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Efficiency and Effectiveness of the Introduction of Unmanned Aerial Vehicles as a Complement to Existing Security Apparatus on a Nigerian University

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ABSTRACT

This study evaluated the efficiency and effectiveness of integrating Unmanned Aerial Vehicles (UAVs) into the existing security surveillance architecture of Obafemi Awolowo University (OAU), Ile-Ife, a large public university with a campus area of 5,619.82 hectares. A mixed-methods case study design was employed, utilizing four-year historical security incident records (2021–2025), financial data on surveillance expenditure, a pilot UAV deployment programme, and structured questionnaires administered to 200 non-security and 50 security personnel. Findings revealed that the existing triad of personnel, vehicle patrols and closed-circuit television (CCTV) leaves over 60% of the campus unmonitored, with personnel alone consuming 97.3% of the security budget yet capable of covering only 20.2% of the total area. The introduction of two civilian-grade XT505 UAVs achieved 100% aerial coverage, detected 15.6% of post-deployment incidents, outperforming both vehicle patrols (9.3%) and CCTV (4.6%), at a cost per incident of ₦33,333 compared to ₦202,590 for vehicle patrols and ₦1,406,250 for CCTV. The UAVs were particularly effective in detecting unauthorized access (61.1% of such incidents) and traffic violations, and reduced response times from 10–15 minutes to 2–5 minutes. Stakeholder acceptance was exceptionally high, with 95.7% of non-security respondents and 100% of security personnel supporting full integration. The study concluded that efficiency and effectiveness of integrating Unmanned Aerial Vehicles (UAVs) into the existing security surveillance architecture of the university represent a financially sustainable, operationally superior force multiplier that dramatically enhanced situational awareness and fills massive spatial surveillance gaps. A phased, integrated deployment model is recommended for OAU and similar institutions.

KEYWORDS: Unmanned Aerial Vehicles, Security Surveillance, Campus Security

I. INTRODUCTION

Universities in Nigeria have, in the last two decades, witnessed an alarming escalation in security threats ranging from petty theft and burglary to armed robbery, kidnapping, and cult-related violence. Ekpoh, Edet and Ukpong (2020) documented that cult-related activities, drug abuse, illegal possession of firearms, room break-ins, stealing and sexual assaults are among the most prevalent security challenges on campuses. The porous nature of many university environments, combined with inadequate surveillance infrastructure, makes them soft targets for criminal elements (Abdullahi & Orukpe, 2016; Enang, 2019). The Obafemi Awolowo University (OAU), Ile-Ife, exemplifies this predicament. With a land area of approximately 5,620 hectares, comprising academic zones, dense residential quarters, agricultural farms, forest reserves, and a large central market, the campus presents formidable surveillance challenges. Over the past four academic sessions, the university recorded 1,498 security incidents, with theft and burglary accounting for 34.6% of all cases. The limitations of conventional surveillance have spurred

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interest in remote sensing aerial platforms, notably Unmanned Aerial Vehicles (UAVs). UAVs offer the ability to cover vast areas rapidly, transmit live video feeds, access difficult terrain, and serve as visible deterrents (Clarke, 2014; Xiao & Jiao, 2021). While drone technology has been deployed successfully in border security, disaster management and large-event monitoring, its systematic integration into Nigerian university security is still nascent. This study therefore assesses the efficiency and effectiveness of introducing UAVs as a complementary security measure on the OAU estate. Specifically, it examines (1) the coverage and detection gaps inherent in the existing surveillance system; (2) the operational and financial performance of UAVs relative to conventional methods; and (3) the acceptance levels among security personnel and the broader university community. By providing empirical evidence from a pilot UAV programme, the study offers a replicable model for enhancing campus safety in resource-constrained settings.

