



An Overview of Unmanned Aerial Vehicles Technologies for Office Use and Services Delivery

Olarewaju T. OGinni

Department of Mechanical Engineering, College of Technology, Bamidele Olumilua University of Education, Science and Technology, Ikere-Ekiti, Ekiti State, Nigeria

oginni.olarewaju@bouesti.edu.ng

Abstract

Universities are transforming into smart ecosystems driven (SED) by technology, transforming office logistics from inefficient processes to faster, more efficient, and innovative ones, thereby enhancing modern communication. Quadcopter drones (QCD) with delivery systems are revolutionizing office logistics by increasing efficiency, reducing costs, and boosting productivity. The paper explores the feasibility and functionality of a drone-based system for autonomously transporting small office items, aiming to improve efficiency, reduce human effort, and provide a reliable, secure intra-office delivery method. Unmanned Aerial Vehicles (drones) are transforming office spaces by eliminating human couriers and facilitating document transportation, especially for physical documents like examination scripts, parcels, and administrative files, thereby improving operational efficiency. The overview examines how automated drone delivery systems (ADDS) can be utilized in offices to improve operational efficiency, productivity, and comfort by focusing on pick-and-delivery mechanisms and technologies that offer practical solutions for office deliveries and automation. It examines the functionality of a quadcopter drone for outdoor delivery applications, focusing on delivery mechanisms, classification, aerodynamics, control systems, power management, battery efficiency, area navigation, obstacle avoidance, challenges, payload capacity, case studies, and security measures. The outcomes showed that drones can carry 500 grams to 2 kilograms and navigate university campuses within 2-5 km, transferring documents like transcripts, letters, memos, and USB drives using lightweight folders, envelopes, or hard cases securely fastened in the drone's payload compartment. The implementation of an autonomous quadcopter drone for university document delivery is expected to enhance inter-faculty communication, decrease staff workload, and boost operational efficiency. The review promotes the integration of smart technologies in corporate operations, aiming to enhance the efficiency and innovation of university campuses.

Keywords: Universities, modern communication, smart technologies, delivery system, operational efficiency.

1.0 Introduction

Researchers are exploring drone delivery for enhanced coverage, document transportation, and last-mile delivery in office delivery systems, aiming to improve accessibility, convenience, and efficiency in the face of increasing automation and fuel efficiency needs [1]. Drone technology enhances students' learning experiences in speaking, writing, and physical education courses and efficiently distributes book content to densely populated areas where central libraries are difficult to access [2]. Efficient internal logistics for universities and hospitals require bicycle-based parcel delivery patterns, enabling smaller businesses to compete by avoiding traffic jams and achieving faster delivery times [3]. Drone deliveries are revolutionizing logistics by offering cost-effectiveness, speed, and reduced transit time, making them a game-changer in time-sensitive situations [4]. Drones offer energy efficiency, reducing environmental impact and enabling delivery systems to operate without road networks, thereby reducing traffic jams and geographical restrictions. Numerous practical applications and analyses have been conducted for this reason [5].

Numerous studies explore drone technologies in logistics, focusing on design optimization for small office spaces, indoor smart delivery, and GPS-denied environments, with research highlighting their significance [6]. Technological advancements have significantly impacted organizational tasks, with the integration of unmanned aerial vehicles (UAVs) in commercial and office environments gaining popularity for speed, efficiency, and automation [7]. Quadcopter drones, with four rotors, are increasingly used for surveillance, mapping, agriculture, and delivery services due to their versatility [8]. Recently, drones are being used for delivery due to the rapid growth of e-commerce and the growing need for timely services, particularly in interdepartmental and interbuilding transfer processes. UAV technology has revolutionized repetitive tasks by incorporating quadcopters with integrated delivery mechanisms, reducing the need for manual labor and enhancing operational efficiency [9]. The creation of a quadcopter drone specifically designed for office use offers a promising avenue to explore automation in confined and structured environments.

Drones offer innovative office logistics, reducing time and human resources and minimizing human contact, making them essential in post-pandemic workspaces [10]-[11]. This paper reviews the technical realization and

performance evaluation of a drone, focusing on its safety, reliability, and efficiency in intra-office service delivery. The review of a drone-based delivery system aims to enhance productivity and alleviate human fatigue in office operations. It therefore explores the practical application of UAVs in modern office environments, specifically designing and implementing a quadcopter drone for light delivery tasks. Drones with pick-and-deliver mechanisms can enhance institutional workflow efficiency by reducing time and work required in traditional delivery techniques, allowing quick product movement across large campuses [12].

The study explores the feasibility and operation of a drone-based system for autonomous office item transportation, aiming to boost productivity, reduce human labor, and improve document transportation efficiency, such as for administrative files, parcels, and exam scripts. The overview provides a foundation for automated drone delivery systems in workplaces, enhancing operational efficiency, productivity, and comfort, offering practical solutions for office deliveries and automation. The building of an autonomous quadcopter drone for university document delivery was supported by descriptive analysis and empirical data in order to improve inter-faculty communication, reduce staff effort, and increase operational efficiency. In an effort to boost university campuses' productivity and creativity, the study advocates for the use of smart technology in business operations.

2.0 Benefits of Unmanned Aerial Vehicles Application

Drones enable vertical transport of office documents, parcels, and academic materials, facilitating faster delivery in areas with elevators or stairs, especially during peak hours. Drones can operate with less power during low demand, reducing energy consumption. Drones enhance operational efficiency by reducing pick and delivery time and resources and allowing for flexible adjustment based on demand, making them more responsive to urban delivery needs [13].

