Unit 5: UAV IoT

Introduction to Unmanned Aerial Vehicles/Drones, Drone Types, Applications: Defense, Civil, Environmental Monitoring; UAV elements and sensors- Arms, motors, Electronic Speed Controller(ESC), GPS, IMU, Ultra sonic sensors; UAV Software –Arudpilot, Mission Planner, Internet of Drones(IoD)- Case study FlytBase.

I. Introduction to Unmanned Aerial Vehicles/Drones:

An unmanned aerial vehicle (UAV) is an aircraft that carries no human pilot or passengers. UAVs—sometimes called drones—can be fully or partially autonomous but are more often controlled remotely by a human pilot. RAND research has contributed to the public discussion on the use of drones for warfare and surveillance.

II. Types of Drones:

Here are the four main types of drones, their uses, their strengths and weaknesses:

1. Multi-Rotor Drones
2. Fixed-Wing Drones
3. Single-Rotor Drones
4. Fixed-Wing Hybrid VTOL

1. Multi-Rotor Drones

- Multi-rotor drones are the easiest and cheapest option for getting an ‘eye in the sky.’
- They also offer greater control over position and framing, and hence they are perfect for aerial photography and surveillance.
- They are called multi-rotor because they have more than one motor, more commonly tricopters (3 rotors), quadcopters (4 rotors), hexacopters (6 rotors) and octocopters (8 rotors), among others.
- By far, quadcopters are the most popular multi-rotor drones.

Advantages:

- It provides better control of the aircraft during the flight.
- Due to its increased manoeuvrability, it can move up and down on the same vertical line, back to front, side to side and rotate in its own axis.
- It has the ability to fly much more closely to structures and buildings.
- The ability to take multiple payloads per flight increases its operational efficiency and reduces the time taken for inspections.

Disadvantages:

- Multi-rotor drones have limited endurance and speed, making them unsuitable for large scale aerial mapping, long-endurance monitoring and long-distance inspection such as pipelines, roads and power lines.
- They are fundamentally very inefficient and require a lot of energy just to fight gravity and keep them in the air.
- With the current battery technology, they are limited to around 20-30 minutes when carrying a lightweight camera payload. However, heavy-lift multi-rotors are capable of carrying more weight, but in exchange for much shorter flight times.
- Due to the need for fast and high-precision throttle changes to keep them stabilised, it isn't practical to use a gas engine to power multi-rotors, so they are restricted to electric motors. So until a new power source comes along, we can only expect very small gains in flight time.

Technical Uses:

- Visual inspections
- Thermal reports
- Photography & Videography
- 3D scans

2. Fixed-Wing Drones

A fixed-wing drone has one rigid wing that is designed to look and work like an aeroplane, providing the lift rather than vertical lift rotors.

Hence, this drone type only needs the energy to move forward and not to hold itself in the air. This makes them energy-efficient.

Advantages:

- Fixed-wing drones cover longer distances, map much larger areas, and loiter for long times monitoring their point of interest. The average flight time is a couple of hours.
- This drone type can fly at a high altitude, carry more weight and are more forgiving in the air than other drone types.

Disadvantages:

- Fixed-wing drones can be expensive.
- Training is usually required to fly fixed-wing drones.
- With fixed-wing, the flight is just the beginning.

Technical Uses:

- Aerial Mapping
- Drone Surveying – Forestry/Environmental Drone Surveys, Pipeline UAV Surveys, UAV Coastal Surveys
- Agriculture
- Inspection
- Construction
- Security

3. Single-Rotor Drones

- Single-rotor drone types are strong and durable. They look similar to actual helicopters in structure and design.
- A single-rotor has just one rotor, which is like one big spinning wing, plus a tail rotor to control direction and stability.

Advantages:

- A single-rotor helicopter has the benefit of much greater efficiency over a multi-rotor, which increases if the drone is gas-powered for even longer endurance.
- A single-rotor helicopter allows for very long blades, which are more like a spinning wing than a propeller, giving great efficiency.
- If you need to hover with a heavy payload (e.g. an aerial LIDAR laser scanner) or have a mixture of

hovering with long endurance or fast forward flight, then a single-rotor helicopter is really your best bet.

