

IoT-Based Real Time Aircraft Monitoring and Safety Management System

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Abstract: *The increasing complexity of modern aircraft systems has made safety monitoring a critical requirement. This paper presents an IoT-based aircraft environment parameter monitoring and safety alert system designed for real-time observation of key parameters such as temperature, vibration, and tilt. The system uses sensors like DHT11, SW-420, and MPU6050, which are interfaced with an ESP32 microcontroller for data collection and processing. The microcontroller continuously compares sensor readings with predefined threshold values to detect abnormal conditions. Whenever unsafe conditions are identified, the system activates a buzzer alert and updates the monitoring dashboard through Wi-Fi communication. A web-based dashboard is used to visualize real-time data and system status for effective monitoring. The system was tested under different conditions and showed reliable performance in detecting abnormal situations and generating timely alerts. The proposed solution is cost-effective, simple to implement, and suitable for improving aircraft safety through continuous monitoring and early fault detection.*

Keywords: IoT, Aircraft Safety, ESP32, Environmental Monitoring, Vibration Detection, Adaptive Threshold, Real-Time Monitoring, Smart Alert System, MPU6050, DHT11

I. INTRODUCTION

The aviation industry has always prioritized safety to ensure reliable and efficient flight operations. Aircraft operate in highly dynamic environments where parameters such as temperature, vibration, and motion can change rapidly. Continuous monitoring of these parameters is essential to detect abnormal conditions at an early stage and prevent potential failures.

Traditionally, aircraft rely on systems such as Flight Data Recorders (black boxes), which store important flight data for analysis after an incident. However, these systems do not provide real-time monitoring or immediate alerts, which can delay response during critical situations.

Therefore, there is a need for systems that can continuously monitor aircraft conditions and provide instant alerts.

With the advancement of the Internet of Things (IoT), real-time monitoring and remote data access have become possible in aviation systems. Recent studies have explored different approaches to aircraft monitoring. For example, digital twin-based systems improve real-time tracking and prediction of aircraft conditions [1], while hybrid health monitoring techniques enhance fault detection accuracy in control systems [2]. IoT-based maintenance systems provide real-time data visualization and monitoring capabilities [3], and IoT applications in air transport improve operational efficiency and safety [4].

This paper presents an IoT-based aircraft environment parameter monitoring and safety alert system designed to monitor temperature, vibration, and tilt in real time. The system uses sensors such as DHT11, SW-420, and MPU6050, which are interfaced with an ESP32 microcontroller. The collected data is compared with predefined threshold values to identify abnormal conditions. When unsafe conditions are detected, the system generates immediate alerts through a buzzer and updates a web-based dashboard for monitoring.



The proposed system is simple, cost-effective, and scalable. It provides real-time monitoring, quick alert generation, and improved situational awareness, making it suitable for aircraft safety applications as well as UAVs and other monitoring systems.

II. LITERATURE SURVEY

1. Digital Twin-Based Aircraft Monitoring (Chen et al., 2025): This study presents a digital twin-based monitoring system that uses IoT sensors along with simulation models to track aircraft conditions in real time. The system helps in predicting system behavior and improving decision-making. It provides a detailed virtual representation of the aircraft, allowing better analysis of system performance under different conditions. However, such advanced modeling increases system complexity and requires skilled implementation.

However, the implementation requires complex infrastructure and high computational resources, making it less suitable for low-cost applications. [1]

2. Hybrid Health Monitoring Approach (Guo et al., 2024): This research introduces a hybrid monitoring technique that combines data-driven and model-based approaches to detect faults in aircraft control systems. While the method improves fault detection accuracy, it involves complex modeling and system design.[2]

3. IoT-Based Smart Aircraft Maintenance System (Mangad, 2024): This work focuses on a web-based aircraft health monitoring system using IoT and embedded technologies. It provides real-time data visualization and supports predictive maintenance. However, the system mainly focuses on maintenance and does not emphasize real-time alert generation during flight.[3]

4. Application of IoT in Air Transport (Baláž, 2023): This study explains how IoT can improve aircraft monitoring, operational efficiency, and passenger safety. It also highlights challenges such as handling large-scale data and emphasizes the need for cost-effective monitoring solutions. [4]

III. PROBLEM STATEMENT

Aircraft systems operate in highly dynamic and unpredictable environments where parameters such as temperature, vibration, and motion can change rapidly during flight. Traditional monitoring systems, such as flight data recorders, mainly store data for post-incident analysis and do not provide continuous real-time monitoring or instant alerts. This delay in identifying abnormal conditions can increase the risk of system failure and reduce response efficiency during critical situations.

