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Article

An analytical view on Unmanned Aircraft Systems

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Abstract: Unmanned Aircraft Systems (UAS) is a booming technology with a future perspective and does have a huge S potential to transfigure warfare and enable up to date civilian applications. It furthermore matures in a technological way as to be impinged into the civil society. In 2010, the importance of scientific applications in the respective field was demonstrated by DOD in the contemporary years. In recent years, UAS has played an integral role in a number of missions that are public like law enforcement which is local, board surveillance, weather monitoring, wildlife surveys, military training. UAS do force some challenges which are numbered as lacking a pilot which is on-board in order to see and hence avoiding supplemental aircrafts and furthermore, the extensive discrepancy in the missions related to UAS and in order to implement the operations in NextGen time frame impinged in NAS, the capabilities of the respective topic must be communicated. The applications of UAS are numbered as Ariel Mapping and Meteorology, intelligence, remote sensing, surveillance and reconnaissance, environmental monitoring and agriculture, border security, security applications and law enforcement, counter insurgency, electronic attacks, attack strike, communication relay, target identification and designation. Via this survey paper, it can be concluded that UAS is emerging as a valuable and helpful technology having tremendous potential for revolting warfare and enabling new applications w.r.t the UAS field.

Keywords: UAS; reconnaissance; NAS; NextGen; time frame; security; payload

1. Establishment of unmanned aircraft

1.1. Introduction

An over unambiguous view of Unmanned Aircraft is a type of aircraft in which the crew of respective aircraft is removed and hence replaced by a system managed by computer and radio- link. For knowing the importance of UA, which is a wholesome system, furthermore including the stations that are groundly operated and launching mechanisms, a term was coined i.e., Unmanned Aircraft Systems (UAS) [1]. Unmanned Aircraft Systems are also named as Unmanned Aerial Systems [2]. This type of system comprises of air vehicles and equipments that are associated to it [3]. No human operator is carried by this class of system [4]. UAS flies automatically or is remotely piloted [5]. UAS is implemented in those systems which includes command, control and communication (C3) systems and a personnel that controls the UA [6].

As **Figure 1** depicts the different components like flight control and operating system which furthermore comprises different control stations, data terminals, communicating links, launching and recovering elements and so on [3]. UAS serves itself in different fields like aerial means, photography, air traffic, weathering, military, navy and airforce missions, agriculture, forestry and many more. Basically the three main features that sum up to be an UAS are the aircraft, ground control stations and the main operator [4].

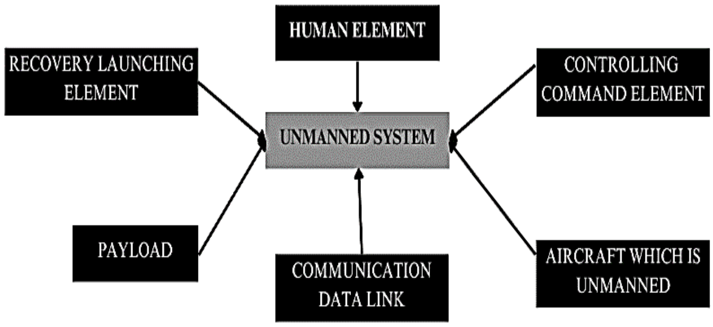

Figure 1. Corresponding elements of an UAS [5].

1.1.1. What does make an unmanned aircraft system

UAS in civilian sector mainly consists of a aircraft remotely piloted or unmanned, element of the human species, payload, elements for controlling factor and architecture w.r.t data link communication. But incase of military sector UAS also consists of platform for weapon system and the supported soldiers. **Figure 1** depicts the various elements joining together to form a UAS.

Aircraft that is remotely piloted

Various classes of UAS that flies with no human on board are: i) Fixed-wing. ii) Rotor-wing or a vehicle that is lighter than air.

(1) Fixed-wing

A number of applications are served via a fixed-wing UAS like gathering intelligent information, surveillance and reconnaissance or ISR. By the joint mission combination of ISR and delivery of weapons os adopted via UAS fixed-wing used in military sector e.g., General Atomics Predator series of aircraft. The advantage of this type is to offer operators for long flight duration via minimized station time or maximized range. Another advantage of this type is to provide the ability for conducting flight at higher altitudes, which are not easily visible to naked eyes. The logistics which are required for launching and recovery are very substantial; which is a disadvantage w.r.t fixed-wing UAS.

(2) Vertical takeoff and landing

VTOL serves a huge contribution in the application field of UAS. VTOL platform is formed like a helicopter; an aircraft that is fixed-wing which can hover, or can be a tilt-rotor. Some examples of VTOL UAS are the Bell Eagle Eye Tilt Rotor. The need of roads for runways or land for takeoff is high; this is the main reason for launching small L&R footprints which is advantageous.

