The unmanned aerial object Drone as both Biplane and Helicopter using one Propeller

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***ABSTRACT*: Drones are a hot topic right now in many industries, including agriculture. Like many technologies that were initially developed for military applications, drones are becoming commercialized and commoditized at an astounding rate. Growth in sales of commercial drones is exceeding market predictions by wide margins. This paper deals with the basic concepts of drone along with its structural details, types, functionality and future scopes.**

***Keywords*: Unmanned Aerial Vehicle, Remotely Piloted Aerial Vehicle, Remotely Piloted Aircraft System, Computing, Sensors, Actuator, Flight controls, Microcontroller unit, Autopilot, RPM.**

I. INTRODUCTION

An unmanned aerial vehicle (UAV) is more commonly known as a drone. It is an aircraft without a human pilot who is driving it. UAVs are a part of an unmanned aircraft system (UAS); which include a UAV, a controller that controls from the ground, and a system of communications between these two UAVs may operate with varied degrees of autonomy: either under remote control by a human or independently by onboard computers. Compared aircrafts with pilots, UAVs were originally used for missions too "dull, dirty or dangerous" for humans being. While they started mostly in military applications, their use is spreading in a rapid level to commercial, scientific, recreational, agricultural, and other varied areas, like photography of aerial objects, agriculture, smuggling, delivery of products , and drone racing. Civilian UAVs have vastly outnumbered the military UAVs, with average estimation of over a million of these products sold by 2015, so they can be observed as an early commercial application of Autonomous Things, to be followed by the autonomous car and home robots and so on.

II. TERMINOLOGY

Large number of terms is used for naming unmanned aerial vehicles, which generally refer to the same idea. The term **drone**, which is more widely used by the public currently, was coined in reference to the similarity of the sound of navigation and loud-and-regular motor of old military drones, to that of the sound of male bee. The term has however encountered strong opposition from aviation professionals and government regulators.

The term unmanned aircraft system (**UAS**) was first coined by the United States Department of Defence (DoD) as well as the United States Federal Aviation Administration in 2005 according to their Unmanned Aircraft System Roadmap 2005–2030[1]. The International Civil Aviation Organization (ICAO) along with the British Civil Aviation Authority adopted this same term. It was also used in the European Union's Single-European-Sky (SES) Air-Traffic-Management (ATM) Research (SESAR Joint Undertaking) roadmap for 2020[2]. This specific term stresses on the importance of elements other than the aircraft as a whole. It includes the different elements such as ground control stations, data links and other different support equipment. A similar term to this UAV is remotely piloted aerial vehicle (RPAV), remotely piloted aircraft system (RPAS) [3].

A UAV basically is defined as a "powered, aerial vehicle that does not carry a human pilot, and uses aerodynamic forces to help vehicle lift. They can fly autonomously or be piloted remotely. They can be expendable or recoverable, and can also carry a lethal or nonlethal payload"[4]. Thus it can be observed that missiles are not considered UAVs because the vehicle itself is a weapon that can never be reused, in spite of the fact that it is also unmanned and in some particular cases remotely guided.

The relation of UAVs to remote controlled model aircraft is not very clear. UAVs may or may not include model aircraft. Some jurisdictions base their definition on size or weight of these UAVs, however, the US Federal Aviation Administration defines any unmanned flying craft as a UAV regardless of its size. For recreational uses, a drone (as apposed to a UAV) is a model aircraft that has first person video, autonomous capabilities or both.[5]

Alternate Names for Drones:

Hobby Names:

- **Quadcopter:** The most famous name for Small UAVs, which has 4 rotors positioned on a horizontal plane like a helicopter.
- **Multicopter:** A generic name for a drone which consist of multiple propellers. This covers quadcopters, octocopters, etc.
- **Hexicopter:** A multi-rotor aircraft having six rotors. The beauty and added advantage of the hexicopter is that even if it loses any single engine it still maintain control to land.
- **Octocopters:** They have eight blades.

The multirotors with a more number of blades are typically much larger and are designed to carry much heavy payload. For example, Amazon's has recently announced about using unmanned aerial vehicles which will deliver packages shows the company utilizes octocopters,

Military Names:

- **RPAS** – Remotely Piloted Aerial System
- **UAV** – Unmanned Aerial Vehicle
- **UAS** – Unmanned Aircraft System
- **SUAS:** Small Unmanned Aircraft System

III. THE HISTORY OF DRONE TECHNOLOGY

The concept of unmanned aerial flight is not a very new concept. The idea first came to prominence on August 22, 1849, when Austria attacked Venice, Italy with unmanned balloons that were fully loaded with explosives. Some balloons were launched from the Austrian ship Vulcano[6]. While some balloons reached their intended targets, most were caught in the change of winds and thus were blown back over Austrian lines itself.