In addition, many existing monitoring solutions are complex, expensive, and not suitable for small-scale or cost-effective implementations. They often lack simple integration of multiple sensors and do not provide an easy-to-use real-time monitoring interface. Therefore, there is a need for a low-cost, reliable, and real-time monitoring system that can continuously track aircraft environmental parameters and generate immediate alerts to improve safety and decision-making.

IV. OBJECTIVES

- To design and develop an IoT-based system for monitoring aircraft environmental parameters in real time.
- To measure key parameters such as temperature, vibration, and tilt using appropriate sensors.
- To implement a threshold-based monitoring approach to identify abnormal conditions during operation.
- To generate immediate alerts using a buzzer when unsafe conditions are detected.
- To transmit sensor data wirelessly and display it on a web-based dashboard for monitoring.
- To create a simple, cost-effective, and scalable system that can be easily implemented and expanded in the future.
- To improve overall safety by enabling early detection of potential issues through continuous monitoring.



V. WORKING OF SYSTEM

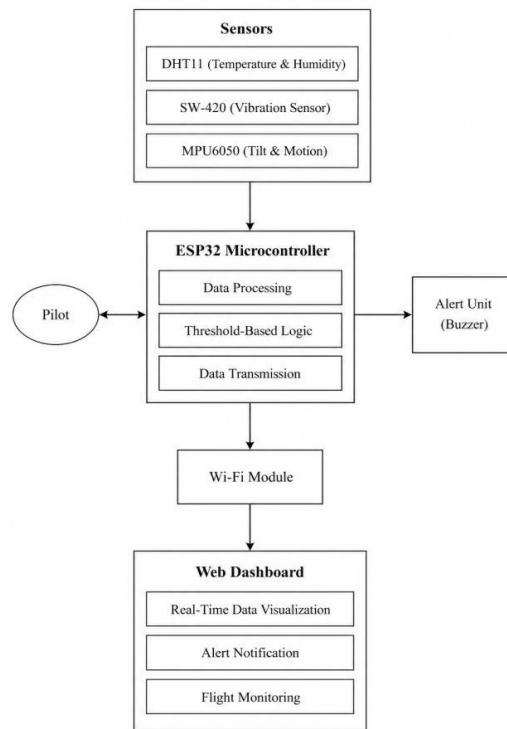


Fig 1: Design of the system

The proposed IoT-based Aircraft Environment Parameter Monitoring and Safety Alert System works by continuously collecting, processing, and transmitting real-time data from multiple sensors to ensure flight safety.

Initially, when the system is powered on, the ESP32 microcontroller initializes all connected sensors, including the DHT11 (temperature and humidity), SW-420 (vibration), and MPU6050 (tilt and motion). These sensors start capturing real-time environmental and motion-related data from the aircraft.

The collected sensor data is then sent to the ESP32, which acts as the central processing unit. It processes the incoming data and compares each parameter with predefined safety threshold values. This comparison helps in identifying whether the system is operating under normal or abnormal conditions.

If all sensor values remain within safe limits, the system continues normal monitoring and periodically transmits the data to the web dashboard through the Wi-Fi module. This allows real-time visualization of parameters such as temperature, vibration, and tilt.

However, if any parameter exceeds its threshold, the system identifies it as an abnormal condition. In such cases, the ESP32 immediately activates the alert unit (buzzer) to provide a local warning. At the same time, the system sends updated data to the dashboard, where the abnormal condition is clearly displayed for monitoring. The Wi-Fi module ensures continuous communication between the onboard system and the ground-based web dashboard. The dashboard presents the data in a user-friendly format, allowing operators to monitor flight conditions and detect issues instantly.

Overall, the system operates in a continuous loop of sensing, processing, decision-making, and communication, ensuring real-time monitoring and quick response to unsafe conditions.



VI. SYSTEM DESIGN

The system design of the IoT-Based Aircraft Environment Parameter Monitoring and Safety Alert System is structured to ensure reliable real-time monitoring, efficient data processing, and quick alert generation. The design is divided into three main modules: the Sensing Module, Processing Module, and Monitoring Module. Sensors.

Sensing Module: The sensing module is responsible for collecting real-time environmental and motion-related data from the aircraft. It consists of multiple sensors integrated with the system.

The DHT11 sensor measures temperature and humidity to detect overheating conditions. The SW-420 vibration sensor identifies unusual vibrations that may indicate turbulence or mechanical issues. The MPU6050 sensor monitors tilt and motion to detect instability or abnormal orientation. All sensors continuously capture data and send it to the microcontroller for further processing.

Processing Module: The processing module acts as the core of the system and is implemented using the ESP32 microcontroller. It receives input data from all connected sensors and processes it based on predefined threshold values. The ESP32 evaluates the sensor readings and determines whether the system is operating under normal or abnormal conditions. If any parameter exceeds its safe limit, the system immediately triggers a buzzer to provide a local alert.