Command and control element

(1) Autopilot

Without any intervention by the operator an execution of a mission via UAS is done which has a preprogrammed set of instructions and hence this explains the definition of autonomy. From takeoff to landing the fully autonomous UAS flies without any intrusion of the operator. The two aspects that are important are: external pilot and remotely controlled program, responsible for the operations regarding aircraft that are on the other end of the spectrum. The landing and taking-off are controlled via autopilot without any pilot intrusion. But a command known as Pilot-in-Command can intrude in between in the case of any emergency. For guidance of a designated path w.r.t a vehicle via predetermined waypoints, autopilots play a vital role in these types of vehicles. For small UASs, autopilot has been made available in recent years. Autopilot systems are programmed with a technology that is redundant in nature. If the communication between control station and ground and air vehicle is disrupted a procedure is performed named as "lost link".

(2) Ground control station

The control center w.r.t GCS is either land/sea-based. It provides the facilities regarding human control w.r.t to UAS in either air or in space. GCSs do vary in size and can be the size of a handheld transmitter or as large as a facility that is self-contained with various workstations. It mainly consists of a pilot station and a station for sensors.

Communication data link

It describes how commands of UAS and controlled information is sent and hence received from GCS and respective autopilot. The categorization is i) radio frequency LOS and ii) beyond LOS.

Payload

For accomplishing a mission it is usually required which should be onboard. Payload is related to surveillance, application, delivery of weapons, communication skills, aerial sensing and cargo.

Launch and recovery

One of the most important aspects related to the UAS operation is L&R element. The runway length is up to 10,000 feet and equipment like ground tugs, trucks etc. are important for large UASs.

Human element

This is the most important element in UAS. The operations are executed by this element in UAS. The different elements contained within this field are pilot, sensors and ground crew. In commercial airlines, automation requires less human elements.

1.2. Evaluation of unmanned aircraft systems

In 180–234 A.D a Chinese general named Zhuge Liang used UAS for the first time. By using balloons made up of paper impined with oil burning lamps in order to heat the air. The main motive for doing such a thing was to make the enemy believe that there is a divine force present at work when they flew over them. In July 1849, warfighting occurred by using UAS via balloon carrier [7]. In 1903, a spanish engineer named Leonardo Torres Yquevdo introduced "Telekino" which is a control system working on radio-based terms in Paris. Academy of science; aiming at the testing of an airship without risking human life [8]. In 1915, an uncrewed aerial combat vehicle fleet was discovered by Dempsey [9]. In 1916, Low attempted "Ariel Target " which was first powered by UAS [10].

On 21 March 1917, Taylor and John by using a radio system flew the first monoplane [11]. In 1918, an aircraft controlled fast motor was developed by Low and

Royal Navy which aimed at attacking ships and installation of ports. A pilotless aerial torpedo was developed by Dayton-Wright Airplane company during World War I [12]. The first scaled piloted vehicle was developed by enthusiast Reginald Denny in 1935 [9]. In the late 1930s, Tupolev TB-1 bombers were experimented and controlled by Soviet researchers remotely [13]. Radioplane company was started by Denny in 1940 and many more models emerged during World War II which furtherly used in training aircraft gunners and to fly attack missions [14]. In 1951, after WWII; the development work of vehicles such as TB-4 continued for civilian use and in 1955, the Model 1001 was developed by Beechcraft for the US Navy [9]. The US Air force in 1959 were concerned in case of losing the pilots over a hostile territory and hence the force started to plan the usage of uncrewed force [15]. In 1960, after the Soviet Union shot down a U-2, the planning intensified. During this phase a program ran under the title, "Red Wagon" [16]. During the years 1967–1970, War of Attrition took place in which the intelligence field of Israel tested the UAS in which a reconnaissance camera was installed. The main task of these UAS were to return back from the Suez canal after taking pictures. UASs were used in Yom Kippur War, Israel as decoys in 1973, serving the main purpose in spurring the enemies into the wastage process of expensive anti-aircraft missiles [17].

In 1987, the UASs were used by Israel performing many purposes for example; jet steering, proof-of-concept of super-agility, 3D thrust vectoring flight control, post-stall controlled flight in combat-flight simulations that involved tailless, stealth-technology-based [18]. A large number of UASs found their active role in the 1991 Gulf war. From 1 May 2002–31 December 2005 a European Union project, CAPECON developed UASs [19]. In 2012, the United States Air Force (USAF) did employ UASs which were 7494 in number [20]. A drone named Kargu2 was hunted down in 2020 for attacking a human target in Libya. This was the pioneer killer-robot [21]. The 2020 Nagorno-Karabakh was successfully won by Azerbaijan against Armenia by using the superior drone name Bayraktar TB2 [22]. NASA developed dragonfly spacecraft in order to reach and study Saturn's moon named Titan.

