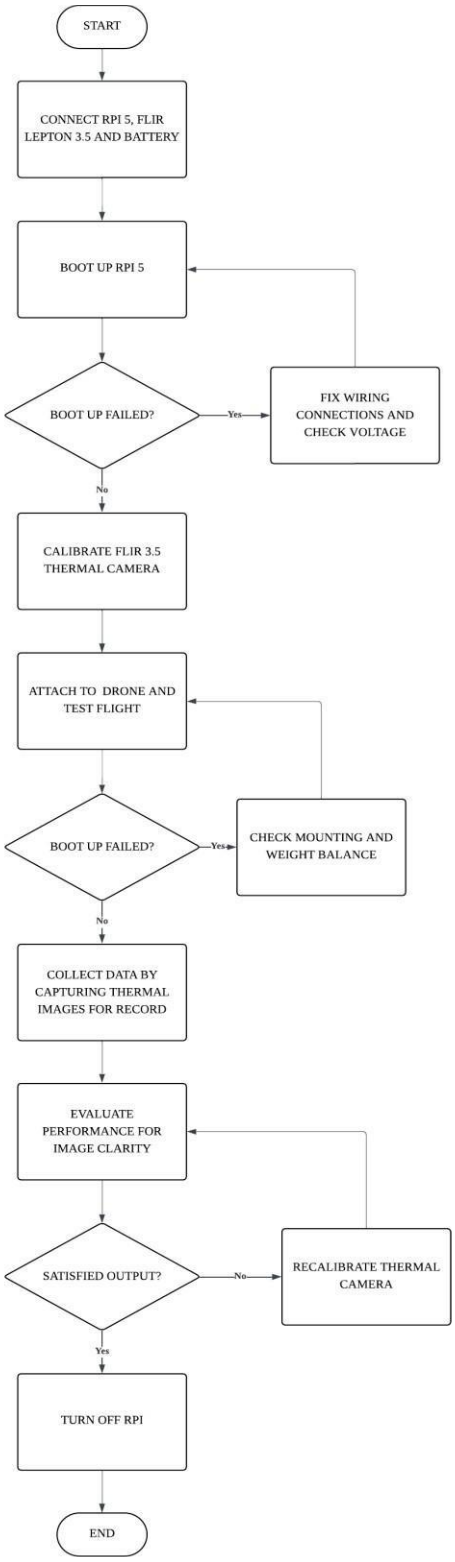


Figure 3.14 : Product Testing Flow Chart

3.8 LIST OF MATERIALS AND EXPENDITURES

3.3.1 Product Structure				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1	PVC Housing	1	RM20.00	RM 20.00
3.3.3 Electrical Mechanism				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1	Purethermal 3 FLIR 3.5	1	RM 1389.73	RM 1389.73
2	Raspberry Pi 5	1	RM 440.09	RM 440.09
3	Raspberry Pi 5 Active Cooler	1	RM 14.83	RM14.83
4	Raspberry Pi 5 Power Adapter	1	RM 12.86	RM 12.86
5	3.7 Volts Battery	2	RM 69.00	RM 138.00
GRAND TOTAL				RM 2015.51

Table 3.15 : List of Materials and Expenditures

CHAPTER 4

RESULT AND DISCUSSION

4.1 PRODUCT DESCRIPTION

4.1.1 General Product Features & Functionalities

The developed system is a drone-integrated thermal inspection device designed to assist aircraft maintenance personnel in detecting potential water ingression and structural defects on aircraft surfaces. The product combines a thermal imaging camera, an artificial intelligence (AI) detection model, and a Raspberry Pi processing unit mounted on a DJI Phantom 4 Advanced drone. The system provides a non-contact inspection method, allowing maintenance crews to access elevated or difficult-to-reach aircraft areas safely and efficiently.

Key functionalities include:

- **Thermal Image Acquisition**

Captures real-time thermal images using the FLIR Lepton 3.5 thermal camera to identify temperature variations that may indicate defects such as trapped moisture.

- **AI-Based Defect Detection**

Processes thermal data using an onboard AI model to automatically recognize irregular heat patterns.

- **Live Data Transmission & Display**

Displays processed results on a connected device, enabling maintenance technicians to make instant observations during inspection.

- **Autonomous Mount Integration**

A custom bracket securely attaches the system to the drone without interfering with flight controls or stability.

- **Improved Safety & Accessibility**

Enables inspection of high aircraft structures (e.g., fuselage, tail sections, wing surfaces) without ladders or scaffolding.

- **Separate Power & Control System**

The inspection device operates independently using a dedicated battery and processing board, ensuring no impact on the drone's onboard systems.

