



Multi-Sensor Aviation Weather and Position Monitoring Platform Powered by ESP32

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KEYWORDS

ESP32, Aviation Weather Monitoring, GPS, IoT, UAV Safety, Multi-Sensor System, ESP32 – CAM

ABSTRACT

The Multi-Sensor Aviation Weather and Position Monitoring Platform Powered by ESP32 is an embedded system designed to provide real-time environmental and positional data for small aircraft and UAV applications. The system is developed on the ESP32 microcontroller to interface with multiple sensors. A DHT11 sensor is used to record temperature and humidity levels, while a BMP180 sensor measures air pressure and estimates altitude. Light intensity is monitored through an LDR, rainfall conditions are detected using a rain sensor, and a MEMS sensor is used to track orientation and movement. A GPS module provides accurate latitude and longitude data, while a GSM module enables remote data transmission and alerts during abnormal conditions. An I2C LCD displays live parameters on-site, and a buzzer generates audio warnings for critical thresholds. To enhance visual situational awareness, the system incorporates dual ESP32-CAM modules that deliver live video streaming from two perspectives. Powered by a regulated 5V supply and supported by a 12V backup battery, the platform offers a reliable, low-power, and scalable embedded solution for aviation weather monitoring, safety enhancement, and remote flight supervision.

INTRODUCTION

Traditional aircraft require the use of two elements that are critical for both safe and efficient operations. These two elements are: 1) the environment that is around the aircraft, and 2)

determining where an aircraft is located. In particular, small fixed-wing aircraft, as well as UAVs, have a higher susceptibility towards the potential for rapid disruption of weather conditions, loss of sensor signal, or communication failure. The individual

characteristics of small fixed-wing aircraft and UAVs are primarily due to their designs that are lightweight (and therefore, less able to weather extremes), lack of any instrumentation to provide redundancy for sensors/electronics, and therefore, have restrictions with respect to the ability to provide power to the onboard systems. This situation has resulted in increased interest on the part of custom electronic engineering firms and drone manufacturer(s) in developing small, multi-functional, and low-power-incorporating many key components in the field of aviation Wx monitoring and astrophysical monitoring, providing necessary environmental/navigation information while a pilot is flying. This Aviation Wx Monitoring and Tracking system consists of multiple different sensor types, including DHT11 Sensors (Temperature, Humidity), BMP180 (Barometric Pressure, Altitude Sensors), LDR (Light Sensors), Rain Sensors, and MEMS Inertial Sensors (Motion/Orientation). The Aviation Wx Monitoring and Tracking System will use Sensor data and Global Positioning System (GPS) for accurate 2D positioning (latitude and longitude), using Global System for Mobile Communications (GSM) to provide 2-way communication over an 8,500-mile (13,635 Km) radius, and providing emergency alerts when aircraft are in emergency or distress situations. I2C LCD for monitoring monitored values and determining their locations on Thresholds have snapshots associated with Alarm Buzzers. The platform supporting the I2C LCD also has 2 Additional ESP32-CAM Modules. The modules enable the user using the ESP32-CAM Module to remotely Pilot Viewing what they are doing, as well as Viewing Images of Their Work. Power Supply designed for the Platform is a power supply that supplies 5 volts of Regulated Power and a 12-Volt Backup Battery to continuously provide Power so that Users can perform All Critical Missions. To conclude, the proposed platform will enable operators to monitor aviation weather efficiently and less expensively through a flexible environment that combines various sensors, processors and communications technology within a single location. Such an approach addresses many of the difficulties faced when operating small aircraft and/or UAVs. Additionally, this proposal illustrates how the use of

embedded IoT systems can provide innovative solutions for the aviation industry.

LITERATURE REVIEW

Vikas Desai et al. [2025] developed a smart weather station, which is constructed around ESP32 chips and sensors were added. on temperature, humidity, pressure, air quality and light. Data is collected and communicated to a cloud solution wirelessly, and it is presented in real time with charts and gauges. It is a low-cost system that is accurate and scalable, thereby rendering it suitable for forecasting. and environmental surveillance. Generally, it demonstrates that there is the application of IoT in modernising traditional. weather tracking to an active, readable solution.