1.3. Contributions

This paper briefly discusses the concept of Unmanned Aircraft Systems. This paper describes the basic introductory concept of UAS and its history. The author successfully describes different classes of UAS, its design and many more concepts related to the respective topic distributed in different sections. In this paper the author has briefly explained classes of UAS in Section-2. In Section-3 the building design of UAS has been explained by the author. Section-4 explains the accord of UAS. Implementation of UAS in different sectors has been noted down in Section-5. Section-6 jot down the difficulties faced via UAS. Section-7 jists to the futuristic approach of UAS. Jist of the study is stated in Section-8 and list of abbreviations is shown in Abbreviations.

2. Classes of unmanned aircraft systems

Categorization of UAS

A non-carrying human vehicle which is powerful in nature can be remotely operated via automatic ways is recovered and expanded and so hence carries payload which can be lethal or non-lethal. There are different types of vehicles which are not considered to be unmanned e.g., mines, satellites, ballistics or non-ballistics vehicles, unattended sensors, cruise missiles, torpedoes, projectiles which are artificial in nature and many more [23]. There has been a noticeable increment in the usage of the respective technology in many fields such as military, civil and a few more areas, serving some special purposes. The different types of UAS are based on size, endurance levels, capabilities etc. is the effort that goes in for the increment of payload and flight endurance [19]. In **Table 1**, historical development of UAS is mentioned w.r.t technological development and sources related to the respective year which helps in understanding the developmental course of action that how the UAS evolved over the years. The categorization into four classes are numbered as follows [19,21,24]:

A. Fixed-wing UAS

This type of UAS does require a runway from which it takes off and lands too. The characteristics that they inhibit are long endurances and high cruising speed while flying. This class is heavier in comparison to an airplane, examples like kits, hang gliders, aircraft and many more using wing morphing do come under the category of fixed-wing aircraft. Different types are:

- Airplane

An airplane is propelled in forward direction via thrust via a jet engine. Planes do come in various sizes, shapes and configurations of wings.

- Seaplane

It is a type of fixed-wing aircraft that can take off and land on the water as well sometimes on dry land too. These are sometimes termed as hydroplanes.

- Powered gliders

By adding small power plants, various forms are mentioned as: motor glider, powered hang glider, powered parachute, power paraglider.

- Ground effect vehicle

It is a type of vehicle that attains flight level which is near to the earth's surface by using ground effect.

- Glider

These are supported via dynamic reaction w.r.t air in flight against the lifting surfaces.

Table 1. Historical development of UAS.

S.No.	Year of development	Technological development	Technological sources
1	1900	Radio and autopilot	Wright Brothers, Nicola Tesla
2	1915–1920	Aerial torpedo	U.S. Navy, World War I
3	1920–1930	First helicopter uass	World War I
4	1930–1940	Target drone	After Wwi, U.S. Army
5	1935	World war ii	Wwii, U.S Navy
6	1940	V-1 buzz bomb	Nazis
7	1940–1950	Wwii german	U.S. Military
8	1950–1960	Unmanned reconnaissance aircraft	North Vietnamese

Table 1. (*Continued*).

S.No.	Year of development	Technological development	Technological sources
9	1950–1960	Radar decoys	U.S. Air Force
10	1960–1970	Long range reconnaissance UAS	U.S. Air Force

B. Rotary-wing UAS

It is also called out by two names which are Rotorcraft UAS and second one is Vertical Take-off and Landing (VTOL) UAS. The advantages of the specific class are as follows: hovering capability and high maneuverability. These characteristics are important in civilian applications especially in robotics missions. The configuration of the respective class includes tail rotors, coaxial rotors, tandem rotors, multi rotors etc.

This kind of aircraft is heavier than aircrafts having rotary wings, and generates lift via the rotation around a mast which is vertical. The classes are:

- Helicopter

In this type of class which is driven via rotors in the engine through the whole flight, for allowing vertical take off and landing and hovering, flying backwards and forward.

- Autogyro

The usage of unpowered rotor is possible in this type; driven via forces which are aerodynamic in the state of autorotation in order to develop lift, which is powered through a propeller engine.

- Gyrodyne

The engine used for takeoff and landing is with anti-torque property and propulsion for the forward flight.

Increment in propeller's power results in the less power requirement via rotor in order to provide thrust in forward direction which reduces the pitch angle and flapping in the rotor blade.

C. Blimps

These are lighter than air. They have characteristics like long endurance, low speed flying and are of large size.

