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An Analysis of UAV Payload and Its Application Based Stratification

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Abstract: The UAV (Unmanned aerial vehicle) also known as drones are the next near future tech which is proving its applications and viability in many industries right now. Currently, drones can be classified on the bases of their structure as fixed wing, single rotor, multi-rotor & VTOL and on the bases of their all up weight as nano, micro, small, medium and large category drones. Other parameters such as size, weight, autonomy and power source too. All these specifications help to determine the cruising range, loading capacity and the flight duration. Now the payload can also belong to different categories like freight (e.g. parcel, mail, medicine etc.) and different categories of sensors (e.g. sensors, and cameras). For UAVs proper maneuvering and functioning, it is necessary to have an uninterrupted communication between the Ground station and the UAV. Also, it is required to have proper communication with the payload as well. For instance, a camera (as a payload) needs constant commands to capture images or for videography with proper axis, angles and camera settings. All this communication between the UAV, payload and ground station should take place within the spectrum allowed by the government. Further in this paper, the methodology behind the drones and the payload functioning and their applications is explained. With the help of an example of a successfully operating drone logistic service, this paper shows all the aspects of UAS (Unmanned Aerial system) and finally a brief comparison between the application and accessibility of fixed wing, single rotor, multi-rotor and VTOL drones. [1]

Keywords - UAV, Drone, Payload, sensors, Fixed wing, Single rotor, Multi rotor, VTOL.

INTRODUCTION

Today's technology revolution has a huge impact on overall humanity's potential and attitude toward its resources. Drone technology has found its possibilities to be involved in various industries like logistics, agriculture, last mile delivery, healthcare etc. Beyond consumer application and business, drone technology is used in the defence department, emergency services and homeland security. In a wider aspect, they are used for rescue missions, fighting wildfires, delivering medical supplies or assisting with crop management. [2].

Consumers now opt for e-commerce platforms for their shopping needs with speedy fulfillment and fast delivery of the goods. But this change in trend and to satisfy a humongous population, an increase in traffic loads on roads can be clearly seen. This is a major problem when it comes to successfully delivering goods on time especially in tier 2 or tier 3 cities. This motivates companies like amazon, Dunzo to adopt and test drone technology for hassle free and quick delivery and meet customer expectations and cut supply chain cost.

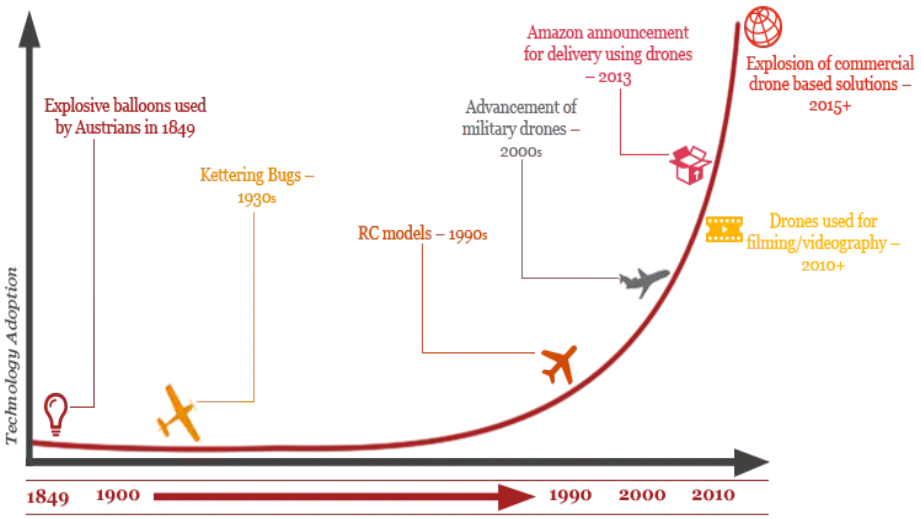

Figure 1

Here's some ways in which drones are being used in different industries.