WORLD WAR I: The first unmanned aircrafts were developed during and just after World War I. The first of them was the "Aerial Target," developed in the year 1916[7]. It was intended to take down Zeppelins, but unfortunately it never flew. Shortly later, the Hewitt-Sperry Automatic Airplane (the flying bomb) made its maiden flight that demonstrated the concept of unmanned aircraft. This UAV was basically intended for use as an aerial torpedo, which is an early version of modern cruise missiles. Control over these aircraft was achieved using gyroscopes[8]. In November 1917, the Automatic Airplane was demonstrated for the US Army so they can utilize it as their advantage. Upon the success of this demonstration, the Army commissioned a project that built an aerial torpedo, which became famous as the Kettering Bug and flew in the year 1918. While the technology was a grand success, it wasn't in time to fight during wartime, which ended before the UAV could be developed and properly deployed.[9] Several successors were developed during the period after WWI and before the break out of WWII. These included the Larynx, that was tested by the Royal Navy between 1927 and 1929; the radio-controlled Fairey "Queen" which was developed by the British in 1931. During the technology rush of WWII, drones were used both as training tools for antiaircraft gunners as well as for aerial attack missions. Nazis of Germany also had produced and used various UAVs during the course of WWII. After the war ended, jet engines were also applied to drones, with the first being the Teledyne Ryan Firebee I of 1951. By 1955, the Model 1001, developed by Beechcraft, was developed for the US Navy — these UAVs were however nothing more than just remote-controlled airplanes until the Vietnam Era.

MODERN ERA: The birth of US UAVs began in 1959 when the US Air Force was too much concerned about losing pilots over hostile territory, and thus they began planning for unmanned flights. Following a Soviet Union shoot down of the secret "U-2" aircraft in 1960, the highly classified UAV program was launched having the code name "Red Wagon." Modern-era UAVs was first used during the Aug 2 and Aug 4, 1964 clash in the Tonkin Gulf between the US and North Vietnamese navies during the Vietnam War. The US military officials did not comment about the fact of using UAVs during the war. However, by 1973, the US military did officially confirmed that they had utilized UAV technology in Vietnam, stating the fact that during the war, more than 3,435 UAV missions were flown, of which about 554 were lost in battle. Interest in UAV technology grew during the 1980s and 1990s – because they were used during the Persian Gulf War in 1991 – and became much more cheap and more capable fighting machines.[10] While most drones of the earlier years were primarily aircrafts for surveillance, some carried munitions. The General Atomics MQ-1, that utilized an AGM-114 Hellfire air-to-ground missile, was known to be an unmanned combat aerial vehicle (UCAV).

POST 9/11: While most drones were utilized for military purposes, the technology was commissioned by the CIA after the September 11, 2001 terrorist attacks. Intelligence gathering operations began in 2004, with CIA-operated UAVs that was primarily flown over Afghanistan, Pakistan, Yemen, and Somalia. The first UAV program of CIA was called the Eagle Program. As of 2008, The USAF has employed 5,331 UAVs, which is actually twice the number of planes controlled by pilots. Of these, the Predators have been the most praise worthy. Unlike the other UAVs, the Predator was armed with Hellfire missiles. The Predators were used during the search for Osama Bin Laden and have demonstrated the capability of pointing lasers at targets for achieving pinpoint accuracy. The overall success of the Predator missions is very much apparent because from June 2005 to June 2006 alone, Predators carried out 2,073 successful missions in about 242 separate raids.

IV. CLASSIFICATION

There is no one standard when we come to classify UAS. Defence agencies have their own standard, whereas civilians have their ever-evolving loose categories for UAS. They are generally classified by size, range and endurance, and use a tier system that is employed by the military. Based on function, drones can be classified into:

1. **Target and decoy :** Provides ground and aerial gunnery.
2. **Reconnaissance:** Provides battlefield intelligence.
3. **Combat:** provides attack capability for high risk mission
4. **Logistics :** Provides cargo.
5. **Research and development :** improve UAV technologies.
6. **Civil and commercial UAVs:** agriculture, data collection.