D. Flapping-wing UAS

They have wings like birds or insects that fly flexibly and are morphing small in nature. They have a convertible configuration in which they can tilt their body/rotor vertically while taking off and hence fly like an airplane just like Bell Eagle Eye UAS. The differentiation of this class from the rest can be done on the basis of size and endurance of an aircraft [19,25,26].

Because of different aspects like capabilities, the size and characteristics of operating systems, UAS has been classified. Most UAS are classified in terms of maximum gross take-off weight (UA with payload), Endurance and altitude, operational areas of radio-link, usage, tasks performed by UAS (dull, dirty, dangerous). Classification is done by the operational requirement.

- High altitude

The range in this type within which the flight operates over 60,000 ft varies between different systems there are Unix, Linux and QNX.

- QNX

Usage is in QUAV group. Usually used in desktop and computing requirements in embedded fields. The advantage of QNX is evident in the process of porting applications from Linux to QNX which are straightforward in nature [27].

- Medium altitude

Flying of aircraft with varying range is 18,000–60,000 ft.

- Low altitude

Flying of aircraft is possible within a range of 18,000 ft and below.

- Very low altitude

Flight is possible below 1000 ft.

- Endurance

In this factor the vehicle operates in the range above than 500 km, or staying in flight more than 20 h in the air. These factors which are mentioned above are considered to be sophisticated due to the high capabilities of these UAS classes. The classification of the UAS from other systems is done by their large dimensions and capabilities [23].

UAS classes are divided on the basis of applications they serve in a particular field.

- Target and decoy

Stimulating the target of an enemy aircraft or any missile by providing a ground and analyzing video.

- Reconnaissance

Intelligence about the battlefield is provided.

- Combat

Provision of attack capabilities regarding high risks which do have missions.

- Research and development

Further UAS technological development is priority as it is impinged into the deployed field of a UAS aircraft.

- Civil and commercial UASs

Designed specifically for applications in civil and commercial fields.

The classes of UASs are classified further on the basis of altitudes which are described as:

- Hale

It is an acronym for high altitude long endurance. The altitude ranges over 15,000 m and the endurance levels above 24 h. This class of UAS is always have increasing arm length. This class is used for long range reconnaissance and so for long range surveillance. This class finds its application in Airforce which operates on fixed bases.

- Male

The full form is medium altitude long endurance. Its altitude ranges from 5000–15,000 m and the endurance levels to 24 h. The operation of this class is similar to that of HALE but somewhat it does operate on a shorter range which values over 500 km, still working from the fixed bases.

- TUAS

It stands for Tactical UAS ranging between 100–300 km. These are operated by either land or naval or both. This type of air vehicles are comparatively smaller in size and the operation is similar to male/hare.

- Close-range UAS

The main three applications of this type of class can be summarized as: i) battle groups for mobile army, ii) some operations related to military or naval and iii) for different civilian purposes. The operating range of these classes is about 100 km.

- Mini UAS (MUAS)

The main ranges are below 20 kg and the operational range is about 300 km. The usage of this class is mobile battle groups and different purposes for civilians.

- Micro UAS (MAS)

This class does have the using span with a value no greater than 150 nm. The application of this class is majorly found in urban environments, most usually within buildings. It is usually launched via land. Because of this reason the loading in the winged versions is low which is furthermore vulnerable in atmospheric turbulence.

- Nano Air Systems (NAS)

It is the size of a sycamore seed. Usually used in radar confusion, camera, propulsion and controlling sub-systems and for surveillance ranging in ultra short range.

3. Building design of UAS

3.1. Architectural design of UAS

The basic architectural design of UAS comprises fewer elements which are depicted as in the **Figure 2** below.

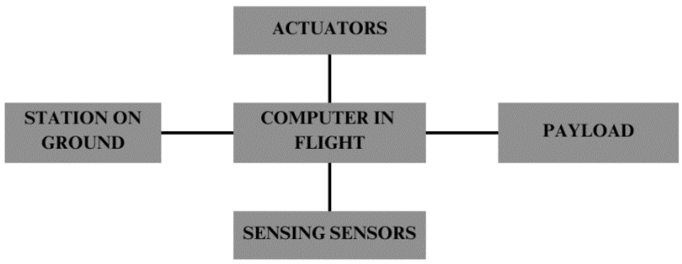

Figure 2. Basic architectural design of UAS [27].

The descriptional points and definition of different elements of UAS are:

- Computer in flight

This element describes the flying phase of UAS. It is an element in which there are two ways described. The first one is for remotely controlling data link radio which is two-way and second is the computer which is onboard, generally connected to aircraft control systems [28]. The system controlling flight and operating systems includes many factors like station(s) that controls UAS, communication links, terminal(s) used for data exchange, launching and recovering system equipment that supports ground system and interfaces for air-traffic control.