At the same time, the processed data is transmitted to a local server using Wi-Fi communication protocols such as HTTP or MQTT. Each data packet includes sensor values, system status, and timestamp information for proper monitoring and tracking.

Monitoring Module: The monitoring module is responsible for displaying system data and alerts to the user. A web-based dashboard is used to visualize real-time sensor readings and system status.

The dashboard provides a clear view of parameters such as temperature, vibration, and tilt, along with alert indications for abnormal conditions. It enables continuous monitoring and helps users quickly identify potential safety issues.

The system operates in a continuous loop of sensing, processing, and monitoring. This modular design ensures flexibility, scalability, and easy integration of additional sensors or advanced features in the future.

VII. RESULT

The proposed IoT-based aircraft environment parameter monitoring and safety alert system was successfully developed and tested under simulated conditions to evaluate its performance and reliability. The hardware prototype of the system is shown in Fig. 2, which demonstrates the integration of sensors, ESP32 microcontroller, and communication modules. The system continuously monitored key parameters such as temperature, vibration, and tilt in real time using the integrated sensors. The ESP32 efficiently processed the sensor data and classified system conditions into Normal, Abnormal, and Critical states based on predefined and adaptive thresholds. The system showed quick response to changes in sensor values, ensuring accurate detection of abnormal situations.

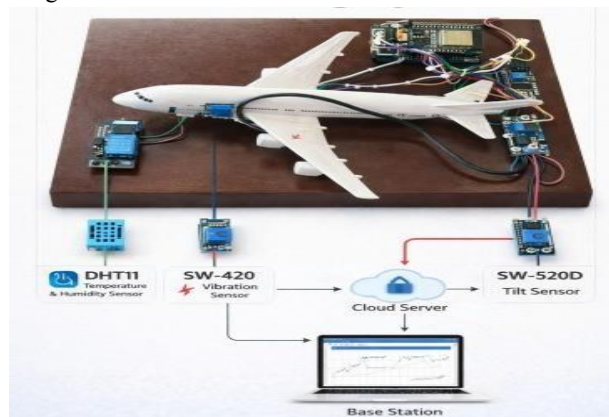


Fig 2: Model prototype



During testing, the alert mechanism worked effectively by triggering immediate buzzer notifications in abnormal and critical conditions. At the same time, the system transmitted data to the web-based dashboard for remote monitoring. The real-time dashboard output is shown in Fig.3 , where sensor values and system status are clearly displayed.



Fig 3: Model prototype

The alert functionality is illustrated in Fig. 4, which shows how the system highlights abnormal and critical conditions using visual indicators. This helps users quickly identify potential risks and take appropriate action.

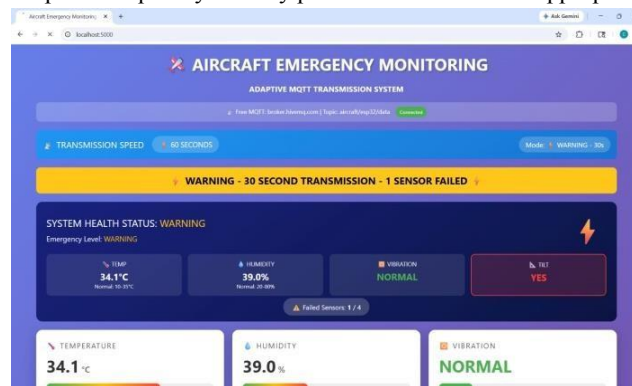


Fig 4: Model prototype

Furthermore, graphical analysis of sensor data provided clear insights into system behavior under different conditions. The graphs of temperature, vibration, and tilt readings (shown in Fig. 5, Fig. 6, and Fig. 7) demonstrate how the system responds to normal and abnormal variations.