- They are built to be strong and durable.

Disadvantages:

- Single-rotor drone types are complex and expensive.
- They vibrate and aren't as stable or forgiving in the event of a bad landing.
- They also require a lot of maintenance and care due to their mechanical complexity.
- The long, heavy spinning blades of a single rotor can be dangerous.

Technical Uses:

- Aerial LIDAR laser scan
- Drone surveying
- Carrying heavy payloads

4. Fixed-Wing Hybrid VTOL

- Hybrid VTOL drone types merge the benefits of fixed-wing and rotor-based designs.
- This drone type has rotors attached to the fixed wings, allowing it to hover and take off and land vertically.
- This new category of hybrids are only a few on the market, but as technology advances, this option can be much more popular in the coming years.
- One example of fixed-wing hybrid VTOL is Amazon's Prime Air delivery drone.

Advantages:

- The autopilot can do all the hard work of keeping the drone stable, leaving the human pilot the easier task of guiding it around the sky.
- Hybrid VTOL drones offer you the best of both worlds – fixed-wing & rotor-based designs.
- They are perfect at either hovering or forward flight.

Disadvantages:

- Only a handful of fixed-wing hybrid VTOLs are currently on the market

- The technology used in these drone types is still in the nascent stage.

Technical Uses:

- Drone Delivery

Drone Types

Some of the popular drone types other than the ones mentioned above include:

1. **Small Drones**
   These drone types are used for recreational purposes; they cannot perform commercial functions that other drone models carry out. Small drones are too light and lack the stability required for accurately capturing images.
2. **Micro Drones**
   These are small drones, but they can still provide valuable intelligence because of their micro cameras. The British military commonly uses this drone, and it's called the Black Hornet. Black Hornets can fly up to 25 minutes (single charge) and have a range of up to one mile.
3. **Tactical Drones**
   These drones are large without being bulky. Equipped with GPS technology and infrared cameras, they measure 4.5 feet and weigh 4.2 lbs. They are often used for surveillance work.
4. **Reconnaissance Drones**
   These drones measure approximately 16 feet in length, over 2200 pounds, and hover for 52 hours at 35,000 feet. They can be launched from the ground and are known as High Altitude Long Endurance drones (HALE) and Medium Altitude Long Endurance drones (MALE).
5. **Large Combat Drones**
   These drone types are approximately 36 feet long and are usually used to fire laser-guided bombs or air-to-surface missiles on targets. They have a range of over 1000 miles and can be used for up to 14 hours at a stretch.
6. **Non-Combat Large Drones**
   Although large, these drones are not for combat. They are more complex than Black Hornet and are used for larger-scaler recon missions.
7. **Target and Decoy Drones**
   These types of drones are used for monitoring and striking targets. The look of the decoy drone usually depends on the mission.
8. **GPS Drones**
   This drone type links to satellites via a GPS hookup to map out the rest of their flight, collecting data that can be extracted to make informed decisions.
9. **Photography Drones**
   Photography drones are outfitted with professional-grade cameras. 4K camera drones can take high-resolution pictures. These drone types make use of automated flight mode and precision stability to take pictures covering vast spaces.

III. APPLICATION OF DRONES: Defense, Civil, Environmental Monitoring:

- An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without a human pilot onboard. UAVs are a component of an unmanned aircraft system, which includes a UAV, a ground-based controller, and a system of communications between the two.
- The flight of UAVs may operate with various degrees of autonomy, either under remote control by a human operator or autonomously by onboard computers.
- Drones are classified into different categories based on the applications. Applications are broad, and from the design perspective, generally fall under three major groups: military, industrial (enterprise), and commercial.

MILITARY:

- Drones in military applications are used for anti-aircraft target practice, intelligence gathering and, more controversially, as weapons platforms. Reconnaissance, Attack, Demining.
- **CIVIL:**
  Recreation, Disaster Relief, Archeology, Conservation of Bio diversity and Habitat, Law enforcement and Crime

Drones are becoming more and more common in many sectors of the economy as they guarantee the fastest and most accurate collection of detailed data.

This technology, which is developing at a very fast pace, means that drones have been used for increasingly complex tasks.