II. RELATED WORKS

The literature consistently portrays Nigerian universities as increasingly vulnerable environments. Ekpoh et al. (2020), in their study of universities in Cross River State, identified cult-related activities, kidnapping, drug abuse and sexual harassment as top security threats, while inadequate security personnel, insufficient patrol vehicles, poor lighting and non-availability of modern security facilities were the principal militating factors. Similarly, Badiroa (2017), in a spatial analysis of crime at a Nigerian university, found that stealing, room break-in, sexual harassment and cultism were the most frequent offences, often concentrated around student hostels and poorly lit pathways. These findings underscore the inability of static, manpower-heavy systems to cope with the dynamism of contemporary campus crime. Adams et al. (2023) further noted that the Nigerian education sector is currently grappling with "topical issues of insecurity" that have led to the destruction of facilities and, tragically, the death of students and staff. This surge in criminality is often a byproduct of broader national issues such as cattle rustling and banditry, which have displaced over 295,000 individuals in 2024 alone (Internal Displacement Monitoring Centre, 2025). Unmanned Aerial Vehicles (UAVs) have evolved from exclusively military applications to versatile civilian tools for surveillance, search-and-rescue, and infrastructure inspection (Colomina & Molina, 2014). Equipped with high-resolution electro-optical sensors, thermal cameras, and real-time video transmission, modern UAVs can provide persistent wide-area monitoring and rapid incident assessment (Watts et al., 2012). Xiao and Jiao (2021) demonstrated from a situational crime prevention perspective that the mere presence of a hovering UAVs increased perceived risk among potential offenders, thereby deterring opportunistic crimes. In the campus context, studies from the University of Connecticut and the University of North Georgia have reported that UAVs enhance crowd monitoring and emergency response (University of North Georgia Public Safety Report, 2021). Furthermore, the integration of artificial intelligence enables automated detection of suspicious behaviours, reducing the cognitive load on human operators (Dash et al., 2023). Recent advancements in autonomous UAV technology have facilitated routine surveillance operations through scheduled perimeter patrols using UAVs equipped with surveillance cameras (Ahmed & John, 2022).

The integration of Unmanned Aerial Vehicles as a remote sensing aerial platform into campus security surveillance has gained momentum over the last few years. According to a report by the Center for the Study of Drone at Bard College, approximately 24% of universities surveyed were using UAVs for campus security monitoring as of 2020 (Bard College, 2020). The University of Connecticut has employed UAVs to assist in monitoring crowds and major events, providing real-time aerial surveillance that enables law enforcement to respond quickly to potential threats.

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Similarly, the University of North Georgia has deployed drones primarily for search and rescue operations and monitoring large gatherings (University of North Georgia Public Safety Report, 2021). The adoption of UAVs for campus security varies significantly among institutions, primarily driven by factors such as institutional policies, budget constraints, regulatory frameworks, and attitudes towards privacy concerns (Smith, 2015). Research indicates that while some universities have fully embraced UAV technology, others remain hesitant due to public perceptions of surveillance and regulatory limitations surrounding the use of drones (Hassan & Maria, 2025). According to Yilmaz (2013), UAVs maximize operational efficiency by reducing the time and costs associated with traditional surveillance methods. They can cover vast areas swiftly, allowing for real-time data collection and analysis, which is critical for proactive security measures. This agility enables security forces to respond more quickly to potential threats, enhancing overall safety. Moreover, Abdelkader et al. (2024) emphasize that UAVs equipped with high-resolution cameras and sensors can gather detailed imagery and data across various environmental conditions, providing invaluable intelligence for security operations. The integration of artificial intelligence (AI) in UAV systems further augments their surveillance capabilities, as AI algorithms can analyze captured data to detect anomalies or potential threats with remarkable accuracy (Sifat & Wooyeo, 2022).

The use of UAVs can significantly reduce the carbon footprint associated with traditional ground-based surveillance methods, which often require extensive vehicular movement and manpower. Abdul et al. (2026) argue that UAVs not only lower operational emissions but also optimize resource allocation by minimizing the need for physical patrolling. The present study draws on three complementary theoretical frameworks. Situational Crime Prevention (SCP) theory posits that crime can be reduced by increasing the perceived effort and risk for offenders while reducing rewards (Clarke, 1997). UAVs contribute directly to increasing perceived risk through visible aerial surveillance and the potential for swift apprehension. The Technology Acceptance Model (TAM) explains user adoption as a function of perceived usefulness and perceived ease of use (Davis, 1989); a high level of acceptance among security operators and the community is essential for successful UAV integration. Finally, Surveillance Theory, rooted in Foucault's panopticism, suggests that omnipresent observation disciplines behaviour (Lyon, 2007). Collectively, these frameworks provide a lens to evaluate both the objective performance and the stakeholder reception of drone technology on campus.