- i. Drones offer increased efficiency by quickly covering large areas, reducing inspection times and costs compared to traditional methods.
- ii. Remote drone operations enhance safety by reducing human risk, particularly in hazardous environments like mines or during disasters.
- iii. High-resolution images, videos, and sensor data offer valuable insights for analysis and decision-making.
- iv. Institutions can experience significant long-term savings due to reduced inspection costs and faster response times.

3.0 Specific Application of Unmanned Aerial Vehicles

Drone technology is being utilized by various industries, including transportation, security, agriculture, military, engineering, maintenance, structural integrity evaluation, visualization, and entertainment. Drones enhance efficiency, safety, and resource management in institutional utilities by efficiently gathering data, assessing conditions, and responding to various needs [14].

- i. Drones are utilized for efficient and secure infrastructure inspections, providing high-resolution images and videos for analysis of structures like buildings, bridges, and power lines.
- ii. Drones play a crucial role in disaster management by providing real-time information on damage, evaluation routes, and search and rescue efforts.
- iii. Drones can enhance resource monitoring by monitoring crop health, wildlife, and environmental conditions, enabling data-driven decision-making in sectors like agriculture and conservation.
- iv. Drones provide a cost-effective and efficient alternative to traditional methods for perimeter security, traffic management, and crime scene surveillance.
- v. Drones aid to mapping and surveying by creating detailed 3D models of areas, enabling efficient planning, construction monitoring, and resource management.

4.0 Classification of Unmanned Aerial Vehicles (Drones)

[15] classify drones based on weight, with super-heavy drones over 2000 kg, heavy drones 200-2000 kg, light/mini drones 5-50 kg, and medium drones 50-200 kg. Micro air vehicles (MAVs) are the most popular for recreational use, weighing less than 5 kg. UAVs can also be categorized based on altitude and endurance. Drones have evolved from military use to commercial and civil applications. They are classified based on size, range, wing configuration, control mechanism, and purpose, making understanding their classifications useful in use-case scenarios like indoor office delivery [16].

4.1 Classification of Unmanned Aerial Vehicles Based on Size

- i. Nano Drones: Drones, originating from micro-robotics research, are used in consumer hobbies, classroom instruction, and covert operations due to their small size (less than 250g) and maneuverability, as presented in Figure 1a [17].

- ii. **Micro/Mini Drones:** The lightweight, 250g to 2kg reconnaissance cameras are commonly used in amateur photography, indoor delivery, and training due to their lightweight nature, as shown in Figure 1b [18].
- iii. **Medium Drones:** Medium drones weighing 2 kg-25 kg were initially utilized for agricultural observation and pipeline inspection, delivering packages, surveying land, and monitoring infrastructure, as shown in Figure 1c [19].
- iv. **Large Drones:** Large drones (above 25kg in size), initially military tools for border surveillance and target practice, are now utilized in logistics, mapping, and emergency relief operations [20]. It is shown pictorially in Figure 1d.

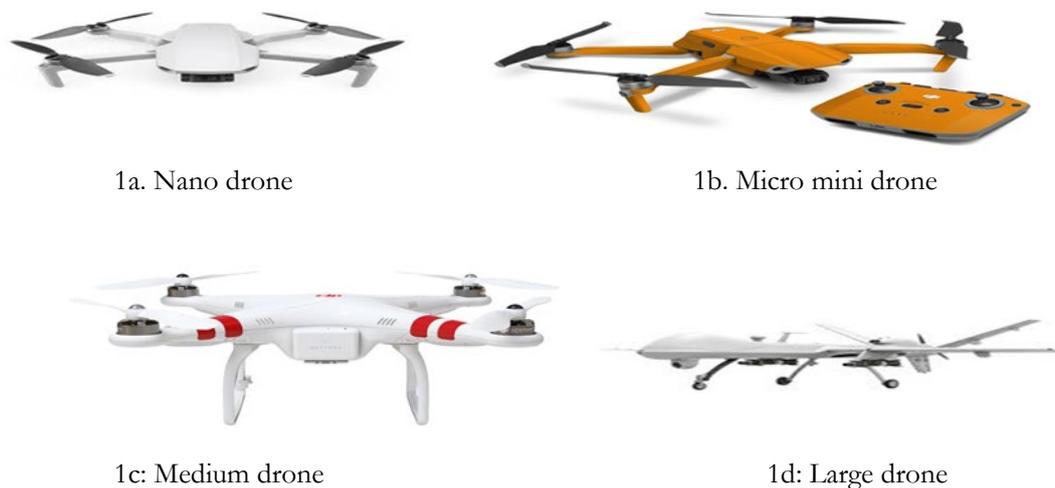


Fig. 1 (a-d): Classification of drones based on size [21]

4.2. Classification of Unmanned Aerial Vehicles Based on Range and Endurance

- i. **Very Short-Range Drones:** Most office delivery drones are designed for light loads within buildings, falling under the less than 5 km category [22].
- ii. **Short-Range Drones:** This device is utilized for security surveillance within a 5–150 km range, forest monitoring, and precision agriculture [22].
- iii. **Mid-Range Drones:** Mid-range drones with a 150-650 km range are utilized by law enforcement agencies, border patrols, and large-scale mapping services [23].
- iv. **Long-Range/Endurance Drones:** Drones, initially designed for military reconnaissance, are now being considered for transcontinental deliveries and long-distance rescue missions over 650 km.