Based on altitude, drones can be classified into:[11]

- **Hand-held** 2,000 ft (600 m) altitude, about 2 km range
- **Close** 5,000 ft (1,500 m) altitude, up to 10 km range
- **NATO** type 10,000 ft (3,000 m) altitude, up to 50 km range
- **Tactical** 18,000 ft (5,500 m) altitude, about 160 km range
- **Male** (medium altitude long distance) up to 30,000 ft (9,000 m) and range over 200 km
- **Hypersonic** high-speed, supersonic (Mach 1–5) or hypersonic (Mach 5+) 50,000 ft (15,200 m) or suborbital altitude, range over 200 km
- **Orbital low earth orbit** (Mach 25+)
- **CIS Lunar Earth**-Moon transfer
- **Computer Assisted Carrier Guidance System** (CACGS) for UAVs

Based on weight, drones can be classified into:[12]

- **Micro Air Vehicle(MAV**) – the smallest UAVs that can weight less than 1g.
- **Miniature UAV** (also called SUAS) – approximately less than 25 kg.
- **Medium weight UAVs** They weigh about 50 to 200 kg.
- **Heavier UAVs** They weigh approximately about 200 to 2000kg.
- **Super heavy UAVs** Their take off weight is greater than 2 tonnes.

V. COMPONENTS

Manned and unmanned aircraft of the same type generally have similar physical components. The main exceptions among them are the cockpit and environmental control system or life support systems. Some UAVs carry payloads (such as a camera) that weigh considerably less than an adult human, thus as a result can be considerably smaller. Though they carry heavy payloads still weaponized military UAVs are much lighter than their manned counterparts with comparable armaments. Control systems for UAVs are often different than that of manned craft. For remote human control, a camera and video link will almost always replace the cockpit windows; radio-transmitted digital commands will replace physical cockpit controls. Autopilot software is used in both manned and unmanned aircraft, with different feature sets. The important components of UAV are:[13]

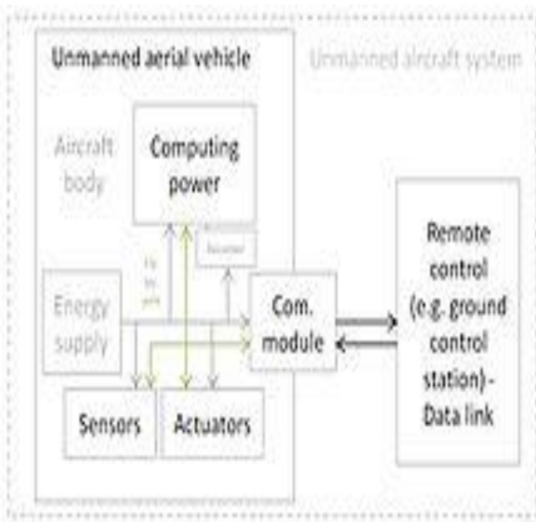

Fig1: Components of UAV

- **Power supply and platform**: Small UAVs on a large basis use *lithium-polymer batteries* (Li-Po). *Battery Elimination Circuitry* (BEC) is used to centralize power distribution and thus often harbors a Microcontroller Unit(MCU). Costlier switching BECs diminish heating due to constant operations on the platform.[14]

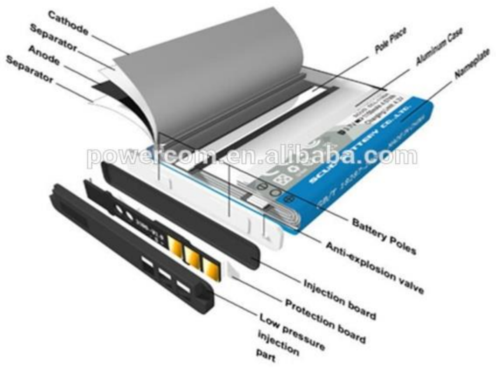

Fig2: Battery

➕ **Computing:** UAV computing capability followed the advances of computing technology, it began with analog control and finally went to control with the help of microcontrollers, then *System on a chip(SOC)* and *single board computers(SBC)*. System hardware used for small UAVs is often called the Flight Controller (FC), Flight Controller Board (FCB) or Autopilot

➕ **Sensors:** The different sensors used are as follows:[15]

1. *Position and movement sensor*: It gives information about aircraft state.

2. *Exteroseptive Sensor*: It deals with external information like distance measurement.

3. *Exproprioceptive Sensors*: Correlate internal and external states.

4. *Non Co operative sensor*: Able to detect target autonomously.[16]

➕ **Actuators:** UAV actuators consist of digital electronic speed controllers (which control the RPM of the motors) linked to motors/engines and propellers, servomotors (for planes and helicopters mostly), weapons, payload actuators, LEDs and speakers.

