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# Review on Airborne Nodes for Unmanned Aerial Vehicles (UAV)

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**Abstract**

Airborne nodes are devices positioned in the air, most often on unmanned aerial vehicles (UAVs) or drones. Each of these nodes have been fitted with numerous sensors, communication devices, and computing capability to carry out specific activities or operations. Airborne node deployment involves several obstacles, including managing power, ensuring communication reliability, maintaining autonomy, and complying with legal regulations. However, technological breakthroughs are continually enhancing their capabilities and expanding their potential uses. The study presents an overview of airborne nodes by reviewing existing works, specifically focusing on Unmanned Aerial Vehicles (UAVs).

**Keywords:** Airborne Nodes, Unmanned Aerial Vehicles (UAV), Frequency, Communication Nodes, Sensors

## 1. Introduction

Any communications or data relay node that functions in the air—on an aeroplane, drone, or balloon—is often referred to as an airborne node. These nodes are essential to the creation and upkeep of communication linkages across different platforms, including satellites, aerial vehicles, ground stations, and other nodes in a network. An aerial node's main function is to enable data transmission and communication across various network elements, especially in situations when ground-based infrastructure could be few or non-existent. An aerial communication node is equipped with signal processing units, transceivers, and antennas for communication. Depending on the application's requirements and operating needs, these


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components allow the node to broadcast as well as receive data wirelessly utilising technologies like radio frequency (RF), communication through satellite, or laser communication.

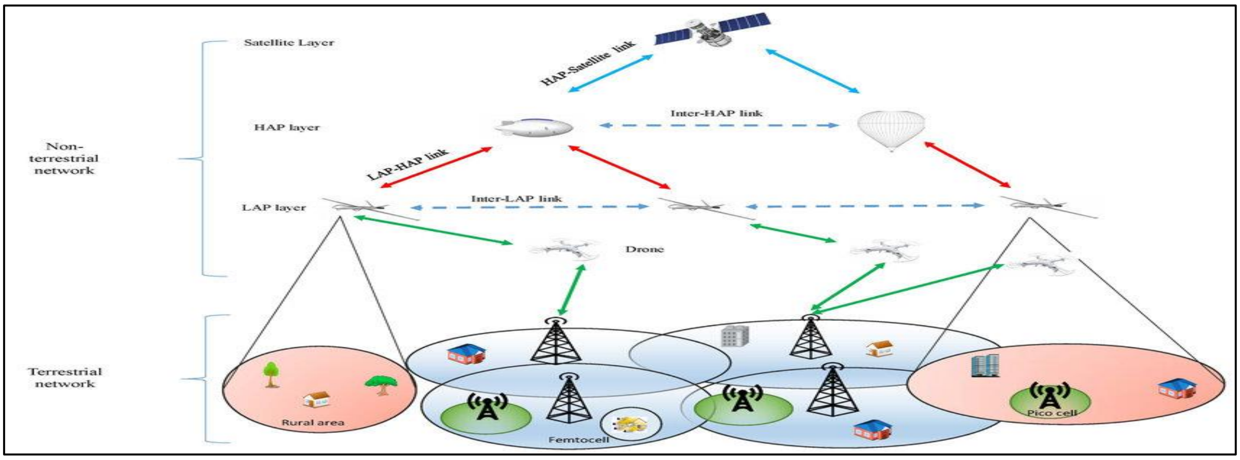


**Figure 1.** Airborne Communication Network [11]

Depending on the specific mission requirements, an airborne node may incorporate additional payloads or sensors alongside its communication equipment. These payloads may consist of specialised equipment for scientific study, LiDAR mapping systems, cameras, sensors for monitoring the environment, or other devices. The way an airborne node operates depends on what kind of airborne platform it is hosted on (such as an aeroplane or UAV). It can function independently or under controlled remotely. Tasks like navigation, flight planning, and data relay may be included in autonomous operation, which enables the node to work alone for long stretches of time. Airborne nodes frequently act as data forwarding relays or middlemen inside networks, transferring data between various organisations. By providing other routes for data transmission, they can improve communication resilience, increase the reach of communication lines, and give connectivity in isolated or unreachable locations. Figure 1. Depicts the airborne communication network.