• **Agriculture and Farming sector:** The concept of "precision agriculture" came into existence because of drone technology which is basically science of improving crop yield, productivity, efficiency and profitability with its use. With the use of this technology the farmers can reduce operational cost, improve productivity & crop quality, optimize workflow, increase yield rate, detect problems early, take necessary decision and can act accordingly. Drones in field have a wide range of uses like planting seeds, spraying insecticides and pesticides, field mapping and more but they are more significantly used for acquiring highly detailed data around soil health, crop health and detecting diseases with the help of different sensors.

• **Medical and Healthcare sector:** The use of drones in the medical and healthcare sector is rapidly increasing for emergency and non-emergency purposes. The quick transport of medical devices and material like blood, vaccines is now possible with the help of drones, that too in a contactless manner, limiting the spread of infectious diseases. It can be used to deliver products, test samples and vaccines at medical institutes, hospitals and at home in case of emergency as well. Drones can help deliver medical facilities to the last mile, hard to reach places or unsafe with existing traditional methods.

• **Government and system management:** Due to their small size, high efficiency and greater manoeuvrability, drones in government and state management systems are used for aerial security and surveillance. It is more efficient than manned aircraft such as helicopters as it can cover a large area in a lesser time and with agility. Governments are now relying on drones for disaster management to monitor wildfires. With drones the area topography, images, videos, fire and heat signatures can be detected with necessary real time data. Along with it, drones can help in firefighting and take precautionary steps by analyzing all the data collected, hence limiting the impact of the disaster. Drones can also help firefighters by informing the safer path they should take to douse the fire quicker by ensuring their lives. In cities, the state government can use drones to do surveillance regularly to enhance city service as well as their citizen's safety and protection.

RESEARCH METHODOLOGY

UAV (Unmanned Aerial Vehicle) or simply known as drones have numerous parts and components for performing different functions, the specific drone is made for. But Payload is defined differently as explained above. Anything which doesn't perform any function to make a drone fly is considered to be Payload. This could be sensors like LIDAR sensor, Optical sensor, Thermal camera, Ground penetrating radar (GPR) etc., lifting mechanism like robotic arm, package drop mechanism, chambers etc., arms and ammunitions in military specific drones and many more.
Most importantly, UAVs payload capacity depends on its size and its power to weight ratio. Having a higher payload capacity of a drone reflects its capability to carry out multiple tasks in a single flight, saving costs and time. [3]

Due to a totally different concept of lifting, transporting objects through air medium. The payload application has found its way in as many industries as possible like pharma, logistics, military, agriculture, Film industry and many more industries to be tapped with more and more advancement in the technology. These industries use different type configurations of drone as per their requirements, advantages and the environment in which it needs to be deployed.

A. Fixed wing payload system : In the United States, there is a quick logistic company which created a delivery system based on fixed wing battery powered glider drones. The company started to fulfill complex and urgent logistics challenges, from Rwanda's national blood delivery network and Ghana's COVID-19 vaccine distribution to fulfill on-demand home delivery. With 33,631,398+ miles flown, 466,022+ commercial deliveries and a huge 25 million serviceable customers.

B. Structural design & capabilities: The company has built this fixed wing in order to maximize the reach and for their motive to provide instant logistics solutions. Carrying along the advantage of high endurance and flight time, these fixed

wing drones have a range of 160 km (80 km radius) and can cruise at a speed of 100 km/h. To ensure light weight structural design, the skeleton of the drone is made up of carbon fiber composite material. Further the outer body or shell is made up of light weight foam, taking the structural weight to 6.4 kg only. The wings weigh nearly 2 kg which is made up of strong plastic and foam filling as well to give strength and maintain its aerodynamic shape. Finally the zip is powered by a 1.25kwh li-ion battery weighing around 10 kg, taking the all up weight to 20kgs.

C. Assembly: The complete drone assembly is divided into four parts. The process of assembly is so quick that the time between order and launch is just 5 minutes. First the product is placed in the chamber located beneath the drone fuselage, and then closed. Next the drone is placed and fixed onto the launcher. Then the plane wings are attached to the fuselage and get checked multiple times for any fault before the launch. Lastly the battery pack is placed into the drone, completing the assembly.