Despite continuous investment in security, OAU has experienced a persistent rise in criminal incidents, with reported cases surging by 53.9% between the first and fourth years under study. The existing surveillance triad—security personnel, a fleet of patrol vehicles covering 35.8% of the campus, and a CCTV network limited to 1.5% of the area—leaves large portions of the university, including agricultural farms, peripheral residential quarters, and recreational zones, entirely unmonitored. Personnel costs alone consume over 97% of the security budget, yet the cost per incident detected by personnel exceeds ₦2.9 million. Meanwhile, the CCTV system, into which ₦45 million was invested, detected only 32 incidents over four years. This inefficient allocation of resources, combined with inadequate spatial coverage, creates substantial security blind spots that are exploited by criminals. There is, therefore, an urgent need to evaluate whether the introduction of UAVs can bridge these coverage gaps, improve detection rates, and yield a more favourable cost-benefit ratio, thereby enhancing the overall efficiency and effectiveness of campus security. This study specifically addresses three research objectives: (1) to assess the coverage and detection gaps inherent in the existing surveillance system; (2) to evaluate the

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operational and financial performance of UAVs relative to conventional methods; and (3) to determine the acceptance levels among security personnel and the broader university community.

III. METHODOLOGY

A mixed-methods case study design was adopted, combining quantitative analysis of institutional data with a pilot UAV deployment and stakeholder surveys. The study was conducted at Obafemi Awolowo University, Ile-Ife, between September 2021 and August 2025. The case study design was chosen to provide a holistic understanding of UAV integration within the specific context of a large Nigerian university (Yin, 2014). Obafemi Awolowo University is situated in Ile-Ife, an ancient Yoruba city considered the cradle of Yoruba civilization. The university's campus is characterized by undulating terrain, lush vegetation, and a mix of forested and developed areas. The precise coordinates of the university's main campus are 7°35'N, 4°27'E; 7°35'N, 4°35'E; 7°29'N, 4°34'E and 7°29'N, 4°27'E. The land use/cover is diversified, including academic and administrative zones, residential areas, agricultural and forested zones, and recreational spaces. The expansive and sometimes isolated nature of the campus makes surveillance challenging, necessitating enhanced security measures. As of 2023, estimates suggest over 35,000 students (undergraduate and postgraduate) and approximately 5,000 staff members (Konwea, 2023). The high population density, coupled with inadequate security infrastructure, has contributed to rising criminal activities.

The data source are historical security data comprising Incident reports for four academic sessions (1,498 records) which were obtained from the university's Security Department, coded by type, location, time, and method of detection. These data covered the period from September 2021 to August 2025. Similarly, financial records comprising maintenance and operational costs for personnel, vehicle patrols, and CCTV were extracted from the university's financial records. Personnel costs over the four-year period totalled ₦3.076 billion, vehicle patrol costs amounted to ₦39.1 million, and the CCTV investment was ₦45 million. Pilot UAV Programme: Two XT505 civilian-grade enterprise drones, equipped with 4K electro-optical cameras and 5G/Wi-Fi real-time video transmission, were deployed on a rotational schedule from April to August 2025. The UAVs operated at altitudes of 50–100 metres and followed pre-planned flight paths using RX drone software. Flight logs, incident detections, and coverage maps were recorded. Key operational parameters included average flight time per mission (28 minutes), battery-swapping protocol (rotational system with 2 UAVs and 6 additional charged batteries), and sustained operational duration (over 6 hours). Weather constraints were noted, with wind speeds above 40 km/h reducing flight time by approximately 15%.

Structured questionnaires were administered to 200 non-security personnel (students, academic and non-academic staff) and 50 security personnel. The questionnaires assessed awareness, perceived usefulness, perceived ease of use, safety concerns, and support for UAV adoption. A 4-point scale was used (1 = Low Acceptance, 4 = High Acceptance). The sample size of 250 was selected from the total population of 35,000, providing a margin of error of ±6% at a 95% confidence level. Data analysis was carried out by computing the Spatial coverage in ArcGIS 10.8 using digitized patrol routes and fixed post locations. Geostatistical tools including Kriging interpolation and Thiessen polygons were used to evaluate coverage gaps and incident distribution patterns. Descriptive statistics, cross-tabulations, and cost-per-incident ratios were calculated. A chi-square test was used to compare acceptance levels between respondent groups (non-security and security personnel). Thematic content analysis of open-ended survey responses complemented the quantitative findings.