- **Advantages**

When performing missions in distant or dynamic situations, airborne nodes offer adaptability and speed in establishing connections for communication or moving quickly to new places. In comparison with ground-based systems, aerial nodes can operate at a higher altitude, increasing the range of communication link and facilitating connection over wider regions or in difficult-to-reach terrain. The likelihood of signals blockage or attenuation due to obstructions like buildings or topographical features is decreased since airborne nodes frequently have a direct line of sight with other node or ground stations. Figure 2 and 3 shows the advantages and disadvantages respectively.

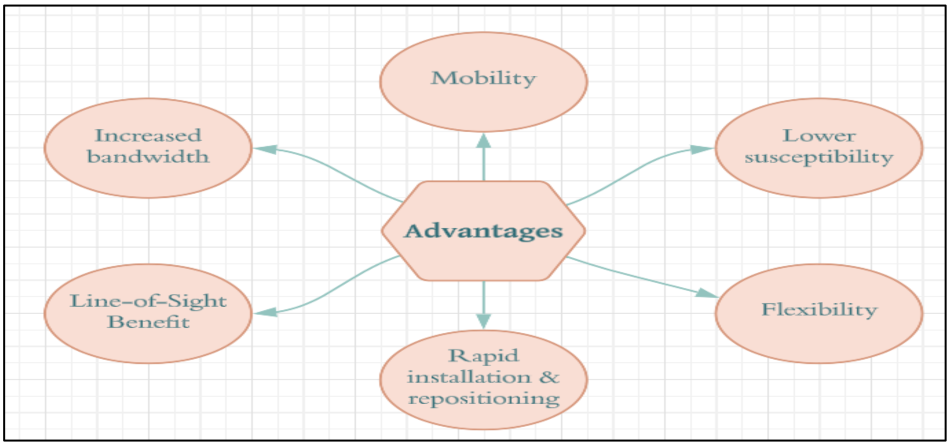


**Figure 2.** Advantages of Airborne Nodes

- **Disadvantages**

Because of things like fuel restrictions and battery capacity, airborne nodes usually have a limited endurance and need to be periodically refuelled or recharged. Unfavourable weather conditions, including as strong winds, turbulent conditions, precipitation, and extreme temperatures, can affect airborne nodes and affect flight stability, communication dependability, and mission efficacy overall. Significant expenditures may be incurred during the creation, implementation, and upkeep of aerial nodes. These costs may include those related to platform procurement, payload integration, operational support, and training.

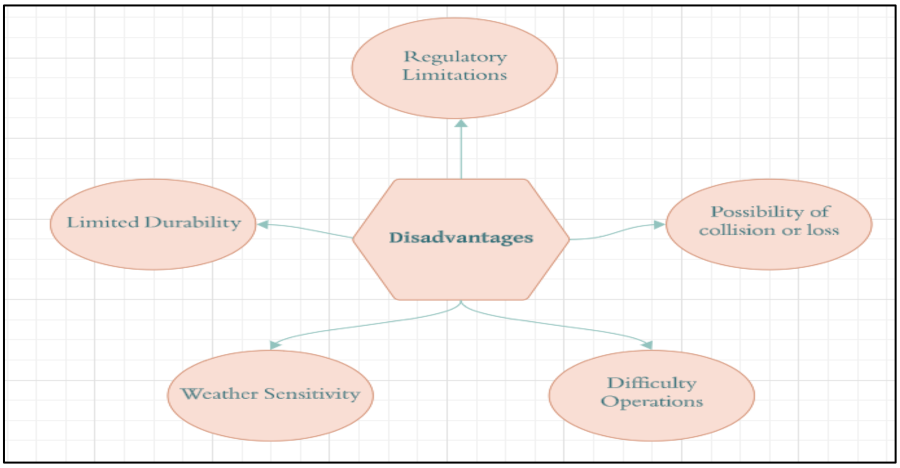


**Figure 3.** Disadvantages of Airborne Nodes

This study presents an overview of airborne nodes by reviewing existing literature on the subject. The following section highlights the uses and functioning of airborne nodes on various host platforms.

## 2. Literature Survey

This study [1] explores how external elements, such as airborne UAVs or drones, can serve as supplementary communication relays to enhance connectivity between ground-bound vehicles and Roadside Units (RSUs), thereby improving vehicular interconnection. In a vehicular sub-networking scenario, a UAV motion theory is developed to analyse the macroscopic movements of UAVs that follow waypoints and operate within a specific highway segment. The simulation framework validates the suggested models and assesses the effectiveness of UAV help in strengthening vehicle connection along with data transmission delay performances.