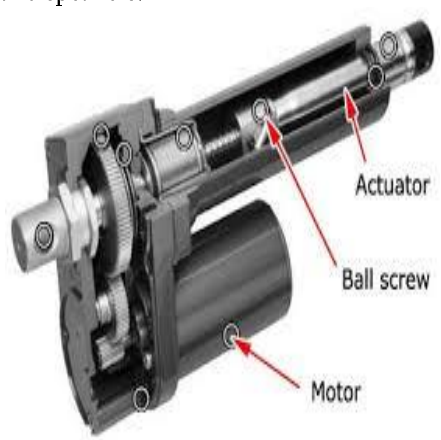

Fig3: Components of actuator

➕ **Software**: UAV software is known as the flight stack or auto pilot. UAVs are generally real time system that requires rapid response when the sensor data changes. Examples of such software are Raspberry Pi, Beagleboards.

➕ **Flight controls**: Flight control is one of the lower-layer system and is very much similar to manned aviation. Automatic flight however involves multiple levels of priority. UAVs can be programmed in such a way that they perform aggressive manoeuvres or landing/perching on inclined surfaces[17], and then to climb toward better communication spots. Some UAVs can also control flight with varying flight modelisation, such as VTOL designs. UAVs can also implement perching on a flat vertical surface[18].

VI. LOOP PRINCIPLES

- Open loop—This type of loop provides a positive control signal (faster, slower, left, right, up, down) without incorporating feedback from sensor data.
- Closed loop – This type of loop does incorporate sensor feedback to adjust behavior (reduce speed to reflect tailwind, move to altitude 300 feet) of the UAV. The PID controller is most common. Sometimes, feed forward is also employed, transferring the need to close the loop further. [19]

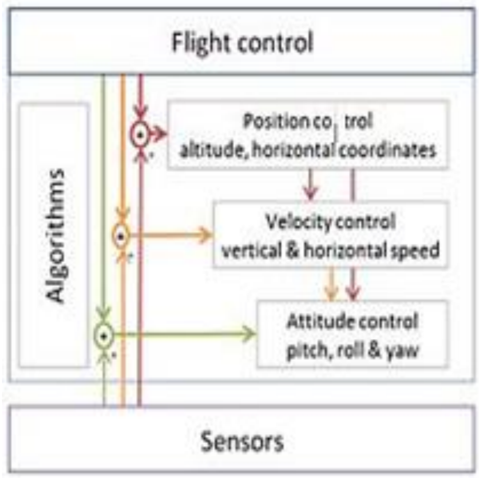

Fig4: The Looping Principle

VII. COMMUNICATIONS

Most UAVs that are common nowadays use a radio frequency front-end that connects the antenna to the analog-to-digital converter as well as a flight computer that controls avionics (and that may be capable of autonomous or semi-autonomous operation). Radio allows remote control and exchange of video as well as other data. Earlier UAVs used had only uplink. Downlinks (e.g., realtime video) came much later. In military systems and high-end domestic applications, downlink may convey management status of payload. In civilian applications, most transmissions are basically commands ranging from operator to vehicle. Downstream is mainly used for video. Telemetry is another kind of downstream link, that transmit status about the aircraft systems to the remote operator. UAVs can use also satellite "uplink" to access satellite navigation systems.

The radio signal from the operator side can be issued from the following:

- **Ground control** – a human who operating a radio transmitter/receiver, a smartphone, a tablet, a computer, or the original meaning of a military ground control station (GCS). Recently control from wearable devices[20], human movement recognition, human brain waves[21] was also demonstrated.
- **Remote network system**, such as satellite duplex data links for some military powers[22]. Downstream digital video over mobile networks has also entered consumer markets, while direct UAV control uplink over the celullar mesh is still under research.
- **Another aircraft**, serving as a relay or mobile control station – military manned-unmanned teaming (MUM-T).[23]

8. Autonomy

ICAO classifies unmanned aircraft in two categories. Either they are remotely piloted aircraft or are fully autonomous. Actual UAVs however may offer intermediate degrees of autonomy. E.g., a vehicle which is remotely piloted in most areas may have an autonomous return-to-base operation. Basic autonomy comes from mainly proprioceptive sensors. Advanced autonomy calls for certain characteristics like situational awareness, knowledge about the surrounding environment, the aircraft from exterioceptive sensors: sensor fusion integrates information from multiple sensors[24]. The different features of autonomy are given below:

- Self-level: attitude stabilization occurs on the pitch and roll axes.
- Altitude hold: The aircraft maintains its altitude by using different parameters like barometric or ground sensors.
- Hover/position hold: it keeps the level pitch and roll, stable yaw heading and altitude while maintaining position using GNSS or several inertial sensors.
- Headless mode: Pitch control is relative with the position of the pilot rather than being relative to the axes of the vehicle.
- Care-free: It helps in automatic roll and yaw control while the drone is moving horizontally
- Take-off and landing (using a variety of aircraft as well as ground-based sensors and systems.)
- Failsafe: It helps in automatic landing as well as return-to-home when loss of control signal takes place.
- Return-to-home: Fly back to the exact point of takeoff (often gaining altitude at first to avoid possible interrupting obstructions such as trees or buildings).
- Follow-me: It helps to maintain relative position to a moving pilot or other object using GNSS.
- GPS waypoint navigation: Using GNSS to navigate to an intermediate location on a course of travel path.
- Orbit around an object: This concept is almost similar to Follow-me but continuously circles a target.
- Pre-programmed aerobatics (such as continuous rolls and loops)

IX. NIGHT VISION

Currently, under FAA rules, drones can only be operated during day-time, and within "civil twilight" hours, which is basically 30 minutes before or after the sun sets. For the commercial companies operating drones, this can be especially a huge restrictiction. Drones are generally used for search and rescue operations, filming different events, capturing news footage, or for the purpose of security. The good news is that it is possible to receive a "night waiver" (§ 107.29) from the FAA if one can prove that the drone, in addition to adhering to all the other normal regulations, has an additional feature that is having at least a three nautical mile radius of visibility. There are many approaches to overcome this particular requirement.[25]

High-Intensity Lighting: The most obvious solution for night visibility is the use of a lighting system—sort of the same way headlights are used on cars at night. There are numerous different approaches to this method: many commercial solutions are already available who add spotlights on your drone, and there are also ways to develop ones own DIY solution as well. Moreover there are companies who are pushing the boundary by adding 1000 Watt lighting systems to their respective drones. This apparently can achieve upto 0.25 million Lumens! Intense lightning like this could be widely used in fields of security, filming, and search and rescue.

Infrared Cameras: In 2015, drone company DJI and infrared imaging company FLIR partnered together to develop a thermal camera imaging solution for the night vision of drone and its navigation. Thermal cameras detect infrared waves being emitted by objects—where warming objects appear red while cold objects appear black. So, even in the absence of visible light, objects can be detected easily. Though these cameras are quite expensive for the hobbyist, they can be excellent solutions for different commercial operators. However, it's also possible to build one's own camera to take images in the infrared light spectrum using an inexpensive digital camera, an infrared spotlight. The best part of this technique is that the IR spotlight isn't visible to human eyes.

X. APPLICATION

Aerospace: *Airlines* and maintenance, repair, and operations contractors use UAVs for aircraft maintenance (visual inspection of aircraft).

Military: Drones are used in situations where flight with human aboard is considered to be too risky or difficult. Moreover they provide troops with a 24-hour "eye in the sky", seven days a week. Each aircraft can stay up in the sky for up to 17 hours at a time, wandering over an area and sending back real-time imagery of activities on the ground. Air strikes are common use of such drones.

Security: The security measures include surveillance, crowd monitoring and control.

Law enforcement — surveillance, traffic monitoring, search and rescue operations are carried out efficiently using drones.

Environmental/meteorology: e.g., climate study, storm monitoring, mapping glaciers, general data collection are made easy by information collected by drones.

Archaeological surveying: The drones are hugely deployed by the archaeological team, which uses the remotely piloted aircrafts to fly close to the terrain and record its features. The data are used in photogrammetric—obtaining information from a series of photos—to ultimately produce a detailed, three-dimensional map of a landscape occupied about 8,000 years ago. The drones are also capable to collect data on the modern problem of antiquities looting, as other strategies have had little success.

11. The Future

There could be 7 million small drones flying in the sky by 2020, according to U.S. aviation officials, who believe that as many as 2.7 million of these drones will be used for commercial purposes. They also predict that small unmanned aircraft systems (UAS) or drones "will be the most dynamic growth sector within aviation" within a few years of time. Some future development areas of drones are mentioned below:

- In railways
- Humanitarian Work
- Archaeology
- Farming
- Expanding Internet Access
- Earthquake ,hurricane or tornado warning systems.
- Advertising

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