© May 2026 | IJIRT | Volume 12 Issue 12 | ISSN: 2349-6002

# Telemetry-Based Live Monitoring of Drone Battery and Flight Parameters

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***Abstract*—Telemetry-based live monitoring is a critical technology for ensuring the safe, efficient, and reliable operation of Unmanned Aerial Vehicles (UAVs). This paper presents the design, implementation, and evaluation of a real-time telemetry system for continuous monitoring of drone battery health and flight parameters. The proposed architecture integrates an APM 2.8 flight controller, multi-sensor array (GPS, IMU, barometer, magnetometer, and power module), and a SiK radio telemetry link to transmit processed data to a ground control station running Mission Planner software. Real-time visualization of battery voltage, current, altitude, speed, GPS coordinates, and flight attitude enables operators to detect anomalies, prevent mid-flight failures, and optimize mission planning. Experimental validation demonstrates stable bidirectional communication, accurate parameter tracking, and reliable alert generation. The system enhances flight safety, operational reliability, and post-flight diagnostic capabilities. Future enhancements include IoT-based cloud integration, AI-driven predictive maintenance, and extended-range communication via LTE/satellite networks.**

***Index Terms*—Telemetry, Unmanned Aerial Vehicle (UAV), Drone Monitoring, Battery Monitoring System, Flight Parameters, Real-Time Data Transmission, Wireless Communication, Ground Control Station, GPS Tracking, Flight Safety.**

## I. INTRODUCTION

Unmanned Aerial Vehicles (UAVs) have become indispensable across surveillance, agriculture, environmental monitoring, disaster response, and aerial photography. Their operational safety and mission success heavily depend on continuous, real-time monitoring of battery health and flight dynamics. Since drones operate remotely in complex and often unpredictable environments, a reliable telemetry framework is essential to provide ground operators with instantaneous situational awareness.

Telemetry systems bridge the airborne platform and ground control station (GCS) by wirelessly transmitting critical parameters such as battery voltage, current draw, temperature, altitude, velocity, GPS coordinates, and system status. Effective battery management is particularly crucial, as lithium-polymer (LiPo) cells have limited capacity and are prone to thermal runaway, voltage sag, or sudden discharge under high load. Concurrent monitoring of flight parameters ensures stable attitude control, precise navigation, and timely corrective actions during anomalies.

This paper proposes a low-cost, integrated telemetry system that combines onboard sensor data acquisition, APM 2.8 flight control processing, and MAVLink-based wireless transmission to a Mission Planner interface. The system enables real-time supervision, early fault detection, and comprehensive data logging, addressing key limitations in existing UAV monitoring frameworks.

## II. LITERATURE SURVEY

Recent research has explored various aspects of UAV telemetry and battery monitoring, yet integrated solutions remain limited.

Zhang et al. [1] developed an IoT-based battery management system for UAVs, enabling cloud-based remote monitoring of voltage, current, and State of Charge (SOC). While effective for fault prediction, it lacks integration with flight dynamics telemetry. Sidhu et al. [2] proposed a cost-effective microcontroller-based battery tracker with threshold-based alerts, focusing on predictive maintenance but omitting altitude, position, or attitude monitoring.

Maharani and Zuhrie [3] implemented a Pixhawk-Raspberry Pi telemetry system for flight parameter tracking over mobile networks, demonstrating robust long-range communication. However, battery health metrics were not deeply analyzed. Jadhav and Bhosale [4] addressed lithium-ion battery safety, emphasizing thermal management and protection circuits, but did not incorporate real-time telemetry for flight parameter synchronization. Istawar and Rosyadi [5] utilized ESP32 and INA219 sensors for accurate voltage/current monitoring with IoT transmission, yet the system remained isolated from comprehensive flight telemetry.

Collectively, these studies highlight a research gap: most existing systems monitor either battery parameters or flight dynamics independently. This work bridges that gap by integrating both into a unified, real-time telemetry framework using open-source flight control and MAVLink protocols.