In this study [2], an extra UAV is used as a relay for connecting the Free Space Optical communication (FSO) link through the airborne platforms to the ground location, avoiding cloud blocking and proposing a unique approach for combination of FSO/RF airborne interactions under hazardous weather circumstances. Furthermore, a weather-dependent connection shifting mechanism is suggested. Additionally, the authors derive closed-form formulas for the system's probability of failure and the bit error rate (BER) considering factors such as air attenuation, turbulent conditions, aiming inaccuracy, and the angle-of-arrival (AOA) induced by the airborne UAV. The numerical findings indicate the efficiency of the approach under various weather situations. Finally, practical design principles for system developers are offered.

This research [3] investigates the impact of connected aerial communication networks on the performance during operation of tiny unmanned aircraft. Smaller unmanned aircraft, capable of developing new applications and businesses in civilian areas, enable disruptive innovations and impose significant challenges on the management of air traffic systems. The research suggests that among currently available networking communication designs, primarily meshed ad hoc networks can handle the communication requirements of the enormous number of smaller aircraft predicted to be deployed in the near future. Experimental outcomes from the heterogeneous unmanned plane system have been presented to demonstrate that meshed airborne interactions is acceptable, and it expands the operating envelope for small unmanned aircraft that the cost greater communication variation, and finally that net-centric functioning involving several collaborating aircraft is achievable. Furthermore, the possibility of aerial networks of tiny unmanned aircraft to benefit from controlled mobility to enhance performance is highlighted.

The review [4] proposed a method is suggested to distribute the target region equally depending on the UAV's beginning position, assuring complete coverage. Furthermore, the algorithm takes into account the variances in durability between various UAVs. This revised method is well-suited for real-world application settings. The outcomes of the simulation show the variations in power control during portable UV-guided UAV flying. Furthermore, the enhanced algorithm's assignment findings are quite similar to the predicted assignment outcomes, taking into account many characteristics such as the total number of UAVs, starting location, and capacity for endurance.

This study[5] discusses artificial potential field-based route planning for unmanned aerial vehicles as a means of achieving constant long-term communications relaying infrastructures. An innovative dynamic method based on the relay-chain concept is proposed to support vehicle communication. The functionality of the suggested system is evaluated using an experiment in the Matlab Simulink along with Network Simulator environments. Matlab generates artificial potential field-based flying structures, and the performance of vehicle communication is evaluated in the Network Simulation scenario. Furthermore, the results of simulations demonstrate that an aerial communications relay may be built automatically utilising an artificial potential field-based autonomous path planning technique. Acquiring a resistant communications relay that relies on artificial potential field-based position method ensures continuous state communication.

Networks that are not terrestrial (NTNs) provide previously unheard-of opportunities for worldwide connection. Furthermore, by offering dependable and widely available connection, the NTN may also assist in supporting the growth in the quantity of Internet of Things (IoT) devices. NTNs have demonstrated encouraging results, but using them comes with a number of difficulties, including interference, delays in signal transmission, security issues, and more. In order to get over the problems with NTN, we have spoken about the potential for reconfigurable intelligent surface (RIS) integration using the NTN platform in this study [6]. Moreover, the experimental validation in the research proves that the use of RIS-assisted NTN may significantly enhance the overall communication system performance.

Because airborne networks only use relay stations, they put less strain on satellites. Precise status and connection information throughout all stakeholders within the working environment is held by the WTW matrix, which meticulously and efficiently accounts for periodic location alterations. The suggested matrix's technique [7] is that it includes the nodes' physical characteristics as well as how they behave in a tactical setting. The reference matrix in each aerial node is built to track the portable ground nodes by guiding aircraft to safety and provide aerial direction as they traverse the tactical environment. This is covered in the WTW matrix building method. The performance indicators are compared to those of other current schemes, and the advantages and disadvantages of the suggested WTW matrix are noted and explored in detail.