Actuators:

- Payload

Payloads are generally high and low resolution camera/video cameras, day and night reconnaissance equipment, high-power radar, gyro-stabilizer, electro-optical signal, meteorological, chem-bio relay, welfare machinery and generally any equipment required for the mission , the UAS is designed [29]. High fuel fraction is demanded by UAS with the desire for endurance. It results in a low payload fraction having a typical value of 10%–20% of gross weight [30].

- Sensors

It provides the basic function for maintaining the flight in the absence of human, pictorial element, radar element, camera for video recording, IR scanners which are very common. For providing a guided path in concern with missiles and sheets that are targeted by a laser i.e., target designation is included in sensors. There are different benefits of sensing payload in a UAS are as follows:

a) Collecting intelligence data.
b) Reconnaissance surveillance.
c) Supporting operations by providing target acquisition.
d) Delivering weapons.
e) Identification and detection of the target.
f) Improvement in aim point accuracy [30].

- Navigation sensors and microprocessors

Sensors are the costliest item in UAS. The main aim of sensors is to navigate and achieve missions. With little or no human element, the processors do allow UAS for flying the entire mission and that to autonomously [19].

- Aircraft onboard intelligence

The basic intelligence of UAS is basically related to the two phenomenons:

a) Directly proportional to Handling power of a UAS in a tedious task.
b) Inversely proportional to the oversight is required by a human element.

It includes guidance, navigation and control [11].

- Communication systems

It is also known as the Air data terminal. The main issues of communication systems are:

a) Flexible capability.
b) Security and cognitive controllability of data flow.
c) Bandwidth on which it works.
d) Frequency of the system [19].

The building elements of UAS data link are: transmitter and receiver of RF, an antenna and connecting modems with sensor systems. There are three main functions served by UAS:

a) Ground station uplinks and/or control data send to UAS via a satellite.
b) UAS downlinks which are used to send data to ground stations via sensors that are onboard and telemetry systems.
c) To allow means for measuring azimuth and range from a ground station and satellite to UAS in maintaining a good communicative relation between them.

Standardizing efforts in concern to data links did result in the usage of common data link (CDL), which has the following characteristics like it is fully duplex, and does work on wide-band data link while using UAS which is usually secure and jam resistant. These types of data links are used in connecting the ground station via UAS which is direct and point-to-point/usage of satellite communication (SATCOM) [31].

Control types:

The central jist of a UAS is the removal of the operator from cockpit; and then controlling the aircraft via other means. Three main types of controls that are exerted over the aircraft as follows:

a. Ground control

The other name for this type is Remotely Piloted Vehicles (RPVs). The main requirement of this type is the operator’s constant input. RPVs are a kind of sophisticated radio-controlled aircraft with the usage of a few basic techniques which are familiar to R/C hobbyists [32]. There are fewer moderation UAS that are remotely piloted.

b. Semi-autonomous

These types of UAS are defined as the input from ground incase of critical portions of some flight which are mentioned as take-off, landing, unemployment of weapons and some evasive maneuver. During different operations w.r.t. the flights like during pre-flight, take-off, landing and operating near base, the operator should have full control. The aircraft will follow a different set of pre-programmed waypoints once airborne an autopilot function is engaged. Throughout the operation, operator takes the full responsibility of UAS [27,28].

c. Fully-autonomous

Within the end of the spectrum of the other side, capability of this type lies. For carrying an objective followed by the decision for taking off, this type does not need any human element. The health status and configuration of this type of UAS is monitored itself. The command and controlling assets onboard the vehicle is inbuilt within the programmed limitations [27,28].

Station on the ground:

It's also know as Ground Control Station (GCS) or C3. There are different fields in which UAS have its own technology like telecommunications, guidance and control technology. The platform has been more reliable incase of flight control after the introduction of solid-state gyros and sensors. The flight is uplinked via modern technology in the field of telecommunications. Over a long distance and at a very long rate the mission is commanded to an aircraft [18,20,21].

Ground station command, control and communications (C3):

Several important points are addressed on the off-board infrastructure like man-machine interfaces, multi aircraft C3, target identification, downsizing ground equipment, noise control etc. A single person can control multiple aircraft with the help in advancement of the state w.r.t. the points mentioned above. By combining planning, personnel, equipment, communications, navigation and technological functions and procedures, command and control function is accompanied [20,33].