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The study addressed the following questions:

(a). What are the coverage and detection capabilities of the existing security surveillance systems at OAU?

(b). What is the comparative cost-effectiveness of UAVs relative to personnel, vehicle patrols and CCTV?

(c). What are the acceptance levels of UAV technology among security personnel and the university community?

IV. RESULTS AND DISCUSSION

The study is centred on four major surveillance systems which include Personnel, Closed Circuit Television (CCTV), Vehicle Patrols, and the pilot deployment of UAVs. A fifth component, involving security incidences, detected by community members and victims' reports, classified as Others. However, analyses were based primarily on Personnel, CCTV, Vehicle Patrol and UAVs. Table 1 summarizes the area coverage and detection contribution of the surveillance systems in OAU. Although vehicle patrols covered the largest area (35.75%), they detected only 12.93% of all incidents. Personnel, covering just 20.18% of the campus, were responsible for 69.55% of detections. The CCTV system, with a mere 1.51% coverage, detected 2.13% of incidents. Over 60% of the university's territory, including critical hotspots and peripheral residential quarters, had no persistent surveillance.

Table 1: Area Covered and Incidents Detected by Pre-UAV Surveillance Systems

S/N	Surveillance System	Area Covered in Square Hectare	Percentage Area Covered
1.	Personnel	1,134.43	20.18%
2.	CCTV	85.16	1.51%
3.	UAV	5,619.82	100%
4.	Vehicle patrol	2,008.35	35.75%
	Total area of university	5,619.82	

Source: OAU Security Department

The deployment of two XT505 UAVs, operating at 50–100 m altitude with pre-planned flight paths, provided 100% aerial coverage of the entire campus. See Figure 1. During the five-month pilot period, the UAVs detected 27 out of 173 security incidents, accounting for 15.61% of total detections. This placed UAVs as the second most effective single detection method, after personnel (36.42%) and ahead of vehicle patrols (9.25%) and CCTV (4.62%). The UAVs were particularly successful in identifying unauthorized access (11 out of 18 such incidents, or 61.1%) and traffic violations (6 out of 15 incidents, 40%). The "Others" category was the most prolific detector of incidents (59 out of 173, or 34.1%). This category includes reports from victims, whistleblowers, or other non-technical means. The high number of incidents like fraud, breach of agreement, and assault detected by "others" indicates a class of crimes that are largely invisible to all electronic and patrol-based surveillance methods, including UAVs.

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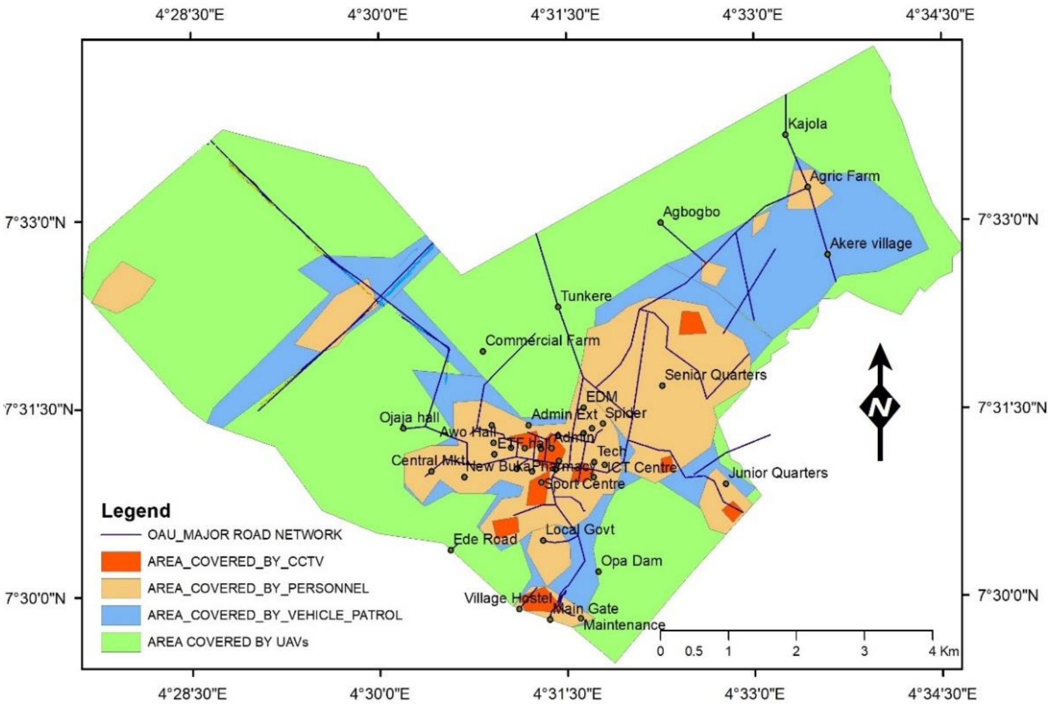