D. Preflight check and sensors: During the assembly processes, it is necessary to get all the moving parts checked thoroughly to avoid a crash. The rudder, elevator and aileron are the most sensitive parts of the drone to be inspected. To ensure proper working, each control surfaces have their unique QR codes. These QR codes message to actuate each control surfaces when scanned with the unique application from the smartphone. The phone then utilizes a computer vision algorithm to make pass or fail judgment for each control surface, The Battery pack, which is installed at the end of the process, has a 24X7 active GPS module and data storage that holds the flight data from all sensors on board. The reason behind adding previously active GPS modules with the battery are to 50 eliminates the delay in activating and connecting the GPS with the satellites.

E. Launch. Delivery and return: The launch of the fixed wing drone is an important aspect as it eliminates the need of a runway for its launch. There is a small rail which is installed at the launchpad, inclined upward at an angle of 45° from the ground. This rail uses pulleys and an electric motor to put drones into air, quickly and safely. Once in the air, it cruises at a speed of 100 km/h. In air, it keeps communicating directly with Rwanda's central air traffic control and can change its route midway in the air if required with the help of route planning software. Many softwares has been built to oversee the planes in air, many sensors equipped, sense other aircraft and avoid them. Finally when it reaches the delivery point, in spite of landing at the destination, it drops the box containing the product with a paper parachute. So that the box lands softly on the ground. This method eradicates the requirement of a landing pad. Lastly the recovery method of the drone is something known as restricted recovery method. In this the small hook at the end of the tail boom of the drone grabs a wire strung between 2 actuated arms on either side of the capture system. This is made possible as the plane communicates its location in 3d space with radio receivers next to the platform. There are also 10% miss chances when the drone is unable to hook with the wire. In this case the drone detects a miss in response of which it throttles up the engine to gain altitude and take another pass.

Figure 2

For Safety reasons, there are two motors on the drone, in which only one is required to push the drone forward. The other motor is for emergency and the same is with every actuator on the drone. Somehow two of something breaks, the plane automatically releases the parachute and lands softly and then a process to recover it can be initiated by the control tower. [4]

RESULTS AND DISCUSSION

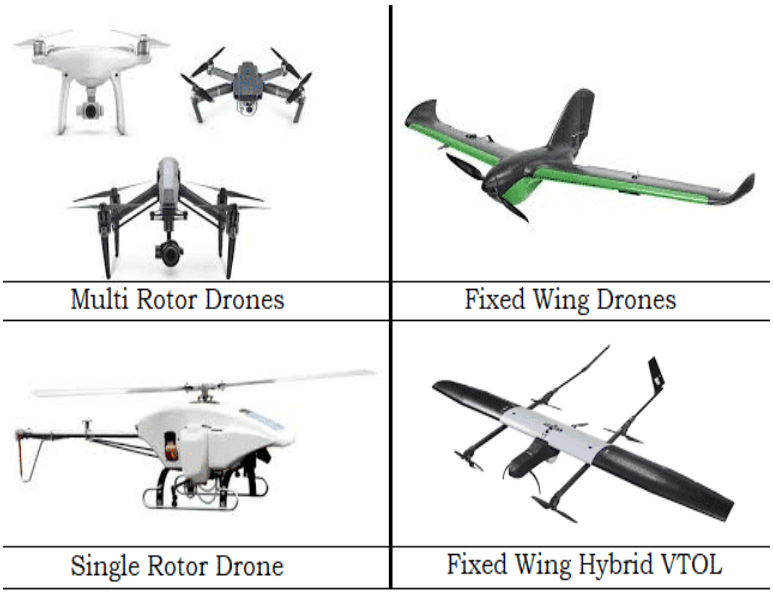

Figure 3

4.1 Fixed Wing Drone

These drones are very similar in design and flying principle to the aircraft which can be seen in our daily life. Fixed wing uses its aerodynamic fuselage to fly through air with least drag to generate lift and thus being the most efficient design type of UAV. These drones generally glide in air rather than hover at a place because it's impossible to hover with a fixed wing. So for tasks like surveillance over a large piece of land or carrying out a military operation in a war zone, fixed wings are capable to act and escape from the point of action. Along with military operations, fixed wings are used in large farmlands to monitor crop health quite efficiently as compared to single rotor or multi rotor. Although fixed wings are efficient in terms of flight time, the payload capacity is lesser as compared to other two types. [5]