They have become a crucial tool for the efficient work that survey technicians and engineers conduct.

Drones effectively support their projects in the matter of:

- Site Reconnaissance
- Roadway Assessment
- Culvert/Bridge Inspections
- Streambank/Steep Slope Access
- Park and Open Space Aerial Imagery
- Water Tank/Standpipe Inspection
- Building/Roof Inspection
- Treatment Plants
- Orthophotography
- Terrain Modeling
- 3D Mapping
- Construction Inspection

Environmental Monitoring:

Remotely managed drones are an excellent tool for environmental field services and contracting. Not only are drones fast, efficient, and accurate, but also they help save costs by reducing the amount of manpower required for tricky monitoring projects. At Environmental Works, we use our in-house drone fleet for a number of client services, particularly when hard-to-reach terrain is involved. Read on to find out more about how we use drones for environmental monitoring.

How We Use Drones

We use drone technology to assist with a variety of environmental monitoring responsibilities, including the use cases listed above. We also offer the following drone services:

- Surveying and mapping: Drones can provide geological and topographical information where other devices may fail. For example, drones can carry out high-quality topographic surveys using a fraction of the time required for traditional surveying methods. Drones can also fly at a significantly lower altitude than devices used for satellite imagery. This means that surveyors never have to worry about unpredictable atmospheric conditions such as cloud cover.

- Inspections using thermal imaging: High-precision thermal cameras are a must for sensitive applications across government projects and private industries. These cameras are often used in refinery and pipeline monitoring, as well as other oil and gas applications. Our drones can employ highly reliable thermal imaging to complete pipeline checks or measure leakage during refinery examinations.

INDUSTRIAL

- The integration of drones and IoT (Internet of Things) technology has created numerous industrial and enterprise use cases: drones working with on-ground IOT sensor networks can help agricultural companies monitor land and crops, energy companies survey power lines and operational equipment, and insurance companies monitor properties for claims and/or policies.

COMMERCIAL

- The commercial field is a growing development, where the largest, strongest, fastest, and most capable drones on the market are targeted toward the professional community. They are the types of machines that the movie industry puts to work and that commercial agencies use to inspect infrastructure.

- Some impressive self-piloted drones survey individual farmer's fields. Commercial drones are the smaller consumer products that make up just a tiny portion of the overall drone market. Look at the picture of commercial drone:

AGRICULTURE DRONES COMMERCIAL DRONES

IV. UAV elements and sensors- Arms, motors, Electronic Speed Controller(ESC), GPS, IMU, Ultra sonic sensors:

Main Components of Drones/ UAVs (Quadcopter):

There are multiple designs used for drones, the most popular is the four-wing structure called Quadcopter. The main components of a Quadcopter are:

1. Propellers/ Wings
2. Chassis
3. DC motors
4. Flight Controller
5. Electronic Speed Controllers
6. Landing Gear
7. Transmitter
8. Receiver
9. GPS Module
10. Battery
11. Camera