4.3. Classification of Unmanned Aerial Vehicles Based on Wing Configuration

- i. **Fixed-Wing Drones:** Fixed-wing drones, derived from traditional aircraft design, are ideal for large-area mapping and agricultural surveying but require runways for takeoff and landing, limiting indoor use [24].
- ii. **Rotary-Wing Drones (Helicopter-style):** Drones, inspired by helicopters, are ideal for deliveries, inspections, and photography, with the quadcopter being the most common subtype, commonly used in office delivery systems.
- iii. **Hybrid Drones (VTOL—Vertical Take-Off and Landing):** Vertical Take-Off and Landing (VTOLs), combining fixed and rotary wings, are newer aircraft designed for endurance and vertical landing/take-off applications, particularly in urban deliveries.

4.4 Classification of Unmanned Aerial Vehicles Based on Control Method

- i. **Remotely Piloted UAVs:** Remotely piloted UAVs, commonly found in consumer drones and indoor delivery system prototypes, are controlled by human operators using remote control systems or ground stations.
- ii. **Autonomous UAVs:** The automated system uses AI, GPS, sensors, and algorithms for navigation and decision-making, making it ideal for repetitive office deliveries without human intervention.
- iii. **Semi-Autonomous UAVs:** Semi-autonomous UAVs combine remote control and autonomous functions, providing flexibility for navigation and payload deployment in controlled environments [24].

4.5 Classification of Unmanned Aerial Vehicles Based on Application

The classification of drones based on their usage context enables optimal design choices, with the optimal drone choice being tailored to operate within building environments [25].

- i. **Military Drones:** Military drones have been extensively utilized in the 20th century for various purposes such as surveillance, combat missions, reconnaissance, border patrol, and target elimination.
- ii. **Commercial Drones:** Commercial drones have gained popularity due to their use in aerial photography, logistics, media, agriculture, construction, and delivery services [25].

- iii. **Industrial Drones:** Industrial drones are autonomous aircraft used for inspecting infrastructure, oil rigs, pipelines, and mining operations in businesses and industries.
- iv. **Recreational Drones:** Recreational drones are popular among hobbyists for their entertainment, aerial photography, and racing purposes.
- v. **Delivery Drones:** Delivery drones were developed to address last-mile delivery challenges, with applications in office document delivery, medical supply drops, and e-commerce logistics [25].

4.6 Classification of Unmanned Aerial Vehicles Based on Rotor Configuration

The category categorizes drones based on their number of propellers and rotor configuration, with four main types listed [26].

i. **Multi-Rotor Drones:** Multi-rotor drones are affordable and easy-to-use aerial photography and surveillance tools. They have multiple motors, including tri-copters, quadcopters, hexacopters, and octocopters. Multi-rotor drones offer enhanced flight control, increased maneuverability, and proximity to structures. They can take multiple payloads per flight, enhancing operational efficiency and reducing inspection time, and can move vertically, back to front, side to side, and rotate. Multi-rotor drones have limitations such as limited endurance and speed, making them unsuitable for large-scale aerial mapping, long-endurance monitoring, and long-distance inspection. They require energy to fight gravity and have limited flight times, while heavy-lift multi-rotors can carry more weight but have shorter flight times. Electric motors are the only practical power source. Multi-rotor drones are versatile tools used for various technical tasks such as visual inspections, thermal reports, photography and videography, and 3D scans [26].

ii. **Fixed-Wing Drones:** A fixed-wing drone, with a rigid wing resembling an airplane, provides lift without vertical rotors, making it energy-efficient as it only needs energy to move forward. Fixed-wing drones can cover long distances, map large areas, and loiter for extended periods, with an average flight time of a few hours, staying aloft for over 16 hours due to higher fuel density. Fixed-wing drones are expensive, require extensive training, and are faster than multi-rotor drones. They require confidence in control and a launcher for flight. Data analysis involves processing hundreds of captured images, including stockpile volume calculations and map overlays. The technical applications of drones include aerial mapping, environmental surveying, agriculture, inspection, construction, and security [27].

iii. **Single-Rotor Drones:** Single-rotor drones, resembling helicopters in structure and design, feature a single spinning wing and tail rotor for direction and stability control. A single-rotor helicopter, particularly gas-powered for longer endurance, offers superior efficiency compared to multi-rotor drones. Its long blades make it ideal for heavy payload hovering and fast forward flight. Its durability is also noteworthy. Single-rotor drones are complex, expensive, vibrate, lack stability, require extensive maintenance, and have dangerous spinning blades due to their long, heavy blades. The technical applications of aerial LIDAR laser scans, drone surveying, and carrying heavy payloads are numerous.

iv. **Fixed-Wing Hybrid VTOL:** Hybrid VTOL drones, featuring fixed-wing and rotor designs, are gaining popularity due to advancements in technology, as seen in Amazon's Prime Air delivery drone. Hybrid VTOL drones offer advantages such as autopilot for stability, fixed-wing and rotor-based designs, and being perfect for hovering or forward flight, while also offering the advantage of a human pilot's easier task. The market currently consists of a few fixed-wing hybrid VTOLs, with their technology still in its early stages, but their technical application is crucial in various industries.