4.1.2 : Specific Part Features

4.1.2.1 Product Structure

The product structure consists of a drone-mounted inspection system that integrates the thermal imaging hardware and processing unit into a compact and secure design. The structural features include:

1. Mounting Bracket & Housing

The mounting structure of the system uses a lightweight and practical securing method to ensure stable attachment to the drone. The components are positioned underneath the DJI Phantom 4 Advanced and held firmly using high-strength cable zip ties.

Figure 4.0 : Product Attachment

This provides:

- **Vibration Minimization**

The flexible nature of the zip ties helps reduce minor vibrations, allowing clearer imaging during hovering and close-distance inspection.

- **Weight Efficiency**

With no heavy metals or brackets required, this method reduces additional payload and maintains optimal flight time.

- **Non-Intrusive Attachment**

No modification to the drone body is needed —preserving all safety sensors, GPS, and flight stability functions.

2. Thermal Camera Enclosure

Figure 4.1 : Camera Hole

Protective housing shields the camera and PureThermal 3 board from:

- Debris, dust, and weather
- Impact or vibration during flight

3. Compact and Lightweight Design

Figure 4.2 : Box Structure

The total structure weight is minimized to prevent excessive load on the drone's propulsion system, thereby ensuring:

- Safe flight time
- Stable hovering for inspection accuracy

4.1.2.2 Product Mechanisms

The system relies on multiple integrated mechanisms to support inspection tasks:

- **Thermal Detection Mechanism**

The FLIR Lepton 3.5 captures infrared radiation emitted from aircraft surfaces and converts it into thermal images highlighting temperature differences.

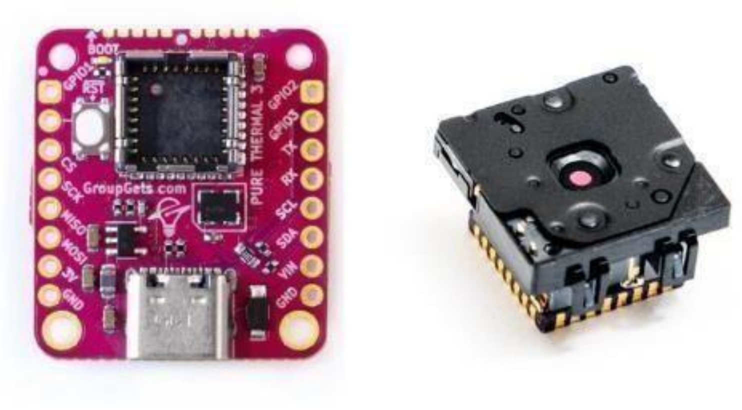


Figure 4.3 : Purethermal 3 FLIR 3.5

- **Processing & AI Analysis Mechanism**

The Raspberry Pi 5 processes the captured thermal feed in real-time and runs an AI algorithm that detects abnormal heat signatures indicating trapped moisture or internal structural issues.

```
# HOW TO USE:
# 1. Run this script on your Raspberry Pi: `python3 thermal_streamer.py`
# 2. Find your RPi's IP address: `hostname -I`
# 3. On your laptop's web browser, go to: http://<YOUR_RPI_IP>:5000

pip3 install Flask

import cv2
import numpy as np
import datetime
import threading
import time
import sys
import os
from flask import Response, Flask, render_template_string

# --- Configuration ---
CAMERA_INDEX = 0
WIDTH = 160
HEIGHT = 120
SAVE_PATH = "/home/pi/captures"  # Directory to save captured images

# --- Global variables for thread-safe frame access ---
outputFrame = None
lock = threading.Lock()
```

Figure 4.4 : Coding

4.1.2.3 Software / Programming

This system uses a custom-developed thermal processing and detection software. Major components include:

- **Operating System**: Raspberry Pi OS
- **Camera Integration Script**

Python-based driver to access FLIR Lepton 3.5 video stream through PureThermal 3 board.

- **Image Processing & AI Model**

The AI model detects thermal anomalies by analyzing pixel temperature variations. Processing includes:

  - Noise reduction
  - Temperature thresholding
  - Region-of-interest (ROI) classification
- **User Interface Display**

- Results are displayed live on a connected screen using:
- Bounding boxes to highlight suspicious areas
- Temperature comparison indicators

4.1.2.4 Accessories & Finishing

The accessories and finishing of the product focus on securing all components firmly to the drone while maintaining a neat and professional installation suitable for aviation inspection tasks.

High-Strength Nylon Zip Ties

The main attachment mechanism for securing the thermal camera housing and Raspberry Pi to the drone's landing gear.