Figure 1: Area Covered by Surveillance System

Table 2 details the post-UAV incident detection by method. The average incident response time for UAVs was 2–5 minutes, compared with 5–10 minutes for vehicle patrols and 10–15 minutes for foot patrols.

Table 2: Post-UAV Incident Detection by Surveillance Method (April–August 2025)

Type of Incidence	Personnel	Vehicle Patrol	CCTV	UAV	Others	Total	%
Abuse of traffic rule	3	6	0	6	0	15	**8.67%**
Accident	8	2	0	2	0	12	**6.94%**
Assault/Harassment	0	0	0	0	7	7	**4,05%**
Breach of agreement	1	0	0	0	15	16	**9.25%**
Damages	5	0	0	0	9	14	**8.09%**
Death	1	0	0	0	0	1	**0.58%**
Fraud	0	0	0	0	7	7	**4.05%**
Hawking/Loitering	10	5	0	3	0	13	**7.51%**
Lost but found	6	0	0	0	0	6	**3.47%**
Suicide	0	0	0	0	0	0	**0%**
Theft/ Burglary	20	0	7	2	8	37	**21.39%**

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Threat	0	0	0	0	2	2	**1.16%**
Unauthorized access	4	1	1	11	1	18	**10.40%**
Other Incidences	5	2	0	3	10	20	**11.56%**
Total	**63**	**16**	**8**	**27**	**59**	**173**	**100%**
%	**36.42%**	**9.25%**	**4.62%**	**15.61%**	**34.10%**	**100%**	

Source: OAU Security Department

Cost-Benefit analysis showed that over four years, the university spent approximately ₦3.076 billion on security personnel, ₦39.1 million on vehicle patrols, and ₦45 million on CCTV. The UAV pilot programme incurred a cost of only ₦900,000, covering drone purchase and basic maintenance. Table 3 presents the cost per incident detected for each method, revealing that UAVs offer a dramatic cost advantage. Each incident detected by UAVs cost ₦33,333, compared to ₦2,952,015 for personnel, ₦202,590 for vehicle patrols, and ₦1,406,250 for CCTV.

Table 3: Comparative Cost per Incident Detected

Surveillance Method	**Total Cost (N)**	**% Cost**	**Incidents Detected**	**Cost Per Incident Detected (N)**
Personnel	3,076,000,000	97.3%	1042	2,952,015
Vehicle Patrol	39,100,000	1.24%	193	202,590
CCTV	45,000,000	1.42%	32	1,406,250
UAV	900,000	0,028%	27	33,333
Others	N/A	N/A	203	N/A
Total	**3,161,000,000**	**100%**	**1498**	

Source: OAU Security Department

Analysis of the questionnaires administered showed that awareness of UAV technology was near-universal (94% among non-security, 96% among security personnel). As shown in Table 4, perceived usefulness and safety ratings were extremely high: 96.8% of non-security respondents agreed or strongly agreed that UAVs deter security threats, 57.4% perceived their use as "very safe," and 95.7% supported university-wide adoption. Among security personnel, 91.7% believed UAVs contribute moderately or very well to public safety, and 100% rated integration with existing systems as moderately or very effective. A chi-square test revealed a statistically significant difference in response distributions between the two groups ($\chi^2 = 11.61$, df = 3, $p < 0.05$), with non-security personnel displaying even stronger enthusiasm, though both groups clearly favoured adoption.