4.7 Classification of Unmanned Aerial Vehicles Based on Size

The size of a drone significantly impacts its functionality, capabilities, and applications, with different sizes, from nano to industrial machines, affecting recreation, professional tasks, and commercial work [28].

i. **Nano drone:** Nano drones are lightweight, affordable, and suitable for indoor or casual use due to their simple controls, short flight times (5-10 minutes), and limited range.

ii. **Small drone:** Small drones, slightly larger than nano drones, are popular for aerial photography, videography, and recreational flying due to advanced features like high-resolution cameras and GPS stabilization, offering flight times of 15-30 minutes and improved flight stability.

iii. **Medium drone:** Medium-sized drones are ideal for professional fields like real estate photography, inspections, and surveying due to their advanced imaging systems, extended flight times, and greater payload capacity.

iv. **Large drones:** Large drones are ideal for heavy-duty tasks in agriculture, construction, public safety, and industrial inspections due to their high payload capacity, long flight times, and rugged construction. Heavy-lift drones are utilized in industries like delivery, filmmaking, and construction for transporting heavy equipment and specialized tools. They have high weight capacity, reinforced frames, advanced stabilization systems, and extended flight times [28].

4.8 Classification of Unmanned Aerial Vehicles by Flight Controls

Remote control (RC) is the primary method for controlling UAVs in military and civilian sectors, enhancing excitement in the civil-entertainment sector, while autonomous UAVs enable devices to move independently in three dimensions [29]. The discussion on the essential elements required for autonomous flying vehicles is crucial.

i. Obstacle avoidance (SAA) is a concept in autonomous vehicles (UAS) that uses sensors to identify objects or their proximity. Advanced technology like machine vision aids in this autonomous characteristic. The ultimate goal is a collaborative SAA, enabling large drones to move efficiently through the airspace.

ii. The fusion of sensors is crucial for the functionality of UAVs, as it allows for the implementation of various sensors, including thermal imaging, temperature, and pressure readings, without the need for a large number of sensors.

iii. Communication. Sensor fusion requires programming for optimal functionality, with appropriate communication between sensors and the implementation of algorithms for various avoidance scenarios achieving high autonomy.

iv. Path planning involves designing a safe and efficient route from point A to point B, considering terrain topography, no-fly zones, and various activities in different locations.

4.9 Classification of Unmanned Aerial Vehicles by Takeoff and Landing Mechanism

Fixed-wing or horizontal takeoff and landing (HTOL) aircraft are high-speed, longer-duration models that require a runway for takeoff and landing. Hybrid types, like tiltwing, body, rotor, and ducted fans, can take off and fly like VTOL drones [29]. UAVs with fixed wings have aerodynamic designs determining flight speed, with motors generating forward thrust and wings producing lift. Control surfaces vector airflow for the correct angle of attack. Rudder, elevator, and aileron are used for yaw, pitch, and roll axis movement [30]. Rotatory Wings (VTOL) drones are popular for surveying due to their small size and maneuverability, making them ideal for difficult-to-reach areas like pipelines, buildings, and bridges. The quadcopter with four propellers is the most popular configuration. Rotary wings offer greater versatility and ease of operation compared to fixed wings. They provide lift and maneuverability, with back rotors pitching the drone and differential thrust controlling the yaw axis [30].

Hybrid drones are being developed to combine the hovering capabilities of rotary-wing helicopters with the cruising flight of an HTOL, using tilt rotors like the Osprey¹, which can tilt forward through 90° and function as a propeller [31]. Tilt rotors in fixed-wing aircraft can be attached to the fuselage, rotated using gears and shafts, or have an engine within rotor pylons. Tilt-wing is more effective in cruise flight, while tilt-rotors are more effective in hovering.

5. Precision Flight, Control and Drag Types

Drone operations require precision flight and control, with lift achieved by accelerating air downwards. Fixed-wing aircraft use forward flight, while helicopters and quadcopters use rotating blades. Subsystems like sensors, actuators, processors, and software algorithms ensure smooth, steady, and accurate movement. Understanding of aerodynamic drag is crucial for drone design optimization, particularly in pick-and-delivery missions, affecting speed, stability, and energy efficiency in drone take-off and movement [31]:

i. Parasite Drag: Unwanted resistance during flight.

ii. Form Drag: Caused by the drone's form and frontal area, resulting from air separation and pressure differential.

iii. Skin Friction Drag: Air contacting the drone's surface, causing minimal friction.

iv. Interference Drag: Arises where the drone's components converge.

v. Induced Drag: Lift produced by rotors increases drag force.

vi. Profile Drag: Mix of skin friction and form drag affecting rotor blades during rotation.

6. Principles Enabling and Enhancing Delivery Mechanism

The drone delivery mechanism utilizes foundational principles to pick and deliver objects effectively. Gripping mechanisms ensure safety by holding the drone on an object, while weight distribution and management determine take-off, speed, and landing, ensuring efficient object delivery. The drone's payload-to-thrust ratio ensures a balance between the drone's thrust and the payload's weight, ensuring proper takeoff. Power efficiency considerations consider the drone's power loss due to the payload, reducing energy consumption. Center of gravity optimization is crucial for maintaining balance during takeoff and delivery, even after adding payloads. Drone delivery effectiveness relies on engineering principles, technological systems, and operational considerations, with core principles enhancing indoor and office delivery in safe and reliable navigation and payload delivery [32]-[33].

i. **Aerodynamic Stability and Flight Control:** Quadcopter drones utilize four rotors for balanced thrust and lift, with flight controllers controlling yaw, pitch, and roll. Advanced control algorithms like PID enhance delivery accuracy and environmental navigation.