Unmanned aerial vehicles (UAVs) serves as communications nodes and 5G technology enables the smart city, which may help resolve problems regarding the environment and traffic surveillance. This will provide the safest and most easy possible management and oversight of the urban surroundings by the city. In order to put the idea of the smart city into practice, this part of the article [8] will look at how unmanned aerial vehicles have been organised in relation to MEC (mobile edge computing) and SDN (Software-Defined Networking) technologies. The functional aspects of possible urban network design are covered in this article. It also shows the features of how the network architecture interacts with urban communication nodes.

A distributed motion control method and a centralised deployment algorithm are the two that is suggested [9]. After a global computation, the first method determines the ideal deployment result based on the positions of user equipment (UEs) on the ground. This method may be used in the situation when a minimum quantity of UAVs is needed to deliver desired services to known on-ground user equipment. On the other hand, the second approach allows each UAV to independently regulate its motion, locate the UEs, and convergence to on-demand coverage without the need for global information or computation. This distributed approach may be used in the situation when UEs are covered by a specified number of UAVs without knowing the precise position of each UE. There is no loss of UAV network connection in any method. We validate our suggested methods using extensive simulations.

In order to cover the IoMT equipment on the ground, the study uses the fewest possible UAVs. An approach based on particle swarm optimisation (PSO) is proposed to address the issue [10]. Specifically, the greedy heuristic approach is implemented to expedite the search. The experimental findings demonstrate that, in terms of optimum values, the recommended algorithms GASM_a and GASM_b is capable of performing better than the greedy and random techniques. In the meanwhile, there is an average 16.51% raise in execution time when compared with GASM_a. Large-scale UAV deployment for IoMT in medical facilities is becoming more and more possible due to cheap hardware expenses. Our study demonstrates the cost-effectiveness and efficiency benefits of UAV-assisted wireless coverage for ground patients, which will further advance the establishment of UAV-assisted healthcare systems.

## 3. UAV

Drones, sometimes referred to as unmanned aerial vehicles (UAVs), are aircraft that fly without a human pilot present. They can be programmed to fly independently over pre-established routes and carry out particular tasks, or they can be remotely operated by a human operator [12]. Unmanned Aerial Vehicles (UAVs) are available in diverse sizes, forms, and configurations, and therefore have a multitude of uses in a variety of sectors and businesses. Here are some notable UAV types (Figure 4) and applications that are discussed on:

### 3.1 Types

• **Fixed-Wing UAVs:** similar to classic aeroplanes, these UAVs have fixed wings. They can travel great distances in an effective manner and are usually employed for long-duration missions.

• **Multirotor UAVs:** These UAVs have several rotors put in a multirotor configuration, typically four or more. They can do vertical take-off and landing (VTOL) and are frequently employed for close-quarters tasks including aerial photography, inspection, and surveillance.

• **Hybrid UAVs:** These UAVs incorporate elements of multirotor and fixed-wing designs, providing longer missions with the effectiveness of fixed-wing flight combined with the benefits of vertically take-off and landing.

• **Nano and Micro UAVs:** Due to their small size, these unmanned aerial vehicles are frequently utilised for close-quarters or inside tasks, including indoor mapping, reconnaissance, and small-space search and rescue missions.