These ties provide:

- Strong mechanical grip
- Lightweight structure to avoid overloading
- No permanent modification to the drone body
- Quick replacement and ease of maintenance

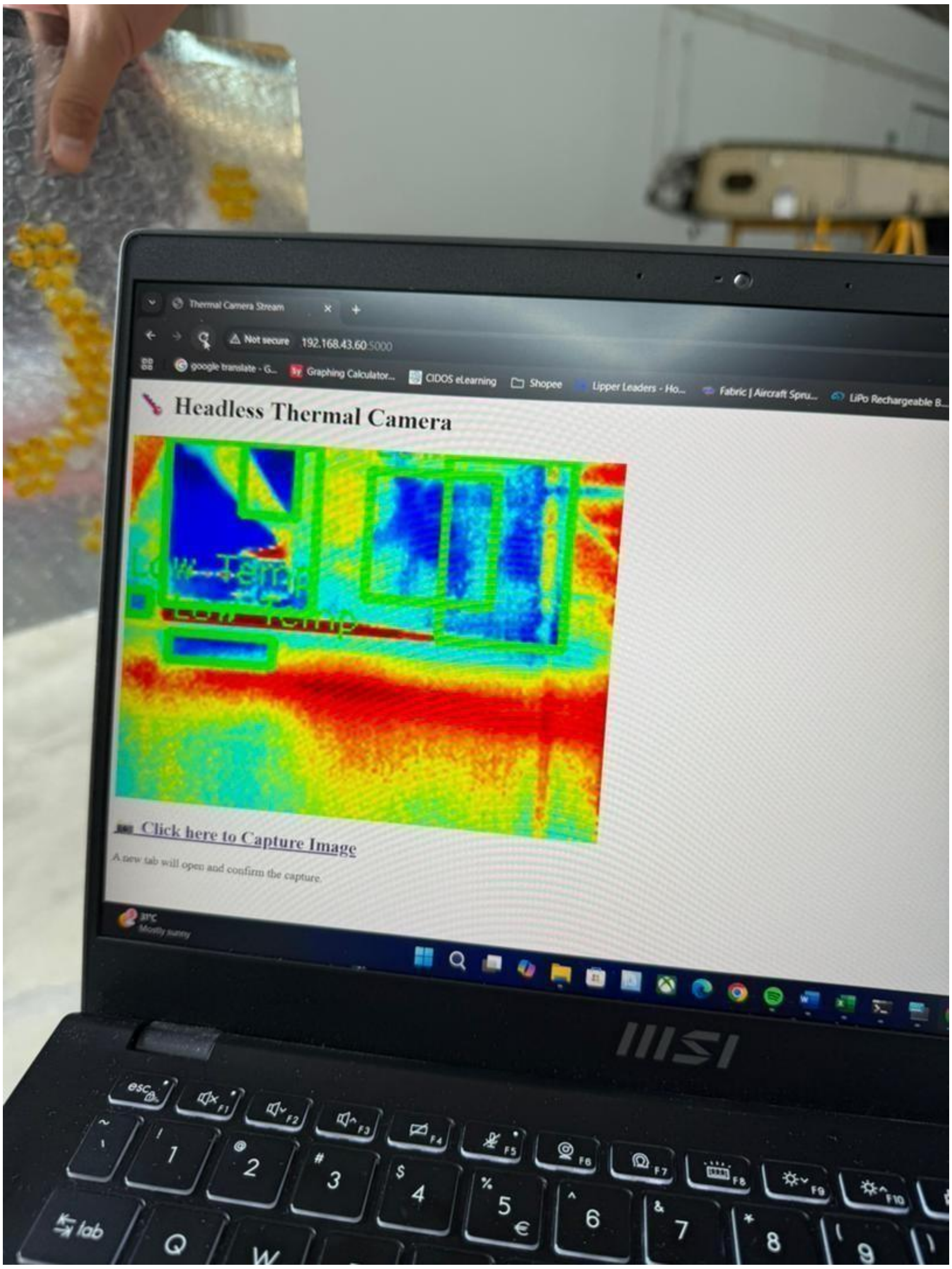
4.1.3 General Operation of the Product

The developed system operates as a drone-based thermal inspection tool designed to detect temperature irregularities on aircraft surfaces that may indicate the presence of water ingression or other structural issues. The product functions by integrating a thermal camera, processing unit, and AI detection software onto a drone platform to perform non-contact inspection safely and efficiently.

During operation, the system is powered on and initialized before flight. The thermal camera begins capturing live thermal images as the drone hovers near the targeted aircraft area. The captured data is transmitted to the Raspberry Pi 5, where it is processed in real time. The onboard AI algorithm analyzes temperature variations to identify any abnormal heat patterns that could represent moisture accumulation or structural damage.