- ii. **Payload Integration and Weight Distribution:** Quadcopter delivery mechanisms balance payload to prevent destabilization, especially in office applications where lightweight items like documents or electronics can be affected by improper alignment or rapid movement.
- iii. **Precision Navigation and Path Planning:** Drone delivery in indoor environments requires precise navigation systems like SLAM, visual odometry, and LIDAR, along with autonomous navigation algorithms and machine-learning-based path planning techniques for efficiency [34].
- iv. **Obstacle Avoidance and Environmental Sensing:** Drones in indoor environments use ultrasonic, IR, and stereo cameras for real-time mapping, detecting environmental changes, and relaying signals to a microcontroller for collision-free trajectory.
- v. **Communication and Control Systems:** Drone delivery necessitates robust wireless communication using technologies like Bluetooth, Wi-Fi, Zigbee, or LoRa, with short-range protocols preferred in office setups for interference and limited flight distance. Real-time telemetry data transmission ensures continuous monitoring.
- vi. **Battery Management and Power Optimization:** Power management is crucial for delivery drones, ensuring limited flight time by monitoring voltage thresholds, using efficient motors, scheduling automated recharging cycles, and using solar-assisted charging.
- vii. **Mechanical Design of Delivery Mechanisms:** Drone delivery relies on physical systems like servo-operated arms, retractable claws, drop boxes, and pulley systems controlled by microcontrollers like Arduino or Raspberry Pi, which open, close, or deploy upon remote or autonomous commands.
- viii. **Automation and Artificial Intelligence (AI):** Drone delivery relies on physical systems like servo-operated arms, retractable claws, drop boxes, and pulley systems controlled by microcontrollers like Arduino or Raspberry Pi, which open, close, or deploy upon remote or autonomous commands.
- ix. **Safety Protocols and Redundancy Systems:** Safety Advanced drone systems use redundant systems like dual power supplies, emergency parachutes, and automatic return-to-home functions to prevent accidents and mishandled deliveries, especially in crowded indoor environments.
- x. **Integration with Smart Office Ecosystems:** Drone delivery systems can be integrated into smart office infrastructures for secure, automated document handling, allowing employees to place requests via intranet portals and autonomously navigate to recipient locations [34].

7.0 Case Studies of Unmanned Aerial Vehicles for Services Delivery

Nigeria's Federal University of Technology, Minna (FUTMinna) integrated drones into administrative workflows to improve document handling and internal communication efficiency, a move backed by research and pilot projects [34]. The institution uses custom-built quadcopters to transfer documents like transcripts, letters, memos, and USB drives. These drones, capable of carrying 500 grams to 1.2 kilograms, operate within a 2 to 3 km range. FUTMinna uses drones for document transfer between faculty offices and administrative buildings, reducing manual document movement delays and minimizing physical contact during peak academic periods and health-sensitive times like the COVID-19 pandemic. The innovation improves administrative efficiency and offers students a real-world testing platform in drone technology, automation, and logistics systems, fostering the institution's goal of becoming a smart campus [35]-[37].

Drone transport system was used to deliver 440 deliveries of 2537 suspicious COVID-19 samples from 10 districts between April 2020 and June 2021. Most suspicious samples were given by the Ejura-Sekyedumase District Health Directorate (765; 30%). The Pru East area, which is 173 kilometers from the Zipline headquarters in Mampong and 270 kilometers from KCCR in Kumasi, was the furthest to deploy the drone. The use of drones for sample transport systems during the COVID-19 pandemic significantly reduced the travel time for samples to be transported by road to the testing site, which has enhanced innovative measures to fight the pandemic using technology. In this case, the average time for drone delivery was 39 minutes, compared to 117 minutes for road transport [38]-[39].

Nigeria's National Centre for Artificial Intelligence and Robotics (NCAIR) integrated drone technology into administrative processes, deploying UAVs for practical government and institutional uses, including document transfer. NCAIR uses drones for document delivery between NITDA and Abuja government offices [40]. Remotely piloted, the drones load documents into compartments (payload hook) and suspend them, improving handling speed and reducing manual workload, showcasing their potential in digital governance. NCAIR drones successfully transport various documents like memos, reports, USB drives, technical proposals, and meeting minutes, secured in sealed envelopes, flat plastic carriers, or protective cases. NCAIR uses local-developed drones in partnership with Nigerian tech startups, designed for urban office environments. These multi-rotor drones carried 500-1.5 kilograms payloads and operate within 3-5 km radius making it suitable for inter-agency document delivery within office clusters in Abuja. NCAIR's work significantly contributes to Nigeria's smart governance and technological independence, serving as a model for government agencies to adopt innovation for efficiency, security, and transparency [41]-[42].

The Nigeria Customs Service has implemented Unmanned Aerial Vehicle (UAV) technology for efficient surveillance and document transfer, enhancing operational efficiency, security, and inter-agency communication. NCS uses multi-rotor drones for short-range, high-precision operations, carrying payloads ranging from 500 grams to 1.5 kilograms, covering up to 5 kilometers for effective communication. NCS employs drones for document transfer between customs posts and central offices, focusing on smart border technologies to reduce travel times and enabling faster dispatch in limited road access areas [[43].

Zipline's UAV technology has revolutionized logistics in Africa, proving its effectiveness in government, health, and office services in Nigeria. This demonstrates its potential in solving logistical challenges. Zipline, a global leader in drone-based logistics, partners with Nigerian state governments (Kaduna, Cross River, and Bayelsa) to provide drone delivery services for medical supplies and documents, including time-sensitive documents like laboratory test results, supply orders, memos, and vaccine inventory sheets, critical in public health administration. Drones, launched from Zipline distribution centers, autonomously fly to designated locations, delivering payloads via parachute drops, covering long distances and ensuring timely, contactless delivery [44]. The drone securely packs and transports various documents and parcels, including official medical records, cold chain monitoring sheets, administrative letters, consent forms, and electronic media for public health reporting. It employed fixed-wing electric drones to carry payloads up to 2 kilograms for document and parcel delivery. The system has efficiently travelled 80-100 kilometers per trip, particularly in urban and rural areas with limited road access [45]-[46].