## III. SYSTEM ARCHITECTURE AND BLOCK DIAGRAM

The proposed system comprises three primary subsystems: onboard data acquisition, wireless telemetry communication, and ground monitoring station.

A. Onboard Data Acquisition the APM 2.8 flight controller serves as the central processing unit, interfacing with:

- Power Module: Measures battery voltage and current.
- GPS Module: Provides latitude, longitude, and altitude.
- IMU (Accelerometer & Gyroscope): Captures linear acceleration and angular rates.
- Barometer & Magnetometer: Estimate pressure altitude and heading.
- ESC & BLDC Motors: Regulate thrust and enable attitude control.
- FlySky FS-iA6B Receiver & FS-i6 Transmitter: Provide manual pilot input for throttle, roll, pitch, and yaw.

B. Telemetry Communication Link Processed sensor data is formatted using the MAVLink protocol and transmitted via a SiK radio telemetry module operating in the 433/915 MHz RF band. The module supports bidirectional communication, enabling both downlink telemetry and uplink command/configuration.

C. Ground Monitoring Station A laptop running Windows OS hosts Mission Planner GCS software. It receives telemetry via USB, decodes MAVLink packets, and renders real-time dashboards, map tracking, parameter graphs, and flight logs.

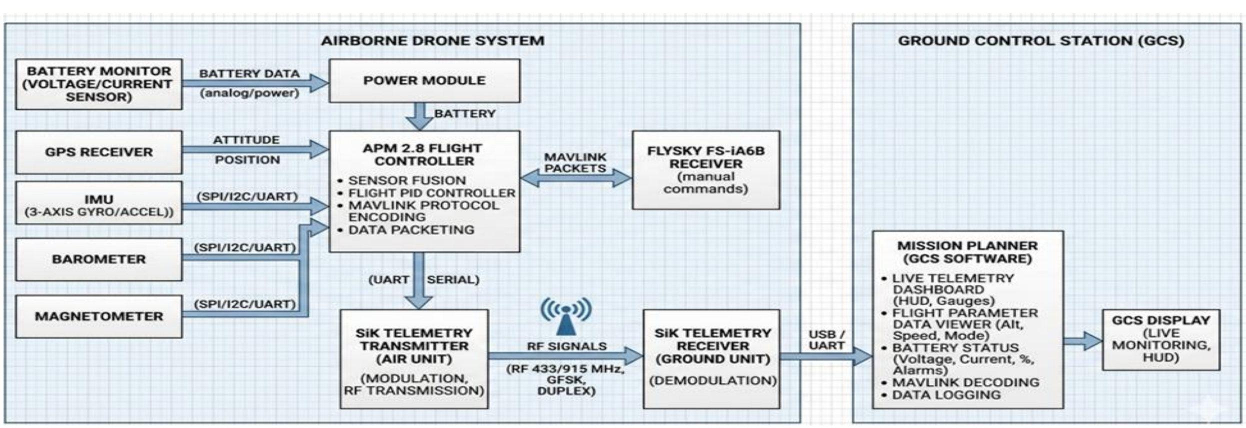

Figure 1: Telemetry-Based Live Monitoring of Drone Battery and Flight Parameters

## IV. MATHEMATICAL ANALYSIS

The APM 2.8 controller processes raw sensor data using established kinematic, electrochemical, and atmospheric models to generate reliable telemetry outputs.

A. Battery State of Charge (SOC) Estimation SOC is computed via Coulomb counting, corrected for temperature and discharge rate:

$$\mathrm{SOC}(t) = \mathrm{SOC}_0 - \frac{1}{C_n \cdot \eta} \int_0^t I(\tau)\, d\tau \qquad (4.1)$$

where $\mathrm{SOC}_0$is initial charge, $C_n$is nominal capacity (Ah), $I(\tau)$is instantaneous current, and $\eta$is Coulombic efficiency. Voltage thresholds trigger low-battery alerts.