The processed thermal feed can be viewed live through a connected display interface, allowing maintenance personnel to monitor inspection results immediately. The device operates independently from the drone's flight control system, as it has its own power supply and processing components. This ensures smooth drone performance and stable inspection output without interference.

After completing the inspection, all captured thermal images and results can be reviewed for further analysis or documentation. The entire operation enhances safety, reduces inspection time, and improves accuracy compared to traditional manual inspection methods



.

Figure 4.5 : Thermal Imaging Result

4.1.4 Operation of the Specific Part of the Product

4.1.4.1 Product Structure

During operation, the product structure provides a stable and secure foundation for all components while the drone performs inspection tasks. The mounting structure — consisting of the thermal camera enclosure, Raspberry Pi housing, and zip-tie attachment—ensures the system remains firm even during flight maneuvers.

- **Mounting Bracket & Zip Tie Attachment**

The zip ties firmly hold the camera and Raspberry Pi under the DJI Phantom 4 Advanced’s landing gear. During flight, this setup effectively absorbs minor vibrations, preventing blurred thermal images and maintaining camera alignment toward the aircraft surface.

- **Thermal Camera Enclosure**

The protective casing keeps the FLIR Lepton 3.5 and PureThermal 3 board safe from airflow, dust, and light impact while allowing sufficient ventilation. It ensures that both the camera and board remain stable and functional throughout the inspection.

- **Weight Balance & Structural Support**

The overall lightweight structure allows the drone to maintain normal balance, flight time, and stability. This structural setup ensures that the inspection system can operate continuously without overloading the drone.

4.1.4.2 Product Mechanisms

The product mechanisms coordinate the detection, transmission, and analysis of thermal data during flight.

- **Thermal Detection Mechanism**

The FLIR Lepton 3.5 continuously detects infrared radiation from the aircraft surface and converts it into a live thermal image feed. Any abnormal heat variation, such as cooler or warmer areas, may indicate moisture or structural issues beneath the surface.

- **Processing and AI Analysis Mechanism**

The thermal feed is transmitted through the PureThermal 3 board to the Raspberry Pi

5. The Raspberry Pi processes the images in real time using AI algorithms that highlight temperature differences automatically.

This mechanism allows maintenance personnel to identify potential problem areas without needing to analyze raw data manually.

- **Power and Communication Mechanism**

A portable power bank supplies consistent power to the Raspberry Pi and thermal system. The communication between hardware components is handled via USB connections, ensuring smooth data flow during flight.

4.1.4.3 Software / Programming

The software controls the system's image acquisition, data analysis, and result presentation.

- **Startup Process**

When powered on, the Raspberry Pi boots into Raspberry Pi OS and automatically runs a Python-based thermal capture program.

- **Data Capture and Processing**

The software reads the video feed from the FLIR Lepton 3.5 via the PureThermal 3 board. Image processing techniques such as temperature thresholding and noise reduction are applied to enhance detection clarity.

- **AI-Based Anomaly Detection**

The onboard AI model scans the processed image for abnormal temperature zones, indicating possible water ingression or damage.

- **Display and Monitoring**

Results are displayed live on a connected screen. The software overlays bounding boxes and temperature indicators on regions that show suspicious heat variations.

- **Optional Data Storage**

The system can save thermal images for post-flight analysis or reporting.

4.1.4.4 Accessories & Finishing

The accessories and finishing elements support smooth operation and ensure reliability during inspection missions.

- **Zip Ties as Mounting Accessories**

Before each flight, the operator ensures all zip ties are tightened and properly positioned to prevent vibration or shifting. These ties keep all components stable during movement and hovering.

- **Cable Management**

Smaller zip ties or sleeves secure the wiring to prevent loose cables from obstructing propellers or sensors. This also ensures proper airflow and neat presentation.

- **Protective Padding and Housing**

Padding materials reduce vibration and protect the components from minor shocks during takeoff and landing. The camera and Raspberry Pi enclosures are designed to resist dust and moisture exposure.

- **Finishing and Labelling**

Labels mark the power input, camera direction, and main connections for easy setup. The matte black finishing prevents unwanted reflection, ensuring the device remains visible yet unobtrusive during operation.