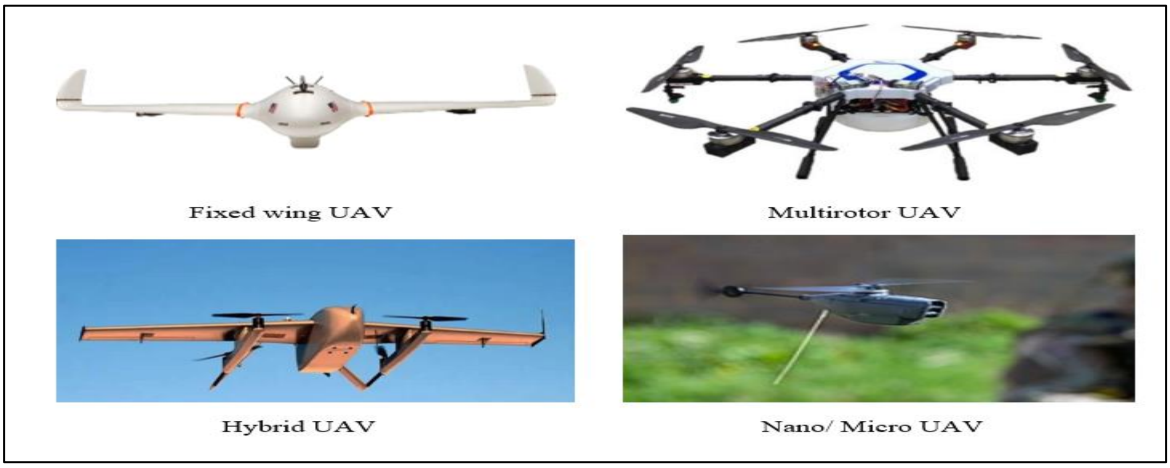


**Figure 4.** Different Types of UAV

### 3.2 Applications

- Precision farming, crop spraying, and crop monitoring are all done with UAVs that have sensors and cameras installed.
- Unmanned Aerial Vehicles (UAVs) are utilised to examine infrastructure, including buildings, electricity lines, pipelines, and bridges. They offer high-definition imagery and data that are useful for evaluation and upkeep.
- UAVs are used to produce 3D models and high-resolution aerial maps of various regions of interest, such as construction areas, archaeological sites, and topography.
- By identifying missing people or supplying awareness of situations in disaster areas, unmanned aerial vehicles (UAVs) fitted with thermal imaging devices and other sensors support search and rescue efforts.
- UAVs are employed to keep an eye on things like animal numbers, forest health, air and water quality, and wildlife quality.

## 4. Discussion

Unmanned aerial vehicle (UAV) performance study of airborne nodes entails assessing a range of factors pertaining to their autonomy, communication, navigation, and mission-specific capabilities.

- **Range and Reliability**

Determining the route where unmanned aerial vehicles (UAVs) may travel to establish and maintain communication links with ground-based station or other nodes in the network. The factors that influence communication reliability, such as signal strength, disruption, and environmental effects are taken in to consideration. By Analysing the range of communication of airborne nodes, taking into account the necessity for safe and encrypted communication pathways to avoid eavesdropping and unauthorised access. The robustness of communication connections against jamming and interference can be evaluated.

- **Security**

Security analysis of airborne nodes for UAVs is essential in both military and civilian applications to protect against cyber assaults, unauthorised access, and information losses. There are several safety measures implemented to protect UAV communication systems from computer hacking, cyberattacks, and unauthorised access and ensure system resilience, assess systems for detecting and preventing intrusions, authentication techniques, and encryption protocols. Analysing certain physical safety precautions are essential to keep airborne nodes safe from stealing, manipulation, and destruction. By using secured enclosures, tamper-evident seals, and access restrictions to prevent unauthorised physically access to UAVs and the parts they contain.

- **Flexibility & Payload Capacity**

The adaptability and versatility of UAV payloads to accept diverse cameras, sensors, communications equipment, and weapon systems. The different payloads may be integrated to enable multi-mission capability in a variety of operational scenarios. Thus, UAV payload capacity and interoperability with different sensors, cameras, and other types of equipment needed for certain applications. This identifies that how varying payloads impact the performance of airborne nodes. Effectively UAVs integrate with various systems and platforms in the operational environment. It is compatible with existing network layouts, control and command systems, and protocols for communication.

- **Mission Goals**

Considering additional performance measurements specific to the aims and demands of UAV operations. This might include parameters such as mission achievement rate, observation protection, identifying targets accuracy, and data transmission reliability. UAV performance study often incorporates analysis of data, testing in the field, and modelling to analyse system capabilities across a variety of missions scenarios and operating situations. Maintaining maximum efficiency and mission performance necessitates continuous monitoring and improvement. The connection of airborne nodes to ground systems for control, mission scheduling programmes, and other infrastructure elements will be evaluated how well data acquired by UAVs is relayed, processed, and used by ground operators.

## 5. Conclusion

In this research, the performance analysis on UAV airborne nodes is extensively reviewed. Various studies on airborne nodes and UAVs are comprehensively addressed in order to expand the knowledge on UAV and airborne networks. There will be a detailed discussion of the many types of UAVs and airborne nodes, as well as their applications and benefits. The performance analysis section provides into further detail on the performance of UAV-related airborne nodes. In the future, UAVs might be used for a number of purposes, including environmental monitoring, traffic control, pollution tracking, civic security management, and products delivery. UAV programmes, among others, may provide cost-effective services to help achieve smart city goals.

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