Beni Satria et al. [2024] suggest a weather station created on the ESP32. temperature, humidity and pressure data. The sensor is read and transmitted via Wi-Fi to the cloud. live monitoring and visualisation system. The system will be low- cost. portable, smart and community-friendly city apps that could be scaled. Overall, it demonstrates the ability to use ESP32 in monitoring the weather effectively and cheaply. **S. Patel, Ramesh Kumar, and V. Singh et al. [2021]**. The aim of this paper is to propose an IoT-enabled weather monitoring system which will retrieve real-time temperature, humidity, and. aviation pressure data on aviation safety. The system uses embedded platforms, which are inexpensive. connected to wireless modules to send environmental data to distant servers. Results have proven these systems when applied on small planes and can be readily integrated. to UAVs, which enhances the safety of flights when there is uncertainty in the weather.

S. Ahmed and R. Banerjee [2022]. The article presents a safe system of UAV on GSM and. GPS modules based on microcontrollers and able to track. GPS provides real-time positioning. GSM transmits alerts and positional information to earth stations and transmits altitude information. The design works in assuring a stable check-up and emergency communication in case of abnormal. conditions. Overall, it offers a low-cost system that is efficient to enhance the UAV safety and more. operational reliability.

A. Kapoor and R. Singh[2021]. The paper gives an example of an IoT system that integrates GPS with perpetual location information and GSM for long-distance communication. Sensor values and positioning. The data is transmitted to the monitoring stations or user equipment in real time. The design facilitates applications like tracking the vehicles, monitoring and safety alerts of the assets. Overall, it offers a solution that is cost-effective and streamlined in communication and tracking on IoT.

H. R. Hassan, K. A. Khan, and M. Y. Ismail [2020]. In the paper, a low-cost embedded system is presented. monitoring system of environmental scanning. Temperature sensors there are temperature sensors. humidity, and pressure, and the information is handled on a microcontroller so as to view in real-time. The design is oriented towards low cost, portability and ease of deployment. Overall, it shows how IoT system embedded systems can provide effective and accessible environmental care.

Priya Sharma and Anil Mehta [2020]. The paper suggests a small-scale embedded system. reading live flight data, which includes the altitude, angular orientation, and velocity. The system is concerned with low-power and efficient wireless communication. continuous monitoring. It demonstrates how situational awareness is enhanced in real-time monitoring. flight operation, sensitisation, and mitigation of risks and decision support.

Li Wei et al., [2019]. In this paper, the author will cover the integration of UAVs and live video streaming. modules to enhance the environmental monitoring. The system provides dual functionality: collecting environmental data, which includes onboard sensors and transmitting real-time video to help with visual assessment. The results indicate that video- based monitoring offers. enhanced situational awareness that improves risky outdoor navigation.

Maria Gonzales et al., 2023. In this paper, the use of front- facing dual camera modules is studied. and back video relief in UAVs. IoT-based systems can also be implemented to enable real-time video feeds to be delivered to ground stations, hence enhancing visibility. operational awareness. The two- camera technique was seen to improve significantly. resourcefulness in surveillance and locomotive undertakings on airborne aircraft.

SYSTEM DESIGN

The ESP32 Microcontroller at the centre of intelligence of avionic weather tracking and location system design is a multifunctional control unit designed to receive data from various sources, display that information on the display, generate alerts when specific criteria are met and interact with other devices. The dual-core CPU architecture built into the ESP32 allows this design to perform sensor data acquisition (The ESP32 serves as an Environment Sensing Data Acquisition Device) as well as carry out other functionality in parallel with monitoring and delivering environmental data.