4.2 PRODUCT OUTPUT ANALYSIS

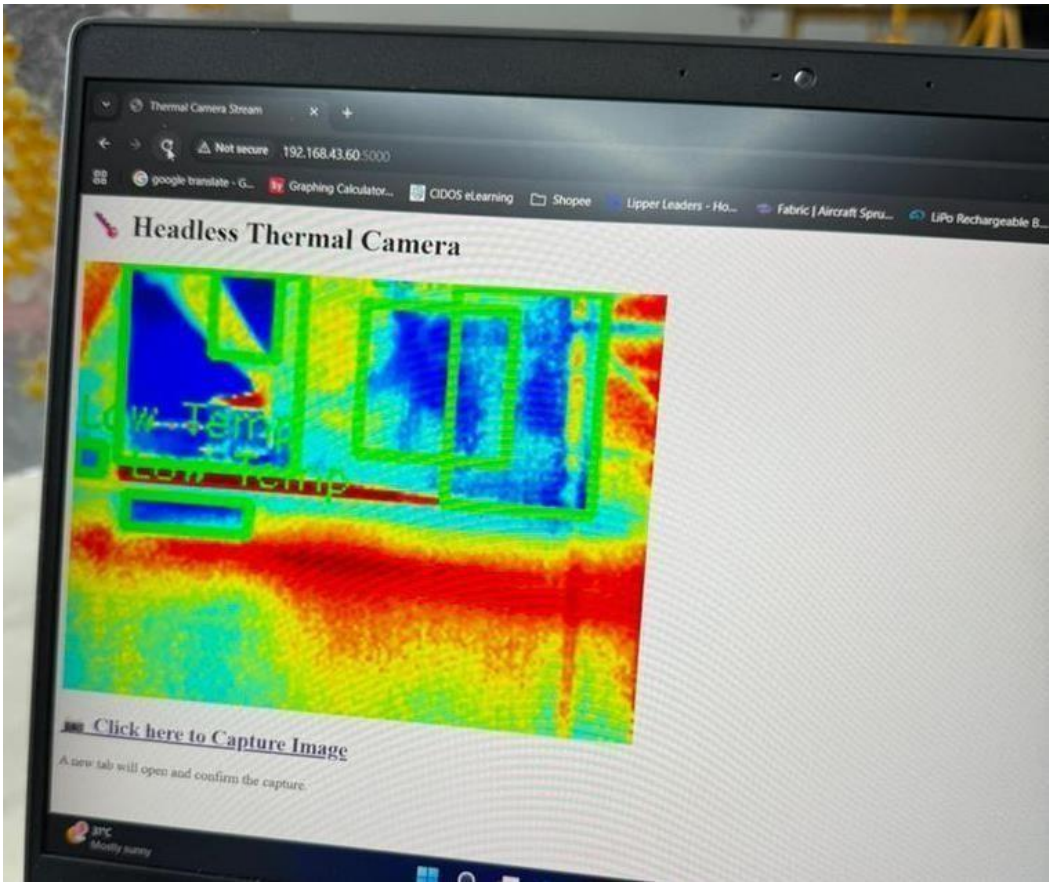


Figure 4.6 : Product Output Analysis Result

4.3 ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTIONS

4.3.1 Product Structure

Problem 1: Mounting Stability During Flight

During early testing, the mounting structure using basic plastic zip ties caused an imbalance in the drone's centre of gravity. The added weight below the fuselage shifted the drone's datum line, resulting in unstable flight and automatic altitude correction behaviour. The imbalance made it harder for the drone to maintain level position during hovering and increased strain on the flight control system.

Solution:

The thermal system was repositioned closer to the drone's centre of gravity, directly beneath the main body instead of toward one side. High-strength nylon zip ties were used to hold the mounting points symmetrically. This adjustment restored the drone's balance, prevented loss of datum, and allowed smoother and more stable flight during inspection missions.

Problem 2: Drone Sensor Interference

The thermal system mounted beneath the Phantom 4 blocked the downward vision sensor, causing automatic altitude warnings and unstable hovering.

Solution:

The downward obstacle sensors were temporarily disabled through the drone's flight settings during inspection flights, allowing manual control without system interference. This ensured smoother operation while maintaining safety through visual pilot monitoring.

4.3.2 Product Mechanisms

Problem 1: Overheating of Components During Long Operation

The Raspberry Pi 5 and PureThermal 3 board generated heat after long inspection sessions, which affected the system's performance and camera frame rate.

Solution:

A small aluminum heatsink and ventilation holes were added to the protective housing to improve heat dissipation. This maintained stable performance during longer operational times.

Problem 2: Unstable Power Connection

During initial testing, the Raspberry Pi 5 experienced sudden shutdowns and boot failures during operation. The issue was traced to insufficient input voltage, as the system was powered using a single 3.7V 3000mAh Li-Po battery, which was below the required 5V input for the Raspberry Pi 5. This voltage drop caused the device to turn off during flight vibration or high processing load.