8.0 Challenges Associated with the Use of Drones

Research on drone delivery primarily focuses on large-scale logistics, but limited studies explore quadcopter drones for intra-office logistics, addressing unique challenges in confined spaces and ensuring precision landing. [47] highlights the challenges preventing widespread drone use, including government regulations, lack of scale economies, technological hurdles, and unknowns surrounding developing technologies.

This review proposes a quadcopter drone system for efficient document and material delivery in offices, enhancing operational efficiency, reducing human workload, and promoting intelligent automation systems, replacing manual couriering methods.

Traditional methods in institutions cause stress, time consumption, and human error, leading to delays, misplacements, and unreliability in office delivery management systems. Research suggests a need for autonomous drones for pick-and-delivery systems to improve workflow and productivity, as traditional methods rely on human effort. Advancements in automation and drone technology had improved service deliveries in multi-story office buildings by reducing human intervention and transporting small office items between departments, thereby enhancing efficiency [48].

The conventional system of office deliveries is characterized by several inefficiencies and challenges.

i. **Time Consumption and Workflow Disruption.** Office employees frequently leave workstations to deliver documents or supplies, causing lost productivity and reducing focus, especially in multi-story buildings with long distances and elevator usage.

ii. **Manual Dependency and Human Errors.** Manual courier dependency can affect delivery efficiency, leading to errors and potential operational setbacks, financial losses, and confidentiality breaches.

iii. **Security and Confidentiality Concerns.** Drone-based delivery systems can enhance security and confidentiality in office documents by incorporating secure compartments or access codes for authorized recipients.

iv. **Office logistics lack automation,** despite drone adoption in e-commerce, healthcare, and logistics, leading to wasted human resources on repetitive tasks.

v. **Inefficiency in Handling Urgent Deliveries.** Automated delivery drones can improve efficiency in urgent deliveries, bypass office congestion, and ensure rapid, precise deliveries thereby prevent deadlines and failed transactions in financial institutions.

vi. **Increasing Operational Costs.** Drone-based systems are being adopted by organizations to reduce labor costs and enhance efficiency, as manual document delivery methods are becoming unsustainable and require a one-time investment.

vii. **Navigation and Obstacle Avoidance in Indoor Spaces:** Drone delivery systems in office spaces require alternative navigation techniques like LiDAR-based obstacle detection, machine vision, or infrared sensors for safe and efficient movement due to signal interference and obstructions.

viii. **Payload Capacity and Secure Delivery Mechanism:** Research on lightweight, energy-efficient drones for office logistics is limited, lacking secure compartments and reliable release mechanisms for smooth, damage-free delivery of sensitive office items.

ix. **Battery Life and Power Efficiency in Indoor Settings:** Li-Po battery technology improves drone endurance, but research on power efficiency, battery management, and wireless charging is underexplored for office-based drones, despite their predominant use in outdoor delivery.

- x. Safety, Privacy, and Legal Considerations: Drones in offices pose safety, privacy, and legal concerns, necessitating strict adherence to workplace safety guidelines and avoiding risks to employees or sensitive office data.
- xi. System Performance Evaluation and Real-World Testing: The study on drone-based delivery systems requires extensive real-world performance testing to ensure flight stability, accuracy, and user acceptance.

9.0 Conclusion

Quadcopter drones (Unmanned Aerial Vehicles) offer numerous benefits in office automation, including enhanced productivity, time efficiency, technological advancements, and reduced risk of loss or unauthorized access to documents. The review presents a novel approach to outdoor office logistics, utilizing drones for efficient management and reducing human dependency, and serves as a reference for future research in drone automation. The study showcases the feasibility of implementing quadcopter technology in office settings, demonstrating its potential to enhance efficiency and cost-effectiveness in corporate operations while also providing practical learning opportunities for students and professionals in robotics, aeronautics, and embedded systems. The review has provided the following useful outcomes as stated.

- i. Drones offer a promising solution for parcel transportation within offices, potentially increasing efficiency, reducing costs, and improving delivery times.
- ii. It can be used for various tasks, such as delivering mail, documents, and small packages between different departments or floors.
- iii. The system enhances productivity by allowing focus on core tasks and is time-efficient due to rapid document and small item transportation.
- iv. Contributes to office automation advancements and minimizes risk of loss or unauthorized access compared to human deliveries.
- v. The system is versatile and efficient, integrating traditional logistics with modern automation, making it suitable for various office settings and enhancing work efficiency and document security.
- vi. The review advocates for smart technology integration in corporate operations, promoting innovation and efficiency, and providing practical learning opportunities for students and professionals in robotics, aeronautics, and embedded systems.
- vii. The study showcases the feasibility of implementing quadcopter technology in office settings, providing technical insights into drone delivery mechanisms.
- viii. The review provides theoretical knowledge by contributing to academic literature and real-world solutions.
- ix. The review provides a basis for automated drone delivery systems (ADDS) in workplaces to enhance operational efficiency, productivity, and comfort, with a focus on pick-and-delivery technologies and procedures. It provides practical solutions for office deliveries and automation made possible.