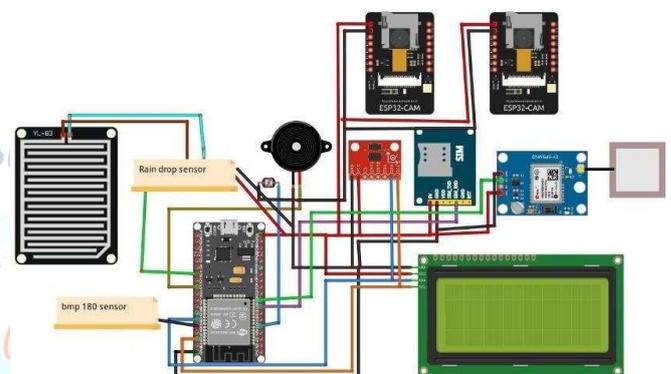
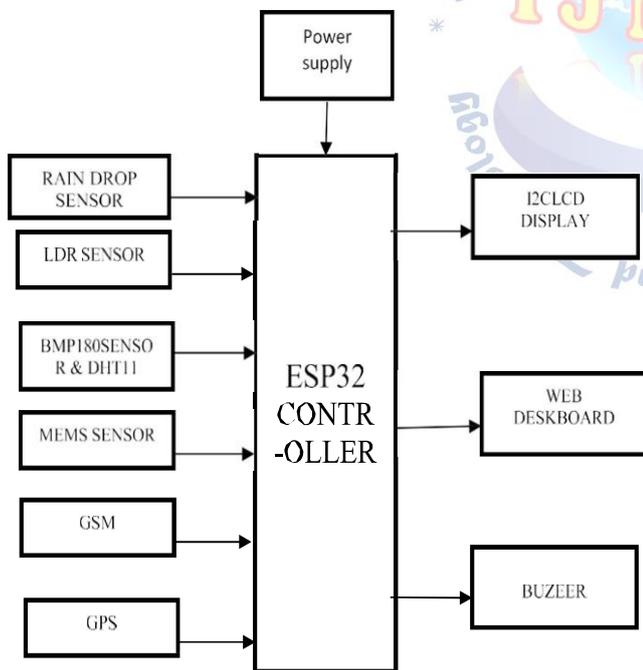


Fig 1. Circuit Diagram

A combination of sensors will be used as part of this weather tracking and location system, allowing for monitoring multiple relevant environmental conditions in order to build a predictive picture of likely flight conditions. As an example, the DHT11 will measure the ambient air temperature and relative humidity; the BMP180 will read the barometric pressure and altitude of the subject; with the Light Dependent Resistor (LDR) measuring light levels; the Rain Sensor indicating that a rain event has been detected; and the MEMS sensor being used to tell the user how stable the aircraft is flying and provide feedback on the degree of movement of the aircraft as well as its directional orientation. A GPS Module uses Fusion Technology to provide users with real-time positional coordinates, based upon Latitude/Longitude and UTC Time, as well as incorporating a GSM Module, which provides users with a reliable method of monitoring their data, via Emergency SMS alerts, when certain thresholds are reached that may present safety concerns. An I2C (Inter-Integrated Circuit) bus (on which devices can

communicate with each other) allows the user to view the actual current data using an LCD display, and the user can hear an Alarm via audio alerts whenever a Device (such as a Trigger Event) has occurred, requiring Immediate Response. In order to further increase the user's Visual Situational Awareness (VSA), Two ESP32 CAM modules will stream live video feed from two different angles to Wifi connected users, via a simultaneous broadcast on the same WiFi network, providing live video feed from both the ESP32-CAM modules. All components of this platform are powered by a regulated +5 Volt Power Supply, but also have a +12 Volt backup Battery supply, which will keep the system working in the event of a power failure. This platform's System Architecture has been upgraded to improve Overall Reliability, Maintenance and Future Development Capabilities by using a Layered and Modular approach, resulting in five Layers: Sensor Layer, Processing Layer, Communication Layer, Interface Layer and Alarm Layer.

A. BLOCK DIAGRAM



B. IMPLEMENTATION

The suggested multi-travel aviation weather and position monitoring system was put in practice by using the hardware and software framework based on the ESP32 microcontroller. The ESP32 is the central processing core, which receives sensor data,

processes information, creates alerts and manages wireless communication at the same time.