3.2. C3 system model

A system model of C3 is shown in **Figure 3.** Within the RF LOS or beyond of this LOS, the operator of an aircraft operates w.r.t. YAS operations. UAS are divided into categories and subcategories on the basis of C3 in relation with technologies and operating procedures. The loss procedures related to current link are described as follows:

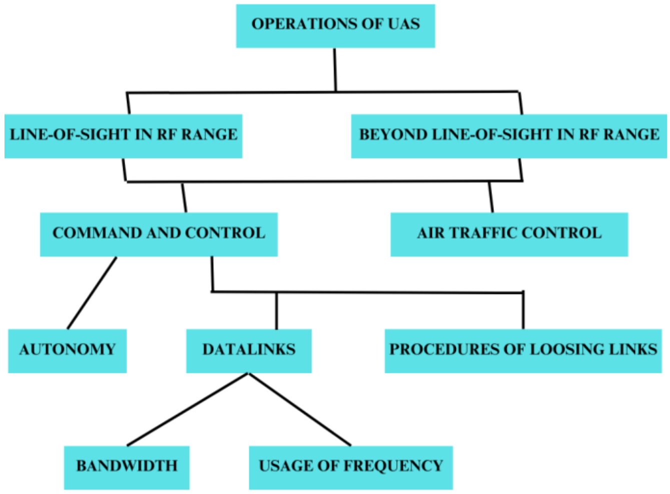

Figure 3. System model of C3 [33].

A. Blos operations

This figure above illustrates the overlapping operating conditions and different UAS classes that operate within these respective areas. **Figure 4** describes the following:

- All the aircraft are included in LOS section
- High and medium endurance is included in BIOS section [33].

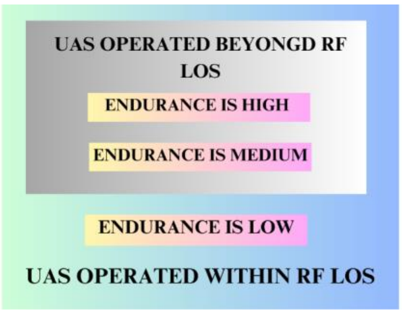

Figure 4. BIOS operation [33].

B. RF LOS C3 technologies and operations

The LOS operation is majorly divided amongst three categories which are: High, medium and low UAS endurance. First class mostly operates in LOS [33].

C. BLOS C3 technologies and operations

BLOS majorly covers the high endurance UAS and a fewer part of medium endurance UAS that does operate beyond LOS [33]. Satellite-based communications (SATCOM) is a used element for beyond LOS command and controls the communication with UAS.

3.3. Mostly commonly used frequency bands for UAS

Links of satellite communication in UAS are used both in LOS and BLOS mode. These types of communications are usually used for RF applications. **Table 2** mentioned below depicts the frequency band w.r.t working of UAS. The commonly used frequency bands for these types of links are [34]:

a. KU band

High speed links found application in this band. Propagation losses are suffered in this band, due to high frequency and short wavelengths. But beyond this disadvantage, this band has an advantage like enabling the data to trespass many obstacles.

b. K band

A large amount of data works in this band which possesses a large frequency range. There are mainly two disadvantages related to this band:

- Requirement of powerful transmitters
- Environmental interferences sensitivity

c. S, L bands

The data exchange is not possible with transmission speeds which are above 500 kbps. The advantage of this band:

- Penetration into terrestrial infrastructure is easily done by using large wavelength signals.
- Requirement of less power by transmitter.

d. C band

Requirement of large transmitting and receiving antenna in this type of band.

e. X band

This band is always received for military application.

Table 2. Frequency band [35].

S.No.	Band	Frequency
1	HF	3–30 MHz
2	VHF	30–300 MHz
3	UHF	300–1000 MHz
4	L	1–2 GHz (general) 950–1450 MHz (IEEE)
5	S	2–4 GHz
6	C	4–8 GHZ
7	X	8–12 GHz
8	Ku	12–18 GHz
9	K	18–26.5 GHz
10	Ka	26.5–40 GHz

4. UAS autonomy

UASs can be the three; automated, autonomous and semi-autonomous. UAS can be accessed remotely and may be mixtures of the above mentioned capabilities [36]. The minimum element in an autopilot system comprises altitude sensors and onboard processor. There are a number of non-linearities in airplane dynamics like:1) PID control, 2) neural network, 3) fuzzy logic, 4) sliding mode control and 5) H∞ logic. These are used for a smooth desired trajectory navigation in an autopilot system. Microelectromechanical Systems (MEMS) are a new day technological advancement which is easy to use.

Manet:

It is a wireless network which is flexible in nature. It applies to the heterogeneous

UAS fleet whose separations are possible without any infrastructure. This type of network orients to collaborate which is commonly known as Mobile Ad-hoc Networks (MANET). MANETs have a nature of self-organized networks. In this type of network, the connectivity is provided in a different wireless node. In this network, every wireless node does act as repeater or a relay. The main purpose of this infrastructure is to forward data to the destined node. Incoming future this network will find its application in civilian and military fields [37,38].