B. Barometric Altitude Estimation Altitude $h$is derived from atmospheric pressure $P$using the International Standard Atmosphere model:

$$h = \frac{T_0}{L}\left[1 - \left(\frac{P}{P_0}\right)^{\frac{RL}{g}}\right] \qquad (4.2)$$

where $T_0 = 288.15\mathrm{K}$, $P_0 = 101325\mathrm{Pa}$, $L = 0.0065\mathrm{K/m}$, $R = 287.05\mathrm{J/(kg \cdot K)}$, and $g = 9.80665\mathrm{m/s^2}$. The barometer provides high-resolution vertical positioning complementary to GPS.

C. Attitude Estimation (Complementary Filter) Roll ($\phi$) and pitch ($\theta$) angles are fused from gyroscope and accelerometer data:

$$\hat{\theta} = \alpha(\hat{\theta}_{prev} + \omega_g \Delta t) + (1 - \alpha)\theta_{acc} \qquad (4.3)$$

where $\omega_g$is angular rate, $\Delta t$is sampling interval, $\theta_{acc} = \arctan\, 2(a_x, \sqrt{a_y^2 + a_z^2})$, and $\alpha \approx 0.98$balances dynamic response with drift correction.

D. Telemetry Data Rate & Latency MAVLink packet structure includes header (8 bytes), payload (up to 255 bytes), and CRC (2 bytes). At a standard SiK radio baud rate of 57600 bps, the system achieves ~40 Hz telemetry update with <100 ms latency, sufficient for real-time operator intervention.

## V. RESULT ANALYSIS

The proposed system was experimentally validated on a quadcopter platform integrated with the APM 2.8 controller, FlySky FS-i6 transmitter, and SiK telemetry module. Key observations are summarized below:

1. Communication Stability: The FlySky FS-iA6B receiver-maintained interference-free 2.4 GHz link control during manual flight, confirming robust RF coordination between pilot and drone.
2. Telemetry Performance: Mission Planner successfully received and rendered real-time data at 40 Hz. Battery voltage stabilized at 12.59 V with 100% SOC during pre-flight checks, indicating healthy cell balance and accurate power module calibration.
3. GPS & Navigation: The GPS module achieved a stable 3D fix within 15 seconds of power-on, providing sub-2.5 m horizontal accuracy. Satellite lock remained consistent during outdoor testing.
4. System State & Safety: Initial state displayed as DISARMED, confirming safe initialization. Threshold-based alerts were successfully triggered during simulated voltage drop and signal loss scenarios, validating fault-detection capabilities.
5. Dashboard Visualization: Real-time graphs, attitude horizon, and map tracking (Fig. 2 in original work) demonstrated intuitive operator supervision. Post-flight logs enabled detailed analysis of power consumption trends and flight path deviations.

The integration of battery and flight telemetry into a single interface significantly reduces cognitive load on operators, minimizes reaction time to anomalies, and supports data-driven mission optimization. Compared to isolated monitoring systems in the literature, this unified approach offers superior situational awareness without compromising cost or complexity.

## VI. CONCLUSION

This paper presented the design, implementation, and evaluation of a telemetry-based live monitoring system for UAV battery and flight parameters. By integrating the APM 2.8 flight controller, multi-sensor array, SiK radio telemetry, and Mission Planner GCS, the system delivers accurate, real-time data transmission with low latency and high reliability. Experimental results confirm stable communication, precise parameter tracking, and effective alert generation, directly enhancing flight safety and operational efficiency.

Future work will focus on cloud-based IoT integration for remote fleet monitoring, AI-driven predictive battery degradation models, autonomous fault-mitigation algorithms, and extended-range communication using LTE or satellite telemetry. The proposed framework serves as a scalable, cost-effective solution for academic research, commercial UAV operations, and advanced aerial robotics applications.

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