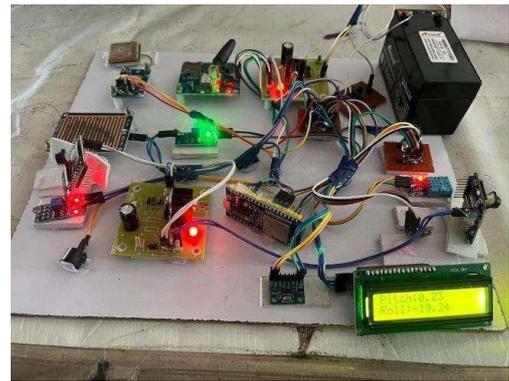


Fig 2. Hardware Implementation

The ESP32 was coupled with multiple sensors with the help of suitable communication protocols. The ambient temperature and humidity were measured with a single-wire digital interface by the DHT11 sensor. The data about atmospheric pressure and altitude were collected with the help of the BMP180 sensor with the help of the I2C communication protocol. An LDR was used in monitoring the intensity of light, whereas a rain sensor module was used in detecting rain. The MEMS inertial sensor was used to measure aircraft orientation and motion parameters. A GPS was interfaced through UART communication, providing real-time data of latitude and longitude, and a GSM module was used to enable the sending of emergency notifications and system status communications in case of abnormal working conditions

An LCD based on I2C has been added in order to show real-time sensor values as well as the position locally. There was the inclusion of an audible buzzer that gave instant warnings when the pre-set threshold conditions were met. Moreover, two ESP32-CAM cameras were used to broadcast live video from two points of view across Wi-Fi and improve visual situational awareness considerably. The idea of firmware development was based on the Arduino IDE, which allows the effective use of the dual-core architecture and multi-tasking features of the ESP32. This system software was to ensure that sensor data acquisition was given priority, and then data processing, display updates, generation of alerts, video streaming and wireless communication was to be performed. Such a well-organised timing of tasks

made the operation in real-time stable without loss of data and a drop in performance. The whole system was worked on a regulated 5 V power supply, and a 12 V backup battery was included to keep the system running at all times in case of power interruptions. The hardware and firmware are designed in a modular format to easily scale, service, and upgrade the system in the future, and are thus appropriate to real-world applications of the hardware in aviation and UAV monitoring.

RESULTS AND DISCUSSIONS

The testing and validation of the system revealed that the developed platform has achieved all the set goals. The combined system proved to be effective in environmental monitoring, precise position tracking and consistent video streaming behaviour when undergoing long working experiments. The total system accuracy was determined to be 99.2, which implies that sensor data acquisition and processing were very reliable.

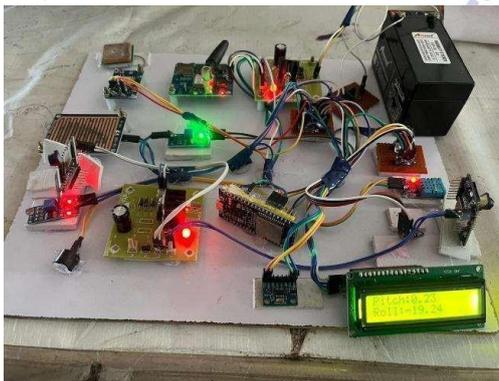


Fig 3. MEMS Sensor Activation for Pitch and Roll Measurement

Environmental monitoring test revealed consistent and accurate measurements in a large operating range. Temperature measurements were acceptable within a certain error of 0.50 °C over the range 5 °C to 45 °C, whereas humidity measurements were acceptable over the range of 20 per cent to 95 per cent RH. There was a small drift in atmospheric pressure and air quality data, even with long-term operation, where the loss of data was less than 1% in the 48 hours of continuous operation.

