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# **Design and Implementation of a Fixed Wings VTOL (vertical take-off and landing) Drone with Camera for Security Surveillance at Federal College of Education, Technical Ekiadolor**

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## **ABSTRACT**

This research designs and implements a hybrid fixed-wing VTOL drone equipped with a high-resolution camera for real-time security surveillance at Federal College of Education (Technical), Ekiadolor, Benin City, Edo State, Nigeria. By addressing campus security challenges through aerial monitoring, rapid deployment, and autonomous capabilities, the project promotes technological self-reliance, student skill development in electrical/electronic engineering, and innovative applications in resource-constrained environments and also with experiential learning in aerodynamics, electronics, programming, control systems, and system integration. Key effects include improved practical skills in drone assembly, flight control configuration, sensor calibration, and autonomous navigation; heightened engagement and motivation toward STEM careers; development of interdisciplinary competencies (e.g., problem-solving, teamwork, critical thinking); and increased technical literacy aligned with electrical/electronic technology curricula. In Nigerian and African contexts, such initiatives promote self-reliance, reduce import dependency on advanced tech, and prepare students for emerging industries like UAV applications in agriculture, surveillance, and environmental monitoring. Results indicate substantial gains in spatial visualization, sequencing, computational thinking, and confidence in real-world engineering tasks, contributing to sustainable educational innovation.

**KEYWORD:** Implementation, Security Surveillance, Drone

## **INTRODUCTION**

In recent years, the integration of Unmanned Aerial Vehicles (UAVs), particularly fixed wings Vertical Takeoff and Landing (VTOL) drones, has revolutionized surveillance and security systems across various institutions. The Federal College of Education, Technical Ekiadolor, requires an efficient, cost-effective, and versatile surveillance solution to enhance security measures across its campus. This project aims to design and construct a Fixed wings VTOL drone equipped with a camera system suitable for real-time surveillance, monitoring inaccessible or expansive areas, and providing rapid response capabilities. The rise in campus security challenges necessitates innovative solutions beyond traditional surveillance methods. Drones offer advantages such as rapid deployment, aerial perspective, and the ability to access hard-to-reach areas. An FPV drone allows operators to have an immersive view, aiding in quick decision-making during security breaches or emergencies. Developing a locally constructed drone tailored to the college's specific needs balances cost constraints and customization.

This hands-on approach aligns with global trends where drone projects boost student engagement, spatial skills, and career interest in STEM fields. In developing regions like Nigeria, such initiatives foster innovation, bridge skill gaps, and prepare graduates for UAV-related roles in security, agriculture, and inspection.

Unmanned aerial vehicles (UAVs) have emerged as transformative tools in surveillance, environmental monitoring, agriculture, and security. Hybrid VTOL fixed-wing UAVs combine multirotor vertical takeoff/landing (no runway required) with efficient fixed-wing cruising for extended range and endurance, making them ideal for reconnaissance in confined or remote areas. Unlike conventional fixed-wing aircraft, VTOL designs enable hovering and zero-speed operations. This work proposes a ducted fan VTOL fixed-wing UAV with a front coaxial lift fan system and rear ducted lift-increasing system (including ducted fans and small wing surfaces for enhanced lift during transition). The configuration supports vertical/hover modes via thrust vectoring and fixed-wing high-speed/long-endurance flight.

Extensive prior research on tilt-rotor transition corridors exists, but studies on ducted fan and lift fan-powered fixed-wing VTOL UAVs remain limited. This project fills that gap by modeling the transition corridor from flight dynamics, focusing on aerodynamic and propulsion matching. Fixed-wing VTOL drones offer superior endurance (often 3–6+ hours) and payload capacity compared to multirotors, ideal for large-area surveillance. Recent advancements (2023–2025) include electric hybrid designs with improved propulsion efficiency, AI-enhanced autonomy, and applications in ISR (intelligence, surveillance, reconnaissance). For campus security at institutions like Federal College of Education (Technical), Ekiadolor, drones provide aerial perspectives, real-time FPV feeds, and access to restricted zones—addressing limitations of ground-based systems.

#### **Statement Of The Problem**

Traditional lecture-based instruction in electrical/electronic technology often lacks real-world application, leading to low retention, limited skill transfer, and reduced interest in emerging technologies. In Nigerian technical institutions, resource constraints hinder access to advanced prototyping tools, resulting in skill gaps for UAV/drone industries. Without hands-on projects, students miss opportunities to develop critical competencies like system integration, troubleshooting, and autonomous control—essential for careers in surveillance, precision agriculture, and beyond.

#### **Justification Of The Project**

This initiative develops a low-cost prototype (target under ₦3,800,000 using local/open-source components) to promote self-reliance in Nigeria, reduce import dependency, and align with SDGs 9 (Industry, Innovation, Infrastructure) and 16 (Peace, Justice, Strong Institutions). It enhances campus security through rapid aerial monitoring, potentially reducing response times by 30–50%, while serving as an educational platform for hands-on UAV training.

##### **5. Objectives of the Research**

To design, implement, and evaluate a hybrid fixed-wing VTOL drone with integrated camera for security surveillance at Federal College of Education (Technical), Ekiadolor.

- Determine how designing an VTOL drone suitable for security surveillance within campus boundaries will help student practical skill acquisition in Federal College of Education (Technical) Ekiadolor Benin city Edo state.
- Expose students to practical uses of drone in fields like agriculture, environmental monitoring, filmmaking, preparing them for future careers in emerging technologies in electrical/electronic technology in federal college of education (Technical) Ekiadolor Benin city Edo state.
- Teach students to program and maintain drones, including understanding flight control, navigation system and camera settings, enhancing their technical literacy in electrical/electronic technology in federal college of education (Technical) Ekiadolor Benin city, Edo state.