References

- [1] Han, S., Lim, S., Ko, J., & Lee, Y. (2019). A mathematical model for the delivery routing problem via drones. *Pamukkale University Journal of Engineering Sciences*, 25(1), 89–97. <https://doi.org/10.5505/pajes.2018.19052>
- [2] Ibrahim, A., & Yusuf, M. (2025a). Development of an Arduino-based quadcopter with document delivery mechanism. *Nigerian Journal of Engineering Research*, 14(1), 88–102.
- [3] Perboli, G., & Rosano, M. (2019). Parcel delivery in urban areas: Opportunities and threats for the mix of traditional and green business models. *Transportation Research Part C: Emerging Technologies*, 99, 19–36. <https://doi.org/10.1016/j.trc.2019.01.006>
- [4] Moshref-Javadi, M., & Winkenbach, M. (2021). Applications and research avenues for drone-based models in logistics: A classification and review. *Expert Systems with Applications*, 177, 114854.
- [5] Alkouz, B., Bouguettaya, A., & Mistry, S. (2020). Swarm-based drone-as-a-service (SDaaS) for delivery. In *2020 IEEE International Conference on Web Services (ICWS)* (441–448).
- [6] Barnhart, R. K., Hottman, S., & Marshall, D. M. (2022). Applications of unmanned aerial systems in urban environments. *Journal of Unmanned Vehicle Systems*, 10(2), 87–97. <https://doi.org/10.1139/juvs-2022-0030>
- [7] Koiwanit, J. (2018). Analysis of environmental impacts of drone delivery on an online shopping system. *Advances in Climate Change Research*, 9(3), 201–207. <https://doi.org/10.1016/j.accr.2018.09.001>
- [8] Patel, R., & Kumar, N. (2025a). Development of a cost-effective drone delivery system. *International Journal of Mechanical Systems*, 19(1), 23–35.
- [9] Rahman, A., Olanrewaju, O., & Adewale, R. (2024a). Sensor integration techniques in logistics drones. *Journal of Intelligent Transport Systems*, 10(3), 114–126.

- [10] Sibiri, H., Zankawah, S. M., & Prah, D. (2020). Coronavirus diseases 2019 (COVID-19) response: Highlights of Ghana's scientific and technological innovativeness and breakthroughs. *Ethics Med Public Health*, 14, 100537. doi:10.1016/j.jemep.2020.100537.
- [11] Aliyu, H. T., Musa, K., & Shehu, M. (2024). Post-pandemic workspaces and technology integration. *Journal of Workplace Innovation*, 8(1), 120–134. <https://doi.org/10.4018/jwi.2024.01.009>
- [12] Li, J., Zhang, J., & Zhou, Y. (2022). A survey of recent trends in UAV-based indoor logistics. *IEEE Internet of Things Journal*, 9(10), 7405–7418. <https://doi.org/10.1109/JIOT.2022.3141569>
- [13] Sudbury, A. W., & Hutchinson, E. B. (2016). A cost analysis of Amazon prime air (drone delivery). *Journal of Economic Education*, 47(1), 1–12.
- [14] Rejeb, A., Rejeb, K., Simske, S. J., & Treiblmaier, H. (2021). Drones for supply chain management and logistics: A review and research agenda. *International Journal of Logistics Research and Applications*, 25(1), 1–24.
- [15] Hassananlian, M., & Abdelkefi, A. (2017). Classifications, applications, and design challenges of drones: A review. *Progress in Aerospace Sciences*, 95, 99–131.
- [16] Veelen M.J, Kaufmann M, Brugger H, and Strapazzon G. (2020). Drone delivery of AED's and personal protective equipment in the era of SARS-CoV-2. *Resuscitation*, 152:1–2. pmid:32380028
- [17] Braun J., Gertz S.D., Furer A., Bader T., Frenkel H., and Chen J. (2019). The promising future of drones in prehospital medical care and its application to battlefield medicine. *Journal of trauma and acute care surgery*. 2019;87(1S): S28–S34. pmid:31246903
- [18] Ahmed, T., & Bakar, M. A. (2025). *Smart logistics and UAVs in office automation*. *International Journal of Robotics Research*, 42(3), 233–245. <https://doi.org/10.1016/ijrr.2025.03.015>
- [19] Gupta, R., & Shukla, P. (2024). Future of UAVs in confined environments. *UAV Systems and Applications Journal*, 15(1), 54–68. <https://doi.org/10.1007/usaj.2024.15.001>
- [20] Sharma, P., & Joshi, K. (2024). Energy-efficient UAVs for document delivery in office environments. *Journal of Applied Engineering and Technology*, 15(2), 62–76.
- [21] Chester, M., & Horvath, A. (2012). High-speed rail with emerging automobiles and aircraft can reduce environmental impacts in California's future. *Environmental Research Letters*, 7(3), 034012. doi:10.1088/1748-9326/7/3/034012.
- [22] Giones, F., & Brem, A. (2017). From toys to tools: The co-evolution of technological and entrepreneurial developments in the drone industry. *Business Horizons*, 60(6), 875–884. doi:10.1016/j.bushor.2017.08.001.
- [23] Nwachukwu, C., & Eze, T. (2025a). IoT-integrated drone delivery in smart workspaces. *International Journal of Smart Systems*, 6(2), 131–144.
- [24] Zhang, X., Wang, R., & Chen, P. (2024). Autonomous navigation of delivery drones in GPS-denied environments. *Journal of Intelligent & Robotic Systems*, 108(1), 155–172. <https://doi.org/10.1007/s10846-023-01826-3>
- [25] Demuyakor J. (2020). Ghana goes digital Agenda: The impact of zipline drone technology on digital emergency health delivery in Ghana. *Humanities*, 8(1):242–53.
- [26] Mbunge E, Chitungo I, and Dzinamarira T. (2021). Unbundling the Significance of Cognitive Robots and Drones deployed to tackle COVID-19 pandemic: A rapid review to unpack emerging opportunities to improve healthcare in sub-Saharan Africa. *Cognitive Robotics*,1:205–13.
- [27] Ulmer, M. W., & Thomas, B. W. (2018). Same-day delivery with heterogeneous fleets of drones and vehicles. *Networks*, 72(4), 475–505. <https://doi.org/10.1002/net.21855>
- [28] Shavarani, S. M., Golabi, M., & Izbirak, G. (2019). A capacitated bi-objective location problem with uniformly distributed demands in the UAV-supported delivery operation. *International Transactions in Operational Research*, 27(6), 3327–3354. <https://doi.org/10.1111/itor.12735>
- [29] Iwen P.C, Stiles K.L, and Pentella M.A (2020). Safety considerations in the laboratory testing of specimens suspected or known to contain the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). *American journal of clinical pathology*, 153(5):567–70.
- [30] Scheduling, S., & Finn, A. (2010). *Developments and challenges for autonomous unmanned vehicles: A compendium of Springer Science & Business Media*.
- [31] Young, L. A. (2018). What is a Tiltrotor? A Fundamental Reexamination of the Tiltrotor Aircraft Design Space. NASA Ames Research Center, Moffett Field, Francisco, CA 94035
- [32] Agatz, N., Bouman, P., & Schmidt, M. (2018). Optimization approaches for the traveling salesman problem with drone. *Transportation Science*, 52(4), 965–981. <https://doi.org/10.1287/trsc.2017.0791>
- [33] Ajayi O. and Ajulo J. (2021). Investigating the applicability of unmanned aerial vehicles (UAV) photogrammetry for the estimation of the volume of stockpiles. FUTMina Institutional Repository. <https://doi.org/10.2478/quageo-2021-0002>