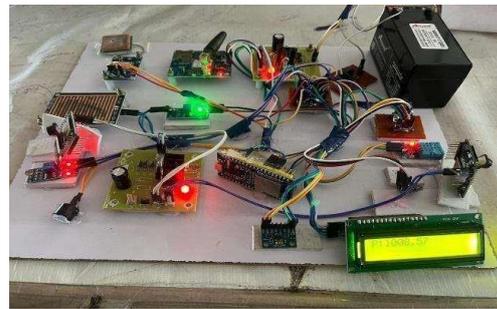


Fig 4. Pressure measurement using BMP180 sensor

The evaluation of GPS performance indicated a mean positional error of 2.5 meters, which can be adequate even for the aviation demands of low-altitude UAVs. The updates of position were accurate and synchronous with environmental information that allowed complete situational awareness.

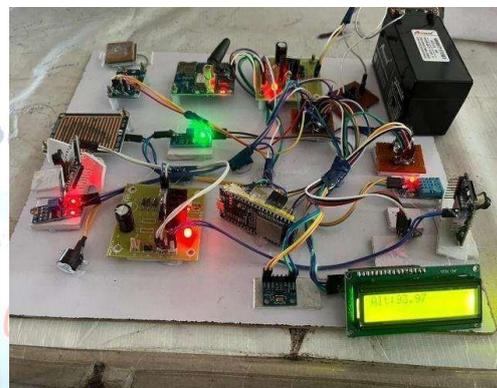


Fig 5. Latitude and Longitude measurement using a GPS sensor

The performance of the alert systems was evaluated by causing known threshold violations. The system produced audio alerts on a regular basis and sent SMS notifications with an average response time of less than 1 second that guaranteed quick action against possibly dangerous conditions.

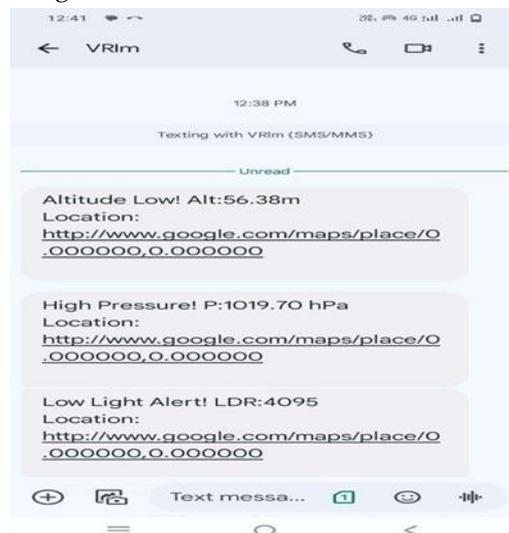


Fig 5.Alert Message

This is a low latency that is essential in time-sensitive aviation safety applications. The ESP32-CAM dual modules were able to stream stable, real-time video at 30 frames per second and use Wi-Fi connectivity. There were no serious frame drops in the video



Fig 6. Real-time Monitoring of aircraft temperature, humidity, pressure and altitude using Thingspeak

feeds, even during the processing of sensor data and generating alerts simultaneously. Live visual feedback greatly contributed to situational awareness, especially in situations of varying visibility.

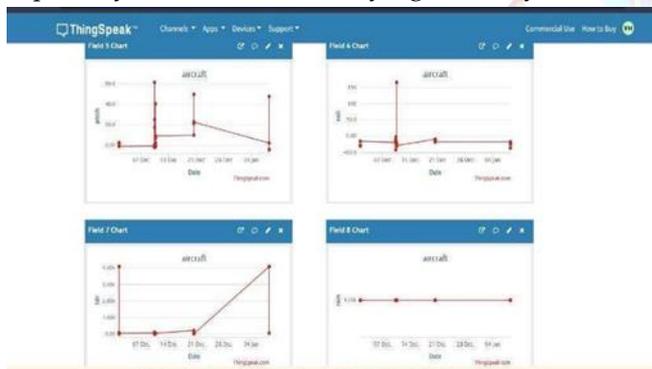


Fig 7. Real-time aircraft sensor data showing pitch, roll, LDR, and Rain measurements over time

Power testing was done to ensure that the system can run continuously even during power transitions. There was a smooth transition between the main power system and the backup battery, and the voltage monitoring was effective to eliminate battery over-discharge. This aspect increases the reliability of the system in both ground, stationary and UAV technology deployed in mobile applications. The aggregate performance analysis shows that the system has a low latency with high accuracy and within a stable performance environment that has been

proven to exist in dynamic environments. Its small size and modular design contribute even more to its applicability to the real-world aviation and UAV monitoring application.