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Table 4: Key Stakeholder Perception Indicators

Indicator	Non-Security Personnel	Security Personnel
Awareness of UAV technology	94.0%	96.0%
Agree/strongly agree UAVs deter threats	96.8%	–
Perceive UAVs as "very safe"	57.4%	–
Likely to support UAV adoption	95.7%	–
Believe UAVs contribute well to crime reduction	–	91.7%
Believe integration with existing systems effective	–	100%

Source: Field Survey, 2025

Discussion

The findings of this study systematically address the three research objectives:
With regard to assessing coverage and detection gaps, this was achieved through the spatial analysis presented in Table 1, which revealed that over 60% of the campus lacks persistent surveillance, with personnel covering only 20.18% of the area yet detecting 69.55% of incidents. This confirms the structural inefficiency noted by Ekpoh et al. (2020), who lamented that poor funding and inadequate technology in Nigerian university security departments lead to reactive rather than proactive crime management. Similarly, for evaluation of operational and financial performance of UAVs, this was addressed through the cost-benefit analysis (Table 3) and the post-UAV incident detection data (Table 2). The UAV pilot closed the spatial gap, delivering 100% aerial coverage at ₦33,333 per incident detected; 88.8 times more cost-efficient than personnel and 42.2 times more efficient than CCTV. This aligns with the resource optimization argument of Yilmaz (2013), who found that UAVs reduce the time and costs associated with wide-area surveillance. For stakeholder acceptance, this was achieved through the questionnaire surveys (Table 4), which showed overwhelming support from both security personnel and the broader university community. This high acceptance level mirrors findings from other university trials, such as at the University of Connecticut, where community support was pivotal to programme success. Generally, the introduction of UAVs fundamentally transforms the surveillance capability of OAU. Prior to UAV deployment, the university's security architecture was marked by a severe spatial mismatch, the method that consumed nearly all financial resources (personnel) covered only one-fifth of the campus, while the only system offering broad mobility (vehicle patrols) could not provide persistent observation. The UAV pilot closed this spatial gap, delivering 100% aerial coverage. The exceptional performance of UAVs in detecting unauthorized access (61.1%) and traffic violations (40%) underscores the situational prevention principle that elevating guardianship through visible aerial surveillance deters and detects opportunistic crimes (Clarke, 1997; Xiao & Jiao, 2021). The presence of a hovering drone increased perceived risk among potential offenders, thereby deterring opportunistic crimes. However, the study acknowledges several limitations. First, the UAV evaluation was conducted over a five-month period, which may be insufficient to draw strong conclusions regarding long-term effectiveness, sustainability, and impact on crime reduction. Second, the study is based on a single university case study; consequently, the findings may not be directly applicable to institutions with different sizes, layouts, security challenges, or regulatory environments. Third, the study did not fully explore the influence of weather conditions on UAV operations, though it was noted that wind speeds above

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40 km/h reduced flight time by approximately 15%. Despite these limitations, the study provides robust evidence that UAVs can serve as a cost-effective force multiplier in campus security. The findings are particularly relevant for other Nigerian universities and similar institutions in developing nations facing comparable resource constraints and security challenges.

From the perspective of the Technology Acceptance Model, the overwhelming positive perception among both security operators and the campus community is a critical enabling factor. Security personnel, though initially more cautious, recognized the operational benefits, particularly the ability to view incidents in real time and direct responses more safely. Non-security stakeholders valued the increased sense of safety and the visibility of the technology. Nevertheless, the study also revealed the inherent limitations of UAVs. They were ineffective in detecting concealed or interpersonal crimes such as assault, fraud, and breaches of agreement, which are typically reported by victims or witnesses. This reinforces the argument that UAVs are a complement, not a replacement, for human personnel and community reporting systems (Gill & Spriggs, 2005). The optimal security posture is a layered one as depicted in Figure 2, where UAVs provide wide-area aerial awareness, CCTV secures fixed indoor chokepoints, vehicle patrols serve as rapid armed response, and personnel handle investigations and community engagement.