4.2 Single Rotor Drone

As the name suggests, these drones have a single rotor for generating lift, move forward, backward or yaw. It looks similar to the Helicopters, which can be seen in our day to day life. These drones have an edge over fixed wing that single rotor can hover at a fixed place for as long as its power source runs out. Also, it is capable of lifting greater payload and changing its direction quickly. Single rotor hasn't found its application in many diverse aspects because of some geometrical constraints, so its usage is limited. For example, it is used in large fields for fertilizer and pesticide spraying, used in military operations to fulfill supply needs.

4.3 Multi Rotor Drone

With more than one rotor, usually three, four, six or eight. A multi rotor drone is the most widely used type of drone across all domains, whether it is agriculture, logistics, filming, transportation, security surveillance or inspections. This is due to its design which makes it very stable if compared to a fixed wing with all its features in it. The orientation of rotors in a multi rotor is such that they complement each other and provide stability. Most of the businesses choses multi rotors for their work because of availability of required components in the market (with a lot of variation like size, capacity, performance, and quality) and easy to assemble calibrate and fly. Most of the payload tasks are carried out in multi rotor drones only. [6]

4.4 VTOL Drone

Considering the pros and cons of fixed wing and Multi rotor drones, engineers put forward the concept of VTOL (Vertical TakeOff Landing) in the 1960s. There are some major drawbacks of both fixed wing and multirotor which are eliminated and advantages which are retained in VTOL models. Considering limitations, Fixed wing drones need a runway to gain velocity and generate lift to take off and landing as well. This is a major issue with the accessibility of the fixed wings as drones are expected/ required to takeoff and land at a constrained space. In a Multi rotor, the limitation is its endurance. [7]

With an average flight time of 20-30 minutes, long distance operations can't be carried out with a multi rotor drone. VTOL drone is a structural combination of Fixed wing and multi rotor drones, eliminating disadvantages of both in one design along with advantages of both too. VTOL can takeoff like a Multi rotor drone and Glide like a fixed wing, increasing endurance, flight time and performance. Major companies like Amazon are testing delivery of orders in the state of Oregon via their fleet of VTOL drones designed specifically. [8]

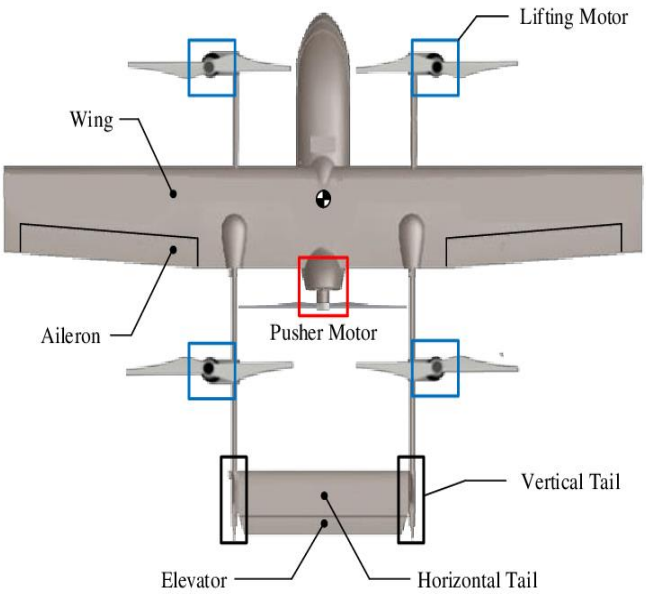

Figure 4

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