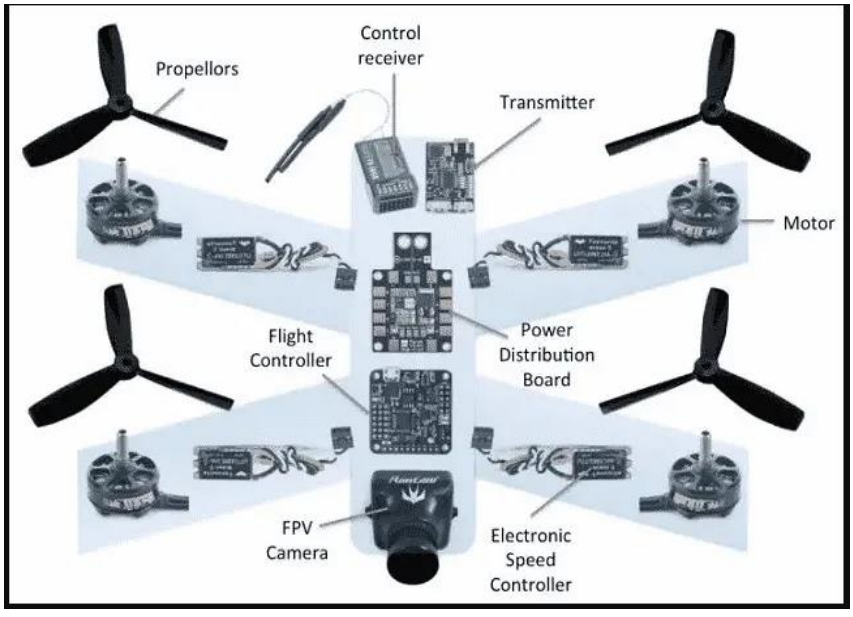

Fig. 5 – Main Components of Drones/ Unmanned Aerial Vehicles (UAVs)

1. Propellers/ Wings

The Drones/ UAVs use either propellers/ wings or both (depending on the availability) to direct them. Propeller driven Drones have two types of propellers onboard for direction and thrust. These are

- Standard Propellers
- Pusher Propellers

Standard Propellers

These are located in the front of Quadcopter. These propellers provide direction to the Drone.

Pusher Propellers

These are located in the back of Quadcopter. These propellers provide forward and backward thrust to the Drone.

2. Chassis

This is the main body of Quadcopter which provides the housing facility to all other components.

3. Flight Controller

The flight controller is usually referred to as the brain of the drone. The flight controller controls the power supply to the electronic speed controller. It is also used to detect orientation changes in the drone. It controls the motors and ensures that the drone is in air.

4. Electronic Speed Controller

Electronic speed controllers (ESC) are the electronic circuits that regulate the speed of the DC motors. It also provides dynamic braking and reversing options.

5. DC Motors

To ensure that the drone is airborne for a good amount of time, we need high torque motors. The high torque also helps to change the speed of the propellers. Brushless DC motors are preferred as they are lighter than the brushed ones.

6. Landing Gear

Landing gears are not required for small drones. However, bigger drones need a landing gear to avoid any damage while landing. The requirement of landing gear varies with functionality of the drone. For example – Delivery drones which carry parcels require a spacious landing gear as they need space to hold the items.

7. Transmitter

The transmitter send signals from controller to the drone to generate command of direction and thrust.

8. Receiver

The receiver receives the signals sent by the transmitter and passes it to Flight Controller PCB.

9. GPS Module

The GPS module provides the navigational data (longitude, latitude and elevation) to the Controller. This module assists the controller in recognizing the taken path and safely return to the initial point in case of lost connection.

10. Battery

It provides power to the drone. Generally, rechargeable battery is used in drone.

11. Camera

There is normally an attached inbuilt camera with drones. If the drone is not provided with inbuilt camera, then it will have a provision of detachable camera.

V. UAV Software –Arudpilot, Mission Planner, Internet of Drones (IoD):

What is ArduPilot?

ArduPilot is a trusted, versatile, and open source autopilot system supporting many vehicle types: multi-copters, traditional helicopters, fixed wing aircraft, boats, submarines, rovers and more. The source code is developed by a large community of professionals and enthusiasts. New developers are always welcome! The best way to start is by joining the Developer Team Forum, which is open to all and chock-full of daily development goodness.

One autopilot for any mission:

ArduPilot enables the creation and use of trusted, autonomous, unmanned vehicle systems for the peaceful benefit of all. ArduPilot provides a comprehensive suite of tools suitable for almost any vehicle and application. As an open source project, it is constantly evolving based on rapid feedback from a large community of users. The Development Team works with the community and commercial partners to add functionality to ArduPilot thatbenefits everyone. Although ArduPilot does not manufacture any hardware, ArduPilot firmware works on a wide variety of different hardware to control unmanned vehicles of all types. Coupled with ground control software, unmanned vehicles running ArduPilot can have advanced functionality including real-time communication with operators. ArduPilot has a huge online community dedicated to helping users with questions, problems, and solutions.

The ArduPilot Project provides an advanced, full-featured and reliable open source autopilot software system. The first ArduPilot open code repository was created in 2009 - since then it has been developed by a team of diverse professional engineers, academics, computer scientists, and other members of our global community. It is capable of controlling almost any vehicle system imaginable: conventional and VTOL airplanes, gliders, multirotors, helicopters, sailboats, powered boats, submarines, ground vehicles and even Balance-Bots. The supported vehicle types frequently expand as use cases emerge for new and novel platforms.