Security issues of UAS C3 technology and operation:

There are many challenges faced by UAS C2 and ATC communications which are numbered as:

a. Jamming
b. Hijacking
c. Spoofing of data link

W.r.t the factor of "immediate control" of the aircraft, UAS is different from the rest of the aircraft which are used conventionally. This term explains that the aircraft which is in the immediate vicinity, in risk of collision can be flown by the pilot of the aircraft. The difference between UAS and conventional aircraft is that UAS as a medium is present between the pilot present in the ground control station and the respective aircraft. The medium present is a data link which is easily prone to threats. To take full control of UA the hacker can do the following activities:

a) he/she can hack the data link
b) can jam the data link network
c) can create a fake UAS signal

As data links are very important for wireless communication, therefore; a precautionary measure should be taken while selecting the data link.

Advances in autonomous UAS technologies:

Some technologies amongst these which are applied to UAS like airframe, propulsion system, structure of aircraft etc. For enabling the autonomous behavior and flight of UAS, other technologies are specified e.g., observe, orient, decide, act [36]. Some of the included technologies are sensors used for navigation and avionics, system for communication, C3 infrastructure, onboard autonomous capabilities.

- Automated system

In this type of system an outcome is achieved by following the pre-defined set of rules w.r.t. response from sensor(s). the output seems to be predictable if the pre-defined set of rules are known.

- Autonomous system

Higher level intent and direction are the two factors which can be understood by an autonomous system. By this kind of understanding, any system can have the desired outcome by taking appropriate steps in a particular state without the dependency on human oversight and control. This system decides the course of action, by using a number of alternatives.

- Navigation

There should be a number of ways in which the location/position of a UAS can be found out and for performing the above process in a navigating system which is robust in nature, with high level of accuracy and high integrity is needed. The solution is GPS.

- Guidance and flight control

To fly along with the chosen flight UAS generates steering commands and control deflections which are subsequent in nature.

- Sense-and-avoid

In civilian airspace one of the major limitations regarding UAS is sense-and avoid [18]. For avoiding the collision of piloted aircraft with each other, this sense-and-avoid is the primary mechanism. The active solution includes usage of radar for detecting collision threats. The basic requirement of this is high power backup.

- Fault monitoring

For ensuring the integrity of the UAS system, there should be a conduction of fault monitoring on the flight and the system for critical missions. This system ensures that the system should not lead to failure which is catastrophic in nature by system faults hence is undetected.

- Intelligent flight planning

For planning and re-planning, the flight of UAS aircraft should be capable enough which results in the requirement of an environment with a high-level computing process system in which algorithms can be run down for planning the flight. The operation related to flight requires planning which includes the surroundings of the UAS, like airspace, terrain, weather, restricted areas, and different obstacles.

- Payload

The two requirements of UAS in civilian application for designing an infrastructure for performing a mission:

a. Lower cost
b. Impact on UAS equivalent

A specific task is performed by an equipment installed an UAS called Payload. The payload requires three factors which are space, weight and allocation of power. A certain type of payload requires access to data of a UAS system e.g., position, speed of air or altitude.

5. Implementation of UAS in different sectors

The main investment in the future in the field of applications of UAS serves in military and defence scenarios. The prime usage of UAS for intelligence, surveillance and reconnaissance (ISR) patrols and strikes. Another usage is served in detection of chemical, biological, radiological and nuclear (CBRN). The advantages of UAS are: better and sustained alter nature in comparison to humans through dull operations. The operations related to UAS are in concern with the scope regarding Japanese Ministry of Agriculture, forest and fisheries and are related associations which are affiliated with Japanese agricultural aviation association [19,20,22,23,25,27,29,30,34].

Applications of UAS

There are number of applications in different fields which are numbered as:

a. Military applications
    - Reconnaissance Surveillance and Target Acquisition (RSTA).
    - Surveillance for peacetime and combat Synthetic Aperture Radar (SAR).
    - Deception operations.