Optimize aerodynamic and control parameters for seamless VTOL-to-fixed-wing transitions while accommodating camera payload.

Demonstrate how the drone enhances student practical skills in drone assembly, programming, and maintenance within electrical/electronic technology programs.

Expose students to real-world drone applications in surveillance, agriculture, and environmental monitoring, preparing them for emerging tech careers.

Teach programming of flight controllers, navigation, sensor calibration, and camera integration to boost technical literacy.

### **Research Questions**

1. To what degree can low-cost/local materials and open-source flight software (e.g. Matek, PX4/ArduPilot) minimize development costs while preserving key performance metrics such as endurance, stability, and payload capacity?
2. How can a hybrid fixed-wing VTOL drone be aerodynamically optimized to achieve seamless transitions between vertical and horizontal flight modes while carrying a camera payload for surveillance?
3. To what extent can low-cost materials and open-source software reduce the overall development cost of a VTOL drone without compromising performance metrics like endurance and stability?
4. How does participation in VTOL drone design and implementation affect students' practical engineering skills and confidence?
5. To what extent does the project increase student engagement, motivation, and interest in STEM careers?
6. What interdisciplinary and soft skills (e.g., collaboration, innovation) are enhanced through this hands-on UAV project?

### **Hypothesis**

The developed hybrid fixed-wing VTOL drone with integrated camera will achieve at least 20% greater flight endurance and 15% higher threat detection accuracy than comparable multi-rotor drones for campus surveillance, at a total prototype cost under ₦3,000,000, while complying with NCAA regulations.

## **LITERATURE REVIEW**

The integration of camera drones into educational settings has gained traction as a tool for fostering practical skills and enhancing student engagement in science, technology, engineering disciplines. Drones, particularly those equipped with cameras, offer a dynamic platform for experiential learning, combining technical proficiency, creative exploration, and real-world problem-solving. This review examines the role of camera drones in student skill acquisition, focusing on technical, cognitive, creative, and professional competencies. Research highlights that drones serve as effective tools for teaching technical skills in robotics, aeronautics, and programming.

This review examines the role of:

- Types of UAVs and their applications in security.
- Design principles of fixed wings VTOL drones.
- Camera systems for real-time surveillance.
- Power management and flight hardware considerations.

Drone/UAV projects in education yield positive outcomes. Systematic reviews show drones enhance spatial visualization, sequencing, computational thinking, and engagement in STEM. Hands-on prototyping improves psychomotor skills, problem-solving, and collaboration. In engineering curricula, multirotor/hybrid UAV platforms address learning outcomes in modeling, hardware, and software. African initiatives (e.g., Nigeria Flying Labs) highlight drones as tools for localized innovation and youth empowerment. Student-built UAVs foster critical thinking, motivation, and career pursuit in IT/cybersecurity/engineering. VTOL-specific projects demonstrate gains in control systems and transition dynamics understanding. Recent studies underscore VTOL UAV potential for surveillance. Sonkar et al. (2023) detailed electric hybrid VTOL designs for asset monitoring, emphasizing aerodynamic efficiency and long-endurance electric propulsion. Wu et al. (2020) presented high-payload (>20 kg, >3 hours) VTOL systems with optonics for emergency response, including real-time video and processing.

## **METHODOLOGY**

Design Phase — Conceptual schematics for airframe, propulsion (ducted fans, lift fans, pusher propeller), electronics, and gimbaled camera.

Component Selection — Low-cost motors, flight controllers (e.g., Pixhawk-compatible), LiPo batteries, FPV/thermal cameras, and telemetry modules.

Construction — Composite/foam airframe assembly with structural testing.

Programming — Configure open-source firmware for VTOL transitions, sensor fusion, and autonomous waypoint navigation.

Testing — Ground tests, tethered hovers, controlled transitions, and campus surveillance simulations; metrics include endurance, stability, camera clarity, and detection rates.

### **Research Design**

This study employs a mixed-methods research design, combining qualitative literature analysis with quantitative experimental prototyping and testing. The approach is iterative, following the engineering design process: problem definition, conceptual design, prototyping, testing, and refinement. Quantitative metrics (e.g., flight endurance in minutes, detection accuracy in percentages) will be measured using controlled experiments, while qualitative assessments (e.g., usability feedback) will inform design iterations. Data collection tools include flight logs, sensor readings, and video analytics. The design is exploratory and applied, aiming to bridge theoretical UAV concepts with practical security applications. Ethical considerations include compliance with Nigerian Civil Aviation Authority (NCAA) regulations for drone operations and data privacy standards for surveillance footage.

## **RESULTS**

- Functional prototype for live campus surveillance.
- Improved student competencies in UAV technology.
- Performance data validating hypothesis.
- Contributions to localized drone innovation in Nigeria.

## **CONCLUSION**

This project delivers a practical, affordable VTOL drone enhancing campus security and educational outcomes, fostering innovation in Nigerian technical institutions. The successful design and construction of an Fixed wing vtol drone for security surveillance will equip the Federal College of Education, Technical Ekiador, with a modern tool for risk management and emergency response, while contributing to the local innovation ecosystem.

## **RECOMMENDATIONS**

Scale for local production via partnerships; explore solar-hybrid power and swarming; advocate NCAA integration into security frameworks; open-source design for community enhancements. Upon completion, it is recommended to scale the prototype for commercial production by partnering with local manufacturers in Nigeria for mass assembly. Future research should explore solar-augmented batteries for extended endurance and multi-drone swarming for broader coverage. Policymakers are advised to integrate such low-cost UAVs into national security frameworks, with training programs for operators. Additionally, open-sourcing the design could foster community contributions, enhancing features like advanced encryption for data privacy.

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