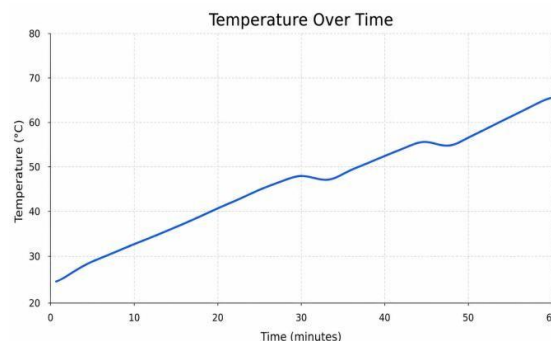


Fig 5: Temperature Variation Graph



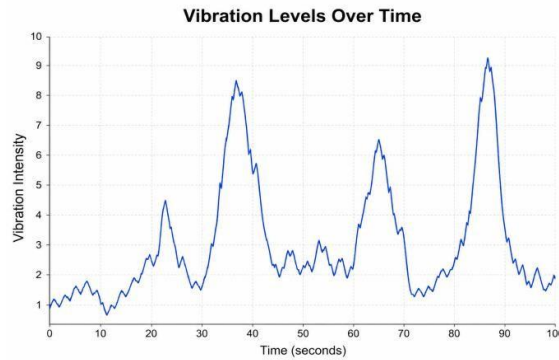


Fig 6: Vibration Sensor Output Graph

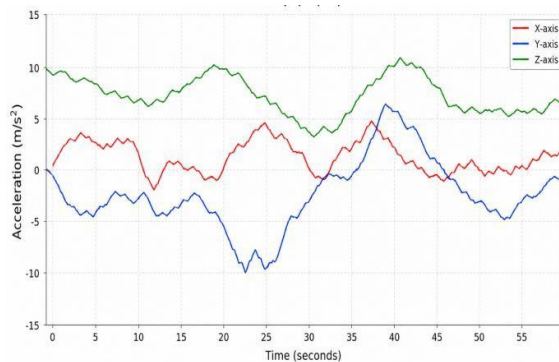


Fig 7: Tilt/Orientation Graph

To further evaluate system performance, different test cases were applied under controlled conditions. The system was able to correctly identify normal, abnormal, and critical states based on the input sensor values.

Parameter	Value	Condition	System Output
Temperature	30°C	Normal	No Alert
Temperature	55°C	Abnormal	Warning
Temperature	70°C	Critical	Alarm Triggered
Vibration	Low	Normal	No Alert
Vibration	High	Abnormal	Warning
Tilt	Stable	Normal	No Alert
Tilt	Sudden Change	Critical	Alarm Triggered

Table 1 : Test Case Evaluation of System

During testing, alerts were triggered accurately whenever the threshold limits were exceeded. The buzzer responded immediately, and the dashboard updated the system status without delay. Overall, the system showed stable and reliable performance in real-time monitoring and alert generation, demonstrating its effectiveness as a low-cost safety solution.

VIII. CONCLUSION

The IoT-Based Aircraft Environment Parameter Monitoring and Safety Alert System developed in this project successfully demonstrates how real-time monitoring can improve safety in aircraft environments. The system continuously collects data from sensors such as temperature, vibration, and tilt, and processes this data using the ESP32 microcontroller to detect abnormal conditions.

During testing, the system was able to accurately identify normal, warning, and critical states based on predefined threshold values. Whenever unsafe conditions were detected, it generated immediate alerts through a buzzer and



updated the dashboard for remote monitoring. This shows that the system is capable of providing timely and reliable safety notifications.

The use of a web-based dashboard further enhances usability by allowing ground operators to monitor aircraft conditions in real time and analyze system behavior. The implementation of both HTTP and MQTT communication ensures flexible and efficient data transmission.

Overall, the proposed system offers a cost-effective, scalable, and reliable solution for aircraft environment monitoring. Although it is currently a prototype, it lays a strong foundation for future improvements such as advanced analytics, additional sensors, and integration with intelligent decision-making systems. This project highlights the potential of IoT technology in enhancing aviation safety and supporting preventive maintenance strategies.

REFERENCES

- 1) Chen, X., Liu, W., Zhang, Y., and Zhao, Q., "Digital Twin Enabled Task Scheduling for State Monitoring in Aircraft Testing Process," 2025.
- 2) Guo, Y., Ma, C., and Jing, Z., "A Hybrid Health Monitoring Approach for Aircraft Flight Control Systems With System-Level Degradation," 2024.
- 3) Mangad, A. A., "Smart Aircraft Maintenance: A Web-Based Predictive Monitoring and Alert System Using Embedded Systems and IoT," 2024.
- 4) Baláz, M., "The Application of Internet of Things in Air Transport," 2023.
- 5) Kabashkin, I., and Shoshin, L., "Next-Gen Embedded Systems in Aviation: Enhancing In Flight Experience and Operations," 2025.
- 6) Bisanti, G., and Mainetti, L., "Digital Twins for Aircraft Maintenance and Operation: A Systematic Literature Review and an IoT-Enabled Modular Architecture," 2023.
- 7) Sharma, P., and Gupta, K., "AI-Powered Predictive Maintenance in Aviation Operations," 2025
- 8) Scarselli, G., and Romano, L., "Machine Learning for Structural Health Monitoring of Aerospace Structures," 2025.
- 9) Rastogi, R., Kaur, P., Biswas, D., Chola, A., and Chaudhary, A., "IoT-Based Predictive Maintenance Tactics, Techniques, and Procedure