Installed in over 1,000,000 vehicles world-wide, and with advanced data-logging, analysis and simulation tools, ArduPilot is a deeply tested and trusted autopilot system. The open-source code base means that it is rapidly evolving, always at the cutting edge of technology development, whilst sound release processes provide confidence to the end user. With many peripheral suppliers creating interfaces, users benefit from a broad ecosystem of sensors, companion computers and communication systems. Since the source code is open, it can be audited to ensure compliance with security and secrecy requirements.

The software suite is installed in vehicles from many manufacturers, such as many from our Partners, and more broadly throughout the global autonomous systems industry. It is also used for testing and development by large institutions and corporations such as NASA, Intel and Insitu/Boeing, as well as countless colleges and universities around the world.

Mission Planner Overview

Mission Planner is a full-featured ground station application for the ArduPilot open source autopilot project. This page contains information on the background of Mission Planner and the organization of this site.

What is Mission Planner

Mission Planner is a ground control station for Plane, Copter and Rover. It is compatible with Windows only. Mission Planner can be used as a configuration utility or as a dynamic control supplement for your autonomous vehicle. Here are just a few things you can do with Mission Planner:

- Load the firmware (the software) into the autopilot board (i.e. Pixhawk series) that controls your vehicle.
- Setup, configure, and tune your vehicle for optimum performance.
- Plan, save and load autonomous missions into you autopilot with simple point-and-click way-point entry on Google or other maps.
- Download and analyze mission logs created by your autopilot.
- Interface with a PC flight simulator to create a full hardware-in-the-loop UAV simulator.
- With appropriate telemetry hardware you can:
    - Monitor your vehicle's status while in operation.
    - Record telemetry logs which contain much more information the the on-board autopilot logs.
    - View and analyze the telemetry logs.
    - Operate your vehicle in FPV (first person view)

All of these and many more features are covered here.

History

Mission Planner is a free, open-source, community-supported application developed by Michael Oborne for the open-source APM autopilot project. If you would like to donate to the ongoing development of Mission Planner, please refer to the following link.

The Help Screen:

Clicking the Help icon at the top of the Mission Planner interface will open a screen with general information about help with Mission Planner. The "Check for Updates" button will check for available updates to Mission Planner manually. Mission Planner automatically checks for updates upon start up and notifies you if an update is available. Please always run the most current version of Mission Planner, although it is not necessary to check for updates more often than upon start up.

The "Check for BETA Updates" button will install the current development version of Mission Planner. This contains all the latest features and updates, but also might have bugs, since it does not have extensive community testing.

At the bottom of the HELP screen is the check box "Show Console Window (restart)" , which enables the console window during Mission Planner operation. That window shows Mission Planner activity and is primarily for diagnostic purposes. It sometimes shows some interesting information. A restart of Mission Planner is required for the option to take effect.

Getting Help:

The support for Mission Planner comes from the community of users like you. All of the documentation is created by users who volunteer their time. If you have questions, first look through the table of contents (upper left of every page) for a topic that may address your question. Next, try a search of the website. If you still need help, then the community forums are the place to go. There you will find may friendly users, developers and often, even Michael will chime in.

The ArduPilot forum here has existed for years and has a very large community and numerous general and vehicle specific topics.

Reporting Issues:

You can often resolve a question on a forum. Sometimes you will discover a bug and use the forums to request it be logged as an official issue. One of the developers will normally be glad to do so.

If you see a need to change or enhance the documentation, please let us know - again using the forums. We welcome your suggestions and there are qualified editors who can implement your suggestions.

Navigating the Documentation

Use the table of contents at the top of each page to navigate the Mission Planner Manual - and the contents of the vehicle specific areas.

This section of our website contains information on how to use Mission Planner as a “general” application. However, some of the pages will also have some vehicle specific information. Those pages will also be contained in the specific vehicle’s section of the website. Information that is primarily specific to a particular vehicle will only be located in that vehicles section so, if you cannot find information here, try the section of the website for the vehicle you are using.