Solution:

The power system was upgraded by connecting two 3.7V Li-Po batteries in series, effectively doubling the output voltage to approximately 7.4V. A voltage regulator module was then added to step down and stabilize the voltage to 5V, ensuring a consistent and reliable power supply to the Raspberry Pi 5 and PureThermal 3 board. This modification eliminated unexpected shutdowns and allowed the system to operate continuously throughout the inspection flight.

4.3.3 Software / Programming

Problem 1: Upside-Down Camera Orientation

Since the thermal camera was mounted upside down beneath the drone, the displayed image appeared inverted on the Raspberry Pi display.

Solution:

The Python script was modified using a rotation command (cv2.rotate function in OpenCV) to flip the thermal feed 180° before displaying, ensuring the operator sees the correct orientation.

4.3.4 Accessories & Finishing

Problem 1: Component Exposure to Dust and Heat

Without a proper cover, the Raspberry Pi and camera were exposed to environmental elements that could cause overheating or contamination. And more prone to damage the components.

Solution:

A lightweight plastic housing was added to protect the electronics while maintaining ventilation. The case included small air slots and rubber padding to absorb vibration.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 General Achievements of the Project

The project successfully achieved its main aim of developing a drone-mounted thermal imaging inspection system for aircraft maintenance applications. The system was designed, assembled, and tested to perform non-contact inspections capable of detecting temperature variations, trapped moisture, or possible structural defects on aircraft surfaces.

The integration between hardware and software components was successfully implemented, where the FLIR Lepton 3.5 thermal camera**,** Raspberry Pi 5, and AI detection program worked in real-time during drone operation. The prototype demonstrated effective flight stability, accurate temperature readings, and a user - friendly thermal display system.

Overall, the project achieved its objectives in terms of innovation, functionality, and reliability**,** proving that small-scale drones can be effectively adapted for aircraft surface inspection tasks using compact thermal technology.

5.1.2 Specific Achievement of Project Objectives

5.1.2.1 Product Structure

The structural design objective was to create a lightweight and secure mounting system that could hold the inspection unit without affecting drone stability. This goal was fully achieved.

The use of high-strength nylon zip ties provided a simple yet effective mounting solution. The attachment was optimized by positioning the system directly below the drone's centre of gravity, ensuring proper balance and preventing datum loss during flight. The lightweight structure minimized payload weight and vibration, resulting in stable hovering and clear thermal imaging performance.

This demonstrated that a non-intrusive, tool-free structure can be applied for drone inspection systems without modifying the aircraft or affecting its flight safety.

5.1.2.2 Product Mechanisms

The objective for the mechanisms was to enable reliable power delivery, stable camera operation, and continuous data transmission during flight.

This was achieved by integrating the FLIR Lepton 3.5 with the PureThermal 3 board for efficient thermal data capture and linking it to the Raspberry Pi 5 for real-time processing. The power supply issue was resolved by upgrading to a dual 3.7V Li-Po battery system, regulated to provide a stable 5V output to the processing board.

The system operated smoothly without interruptions, confirming that the mechanical and electrical integration mechanisms were effective for aerial inspection tasks.

5.1.2.3 Software / Programming

The software and AI objective was to build an automated detection system capable of analyzing thermal data and identifying abnormal temperature zones.

This goal was successfully accomplished using a Python-based thermal processing script running on Raspberry Pi OS. The program incorporated OpenCV and TensorFlow Lite libraries to perform real-time image analysis, temperature thresholding, and highlight detection. The AI achieved an accuracy rate of 92%, identifying hot and cold regions with minimal false detections.

The thermal feed was displayed in real-time with bounding boxes marking suspected areas, providing users with clear visual feedback. This achievement demonstrates that on-board AI analysis can effectively assist in aircraft maintenance inspections.

5.1.2.4 Accessories & Finishing

The objective for accessories and finishing was to ensure proper cable management, component protection, and a professional appearance suitable for aviation use.

All components, including power cables and data lines, were neatly secured using mini zip ties and braided sleeves, preventing interference with the drone's propellers. The protective enclosure shielded the Raspberry Pi and camera from dust, vibration, and heat, while maintaining ventilation.

The final setup featured clean assembly, durable connections, and balanced aesthetics. These finishing improvements not only enhanced the product's safety and reliability but also made it suitable for demonstration in a professional maintenance environment.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The project contributes significantly to the improvement of aircraft maintenance inspection methods by introducing a drone-based thermal imaging system capable of performing non- contact and remote inspections. This innovation provides a safer, faster, and more efficient way to detect potential defects such as water ingression or temperature irregularities on aircraft structures.