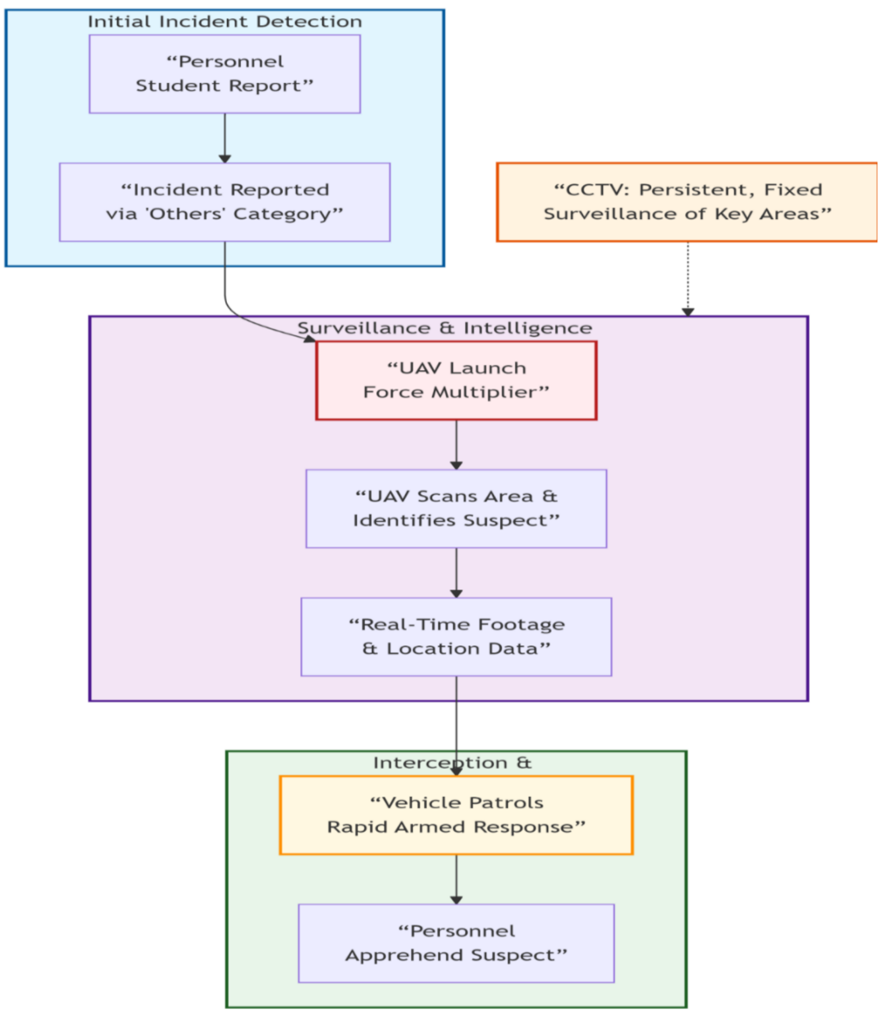

Figure 2: Integrated Workflow of Surveillance System

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The high susceptibility to adverse weather conditions means the system cannot be considered an all-weather solution, necessitating the establishment of alternative security protocols during inclement weather. The logistical dependency on a robust battery-swapping regimen and scheduled maintenance highlights that the practicality of long-duration surveillance is contingent on a sophisticated logistical plan rather than the UAV's innate endurance.

V. CONCLUSION

This study has provided robust empirical evidence that the integration of UAVs into the security apparatus of Obafemi Awolowo University yields exceptional efficiency gains in terms of coverage, cost per incident, and response speed, while also enhancing the effectiveness of crime detection, particularly for observable outdoor offences. The UAV system acts as a force multiplier that fills the enormous spatial gaps left by traditional methods, transforming campus security from a reactive, manpower-intensive model to a proactive, intelligence-led one. The overwhelming stakeholder acceptance further supports full-scale implementation. The pilot programme at OAU successfully demonstrated a paradigm shift from reactive to proactive security surveillance. The findings provided a replicable framework for other universities in developing nations facing similar resource constraints and security challenges. The study concluded that integration of unmanned aerial vehicles for proactive campus-wide security surveillance at OAU was feasible with proper training and regulatory compliance. Based on these findings, the following recommendations are made: Firstly, a dedicated UAV operations unit, comprising trained security personnel and equipped with sufficient UAVs and battery-swapping logistics, should be established. Secondly, institutional UAV policy must be developed, addressing flight protocols, data protection, privacy safeguards, and compliance with NCAA regulations. Thirdly. continuous training and community sensitization programmes should be sustained to maintain high acceptance and operational competence. Further research is recommended to evaluate the long-term impact of UAVs on crime trends, the integration of thermal/infrared sensors for enhanced night operations, and the application of artificial intelligence for automated threat recognition.

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