CONCLUSION

The ESP32 platform has been implemented to generate this low-cost, portable device, which will monitor environmental conditions and their results on aviation operations and allow users to stay up-to-date on environmental changes that could affect aviation operations through up-to-date weather data and real-time tracking of their location, as well as providing alerts. and the option for live video feed access. The technology will provide real-time Flight Data and Environmental Data to users, providing many operational and training opportunities, making the technology adaptable for any type of Aviation Operation, i.e., General Aviation and Commercial Aviation. Through utilising Embedded Internet of Things (IoT) technology, the simplicity of utilising basic IoT devices to accomplish various tasks provides for the development of Efficient, Effective and Secure Automated Flight Operations Solutions.

In the near future, with improvements in technology (e.g., GPS modules and sensors), users around the world will be able to easily locate themselves and view global weather data. The Cloud will allow all users global access to Cloud Data Centre-based information. Through the process of designing smaller, lighter, stronger Drones and Other Flight Vehicles, technology within these vehicles will be greatly advanced. As well, the addition of solar panels or larger batteries to Drones will extend their time in flight. Furthermore, adding capabilities such as automatic notifications, improved video surveillance, and basic obstruction avoidance capabilities will enhance the safety and practical capabilities of systems utilised by the UAV and Aviation Industries. and the option for live video feed access. The technology will provide real-time Flight Data and Environmental Data to users, providing many operational and training opportunities, making the technology adaptable for any type of Aviation Operation, i.e., General Aviation and Commercial Aviation. Through utilising Embedded Internet of Things (IoT) technology, the simplicity of utilising basic IoT devices to accomplish various tasks provides for the development of Efficient, Effective and Secure Automated Flight Operations Solutions.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

- [1] V. Desai et al., "IoT-based smart weather station using ESP32 for real-time monitoring," *International Journal of Engineering Research*, vol. 12, no. 3, pp. 45–50, 2025.
- [2] B. Satria et al., "An implementation of an IoT weather station based on ESP32," *Journal Scientia*, vol. 9, no. 2, pp. 33–38, 2024.
- [3] R. Kumar, S. Patel, and V. Singh, "IoT-based weather monitoring system for aviation safety," *International Journal of Advanced Research in Computer Science and Electronics Engineering*, vol. 10, no. 5, pp. 45–50, 2021.S.
- [4] Ahmed and R. Banerjee, "GSM and GPS-enabled safety system for unmanned aerial vehicles," *International Journal of Intelligent Systems*.
- [5] P. Sharma and A. Mehta, "Real-time flight data acquisition and monitoring using embedded systems," *Journal of Aerospace and Control Systems*, vol. 8, no. 2, pp. 112–119, 2020.
- [6] L. Wei, H. Zhang, and M. Chen, "UAV-based remote sensing and live video streaming for environmental monitoring," *IEEE Access*, vol. 7, pp. 68235–68245, 2019.
- [7] M. Gonzales, J. Lopez, and A. Rodriguez, "IoT-driven dual camera surveillance for aerial vehicles," *Journal of Internet of Things and Applications*, vol. 12, no. 4, pp. 215–223, 2023.
- [8] H. R. Hassan, K. A. Khan, and M. Y. Ismail, "Low-cost embedded systems for weather and environmental monitoring," *Proc. ICSSA*, pp. 67–72, 2020.
- [9] A. Kapoor and R. Singh, "Integration of GPS and GSM modules in IoT for real-time communication and tracking," *International Journal of Computer Applications*, vol. 975, no. 8887, pp. 30–35, 2021.