- [34] Chamola V, Hassija V, Gupta V, and Guizani M.A (2020). Comprehensive review of the COVID-19 pandemic and the role of IoT, drones, AI, blockchain, and 5G in managing its impact. IEEE access. Dio:10.1109/ACCESS2020.29923412020;8:90225–65.
- [35] Gilbert, M., Pullano, G., Pinotti, F., Valdano, E., Poletto, C., Boëlle, P.-Y., and Colizza, V. (2020). Preparedness and vulnerability of African countries against importations of COVID-19: a modelling study. *The Lancet*, 395(10227), 871–877. doi:10.1016/s0140-6736(20)30411-6.
- [36] Abiodun T.F. (2021). Public support and prospects of drones or unmanned aerial vehicles (uavs) technologies for effective transport and logistics delivery in Nigeria. *International Journal of Advanced Academic Research*, 7(1), 43-63
- [37] Abubakar, M., & Yusuf, K. (2021). Application of UAVs in administrative tasks in Nigerian tertiary institutions: A pilot study at FUTMinna. *Nigerian Journal of Mechatronics and Automation*, 3(1), 45–52.
- [38] Abubakar, M., & Yusuf, K. (2021). Application of UAVs in administrative tasks in Nigerian tertiary institutions: A pilot study at FUTMinna. *Nigerian Journal of Mechatronics and Automation*, 3(1), 45–52.
- [39] Sylverken A.A., Owusu M, Agbavor B, Kwarteng A, Ayisi-Boateng N.K., and Ofori P, (2022). Using drones to transport suspected COVID-19 samples; experiences from the second largest testing centre in Ghana, West Africa, 17(11): 65-82. e0277057. <https://doi.org/10.1371/journal.pone.0277057>.
- [40] Markus, K. and Denis, N. (2019). DHL Customer Solutions and Innovation in Logistics Industry. *International Journal of Advanced Academic Research*, 7(1). doi: 10.46654/ij.24889849.e712662
- [41] Abiodun T.F. (2020a). Usage of drones or unmanned aerial vehicles (UAVs) for effective aerial surveillance, mapping system and intelligence gathering in combating insecurity in Nigeria. *African Journal of Social Sciences and Humanities Research*, 3(2), 29-44
- [42] NITDA (2022). Annual Report on Emerging Technologies and Innovation Activities. Abuja: NITDA Press.
- [43] Birmah M.N., Buba Y.A., Audu M.J., Jibrin S. and Maton D.J. (2021). The Importance of Drone Technology in Nigerian's Construction Industry. *International Journal of Scientific Research & Engineering Trends*, 7(2), 87-98.
- [44] Fabian, C. (2017). Malawi's Unique Drone Corridor the Government of Malawi and UNICEF test drones to improve children's lives, Office of Innovation, UNICEF. <https://www.unicef.org/innovation/drones/malawi-unique-drone-corridor>.
- [45] Ackerman, E., & Koziol, M. (2019). The blood is here: Zipline's medical delivery drones are changing the game in Rwanda. *IEEE Spectrum*, 56(5), 24-31. doi:10.1109/MSPEC.2019.8701196.
- [46] Abiodun, T. F. (2020). Usage of Drones or Unmanned Aerial Vehicles (UAVs) for Effective Aerial Surveillance, Mapping System and Intelligence Gathering in Combating Insecurity in Nigeria. *African Journal of Social Sciences and Humanities Research*, 3(2), 29- 44.
- [47] Chowdhury, K., Banerjee, S., & Ray, A. (2024a). Smart office automation using autonomous drones: A practical framework. *Journal of Engineering Innovation*, 7(1), 59–68.
- [48] Musanabaganwa C, Semakula M, Mazarati J.B, Nyamusore J, Uwimana A, and Kayumba M (2020). Use of technologies in Covid-19 containment in Rwanda. *Rwanda Public Health Bulletin*, 2(2):7–12.