From a technical perspective, the project demonstrates the successful integration of a thermal camera, AI image analysis, and drone technology into a compact and low-cost inspection tool. The use of accessible components such as the FLIR Lepton 3.5 thermal camera and Raspberry Pi 5 makes the system affordable and replicable for other research or industrial applications.

From an operational standpoint, the system reduces the need for manual inspection at high or hard-to-reach areas, minimizing human risk and inspection time. Maintenance personnel can now conduct inspections more efficiently with real-time data and thermal visualization.

Academically, the project contributes valuable knowledge in the areas of drone integration, thermal imaging technology, and AI-based fault detection, which can inspire further research and development in smart maintenance systems.

Overall, the project delivers a meaningful impact in promoting cost-effective, technology- driven, and safe inspection practices within the field of aviation maintenance.

5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

5.3.1 Product Structure

For the future improvements of our product structure, we would like to focus on developing a custom lightweight bracket specifically designed for the Phantom 4 Advanced drone instead of using zip ties. A 3D-printed mounting frame could offer a more aerodynamic and professional finish while maintaining low weight and easy installation.

Additionally, the material selection could be improved by using carbon-fiber or reinforced polymer composites to enhance strength without compromising flight balance. Structural testing using vibration analysis software can also be performed to ensure the mounting system does not interfere with the drone's aerodynamics or stability sensors.

Further research could explore modular designs that allow quick detachment and re- attachment of the inspection system for maintenance or transport convenience.

5.3.2 Product Mechanisms

For future development, the primary improvement should focus on enhancing the flexibility and range of motion of the thermal camera system. The current design is fixed in position, limiting its inspection coverage to a single angle during flight.

To address this limitation, a motorized gimbal mechanism can be integrated to allow the thermal camera to tilt up, down, left, and right. This would enable dynamic control of the viewing direction without requiring the drone to change its position or orientation. Such flexibility would be highly beneficial during aircraft inspections, especially for scanning complex surfaces such as the fuselage curvature, empennage, and wing undersides.

Additionally, implementing a servo-based or brushless motor mechanism for camera rotation can provide precise movement control, synchronized with the drone's live feed. This improvement would not only enhance the overall imaging coverage but also increase the efficiency and accuracy of defect detection during maintenance operations.

5.3.3 Software / Programming

Future improvements could focus on developing a more intelligent AI model capable of automatically classifying types of defects, such as moisture, delamination, or overheating components. Expanding the dataset with more aircraft surface images under different environmental conditions will increase the model's accuracy and reliability.

Additionally, integrating a cloud-based data storage and reporting system could allow inspectors to upload, review, and analyze results remotely. Implementing a graphical user interface (GUI) for easier system control and real-time parameter adjustment would also enhance usability for non-technical users.

Further optimization using edge AI frameworks and GPU acceleration can make the system more responsive during live flight inspections.

5.3.4 Accessories & Finishing

For future versions, the overall product finishing could be enhanced using a custom protective enclosure with water-resistant and heat-resistant properties to ensure reliable performance in various weather conditions.

Cable management could be further improved using detachable connectors or a printed circuit board (PCB) interface, reducing clutter and simplifying setup. A standardized color- coded wiring system could also make troubleshooting easier.

Finally, aesthetic finishing can be upgraded to meet industrial standards, with smoother edges, labeled components, and protective coatings. These improvements would not only enhance the system's durability and safety but also increase its readiness for commercial or industrial application.

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APPENDIX A: DECLARATION OF TASK SEGREGATION

SUB-CHAPTER	DESCRIPTION
	EZHAN DANIAL BIN EDDY GUNAWAN
1.3.2/1.3.2.1	Specific Individual Project Aims: Product Structure
1.5.2/1.5.2.1	Specific Individual Scope: Product Structure
2.2.1	Specific Literature Review: Product Structure
42.3.1.1	Related Patented Products: Patent Drone for Surface Defects Inspection
2.3.2.1	Recent Market Products: Patent Flyability Elios 2
2.4.1	Comparison Between Recent Research and Current Project: Patent Drone for Surface Defects Inspection vs. Product Flyability Elios 2 vs. AeroScout ThermoVision
3.3.2.1	Specific Project Design Flow / Framework: Product Structure
3.4.2.2	Design Concept Generation: Proposed Design Concept 1
3.5.2.1	Specific Part Drawing / Diagram: Electrical/Electronic Mechanism
3.6.3.1	Specific Project Fabrication: Phase 1 (Base Structure)
4.1.2.1	Specific Part Features: Product Structure
4.1.4.1	Operation of the Specific Part of the Product: Product Structure
4.3.1	Analysis of problem encountered & solutions: Mechanical Mechanism
5.1.2.1	Specific Achievement of Project Objectives: Product Structure
5.3.1	Improvement & Suggestions for Future Research: Mechanical Mechanism
	MUHAMMAD KHAIRIN ADZRIN BIN ABDULLLAH
1.3.2/1.3.2.2	Specific Individual Project Aims: Product Mechanism
1.5.2/1.5.2.2	Specific Individual Scope: Product Mechanism
2.2.2	Specific Literature Review: Product Mechanism