- Maritime operations (Naval fire support, over the horizon targeting, anti-ship missile defence, ship classification).
- Electronic Warfare (EW) and SIGINT (SIGnals INTelligence).
- Special and psyops.
- Meteorology missions.
- Route and landing reconnaissance support.
- Adjustment of indirect fire and Close Air Support (CAS).
- Battle Damage Assessment (BDA).
- Radio and data relay
- Nuclear cloud surveillance Military roles according to arm and forces [39].

b. Navy applications
- Shadowing enemy fleets
- Decoying missiles by the emission of artificial signatures
- Electronic intelligence
- Relaying radio signals
- Protection of ports from offshore attack
- Placement and monitoring of sonar buoys and possibly other forms of anti-submarine
- warfare Army
- Reconnaissance
- Surveillance of enemy activity
- Monitoring of nuclear, biological or chemical (NBC) contamination
- Electronic intelligence
- Target designation and monitoring
- Location and destruction of land mines Air Force
- Long-range, high-altitude surveillance
- Radar system jamming and destruction
- Electronic intelligence
- Airfield base security
- Airfield damage assessment
- Elimination of unexploded bombs

c. Civilian applications
- Policing duties (civil)
- Traffic spotting (civil)
- Fisheries protection (civil)
- Pipeline survey (civil)
- Sports events film coverage (civil)
- Agricultural operations (civil)
- Power line survey (civil)
- Aerial photography (civil)
- Border patrol (civil)
- Surveillance of coastal borders, road traffic, etc. (civil)
- Disaster and crisis management search and rescue (civil)
- Environmental monitoring (civil)
- Agriculture and forestry (civil)
- Firefighting (civil)

- Communications relay and remote sensing
- Aerial mapping and meteorology.
- Research by university laboratories (civil)
- Communications relay (civil)
- Law enforcement

Security is the main aim for the applications of UAS in every field [40].

6. Difficulties faced via UAS

The below mentioned challenges are just numbered due to the census gained in the respective field, so hence the challenges are numbered as:

a. Sense and avoid technology

The important factor for the civilian application in a shared airspace is to "see and avoid" for the pilots is to use the sensors and different other tools which are used to find and in order to maintain the awareness of a situation w.r.t. the traffic [30].

b. Regulation of bandwidth

c. Procedures of lost link

In all the fields which are UAS related, it must be provided with a number of recovery means in case of lost link. The aim is to make sure that airborne operations are predictable in case of lost links [3].

d. Flight termination system

For ensuring overall safety and a system, the desired characteristics are redundancies and independent functioning nature. If the above point is not satisfied, the pilot manually activates the termination system in which the command of a UAS pilot is required for safeguarding the public.

e. On-board intelligence challenges

On-board intelligence, teaming/swarming [35], health management, collision avoidance, affordability, sensing.

f. Interoperability

The UAS should be compatible enough in order to serve in the domains of air, ground and marine fields seamlessly. The robust implementation process of interoperability tents enables UAS to perform the above tasks smoothly.

g. Autonomy

The introduction of incremented UAS autonomy must include affordability, utilities that are operational, developments related to technology, policies, opinion related to public phase and the respective associated constraints with it.

h. Airspace integration

DoD with integration with Federal Aviation Administration (FAA) ensuring the access routine of the UAS with meeting the training process impinged with National Airspace System (NAS). The main purpose is to meet the training and operational requirements.

i. Training

A continued and joint training process is assessed in UAS for a fruitful work. Improvement in basing decisions, standardizing the training and operational training process, it improves the effectiveness and efficiency.

j. Propulsion and power

Increased demand for efficiency and logical sources of propulsion and power, results in rapid development of UAS deployment.

Table 3 shows the main differences between manned and Unmanned aircraft systems.

Table 3. Difference between manned and unmanned aircraft.

S.No.	Manned aircraft	Unmanned aircraft
1	Suitable for both projects which are large and small in size.	The operations that are executed via their aircrafts are low-cost.
2	Capable of carrying sensors that are used for high end-mapping.	This type of aircrafts has high resolution power.
3	Suitability for operations which are airspace-friendly.	These aircrafts are suitable for very small projects.
4	Aviation is safer.	Aviation is at high risk.
5	Operations are high-costed.	Aircrafts are not able to carry sensors for high-end mapping.
5	Not suitable for very small size projects.	Are not suitable for large projects.
6	Low resolution power.	Flying UAS over people is restricted via the FAA.

7. Futuristic approach

The next of UASs will be needing more execution of difficult missions like air combat, target detection, recognition and destruction, strike of an enemy's defense related to an electronic attack etc. [24]. The respective technology of autonomy will be important in the future for UAS development falls under the numbered classes: sensor fusion, communications, motion planning, trajectory generation, task allocation and scheduling cooperative tactics. For the development of UAS intelligent mission management is important. For future generations, intelligent Autonomous Architecture plays an important role which combines the onboard and ground- band systems for controlling vehicles and its payload.

8. Conclusion

This paper is all about the phenomena related to Unmanned Aircraft Systems i.e., what is UAS, how it works, what are its applications, drawbacks and how it will affect the future or what developments will be there in relation to the respective subject.

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Abbreviations

e.g.,	For example
UAS	Unmanned Aircraft System
i.e.,	That is

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