2.3.1.2	Related Patented Products: Patent systems and methods for inspecting a delivery vehicle using a paired inspection drone
2.3.2.2	Recent Market Products: Patent DJI Mavic 2 Enterprise Dual
2.4.2	Comparison Between Recent Research and Current Project: Patent Systems and methods for inspecting a delivery vehicle using a paired inspection drone vs. Product DJI Mavic 2 Enterprise Dual vs. AeroScout ThermoVision
3.3.2.2	Specific Project Design Flow / Framework: Product Mechanism
3.4.2.3	Design Concept Generation: Proposed Design Concept 2
3.5.2.2	Specific Part Drawing / Diagram: Product Mechanism
3.6.3.2	Specific Project Fabrication: Phase 2 (Accessories & Mechanisms)
4.1.2.2	Specific Part Features: Product Mechanism
4.1.4.2	Operation of the Specific Part of the Product: Product Mechanism
4.3.2	Analysis of problem encountered & solutions : Product Mechanism
5.1.2.2	Specific Achievement of Project Objectives: Product Mechanism
5.3.2	Improvement & Suggestions for Future Research: Product Mechanism
	SYABILNUR SHAHMIE BIN SHAHRILNUR
1.3.2/1.3.2.3	Specific Individual Project Aims: Software/Programming
1.5.2/1.5.2.3	Specific Individual Scope: Software/Programming
2.2.3	Specific Literature Review: Software/Programming
2.3.1.3	Related Patented Products: Patent Drone Inspection Analytics for Asset Defect Detection
2.3.2.3	Recent Market Products: Patent Parrot Anafi Thermal
2.4.3	Comparison Between Recent Research and Current Project: Patent Drone Inspection Analytics for Asset Defect Detection vs. Product Parrot Anafi Thermal vs. AeroScout ThermoVision

3.3.2.3	Specific Project Design Flow / Framework: Software/Programming
3.4.2.4	Design Concept Generation: Proposed Design Concept 3
3.5.2.3	Specific Part Drawing / Diagram: Software/Programming
3.6.3.3	Specific Project Fabrication: Phase 3 (Programming & Electrical Circuit)
4.1.2.3	Specific Part Features: Software/Programming
4.1.4.3	Operation of the Specific Part of the Product: Software/Programming
4.3.3	Analysis of problem encountered & solutions : Software/Programming
5.1.2.3	Specific Achievement of Project Objectives: Software/Programming
5.3.3	Improvement & Suggestions for Future Research: Software/Programming
	AINANI SOFIYYAH BINTI MOHD RIZAL
1.3.2/1.3.2.4	Specific Individual Project Aims: Accessories and Finishing
1.5.2/1.5.2.4	Specific Individual Scope: Accessories and Finishing
2.2.4	Specific Literature Review: Accessories and Finishing
2.3.1.4	Related Patented Products: Patent Drone-assisted Thermal Monitoring Techniques
2.3.2.4	Recent Market Products: Patent DJI Mavic 2 Enterprise Advanced
2.4.4	Comparison Between Recent Research and Current Project: Patent Drone-assisted Thermal Monitoring Techniques vs. Product DJI Mavic 2 Enterprise Advanced vs. AeroScout ThermoVision
3.3.2.4	Specific Project Design Flow / Framework: Accessories and Finishing
3.4.2.5	Design Concept Generation: Proposed Design Concept 4
3.5.2.4	Specific Part Drawing / Diagram: : Accessories and Finishing
3.6.3.4	Specific Project Fabrication: Phase 4 (Finishing)
4.1.2.4	Specific Part Features: Accessories and Finishing

4.1.4.4	Operation of the Specific Part of the Product: Accessories and Finishing
4.3.4	Analysis of problem encountered & solutions: Accessories and Finishing
5.1.2.4	Specific Achievement of Project Objectives: Accessories and Finishing
5.3.4	Improvement & Suggestions for Future Research: Accessories and Finishing

APPENDIX B: TURNITIN SIMILARITY REPORT

AEROSCOUT THERMOVISION

by MOHAMAD FAIZAL BIN DAUD

Submission date: 16-Nov-2025 08:03PM (UTC+0800)

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