UAV Elements

Topics

- **Components: Arms, motors, propellers, electronic speed controller (ESC), flight controller, Propulsion**
- **Sensors and Payloads: GPS, IMU**
- **Data Link System**
- **Classification of payload based on applications; Hyper-spectral sensors; Laser Detection and Range (LADAR); Synthetic Aperture Radar (SAR); Thermal cameras; ultra-sonic detectors; Case study on payloads. Introduction to Navigation systems and types of guidance**
- **Mission Planning and Control.**

Introduction to Drones/UAV/UAS

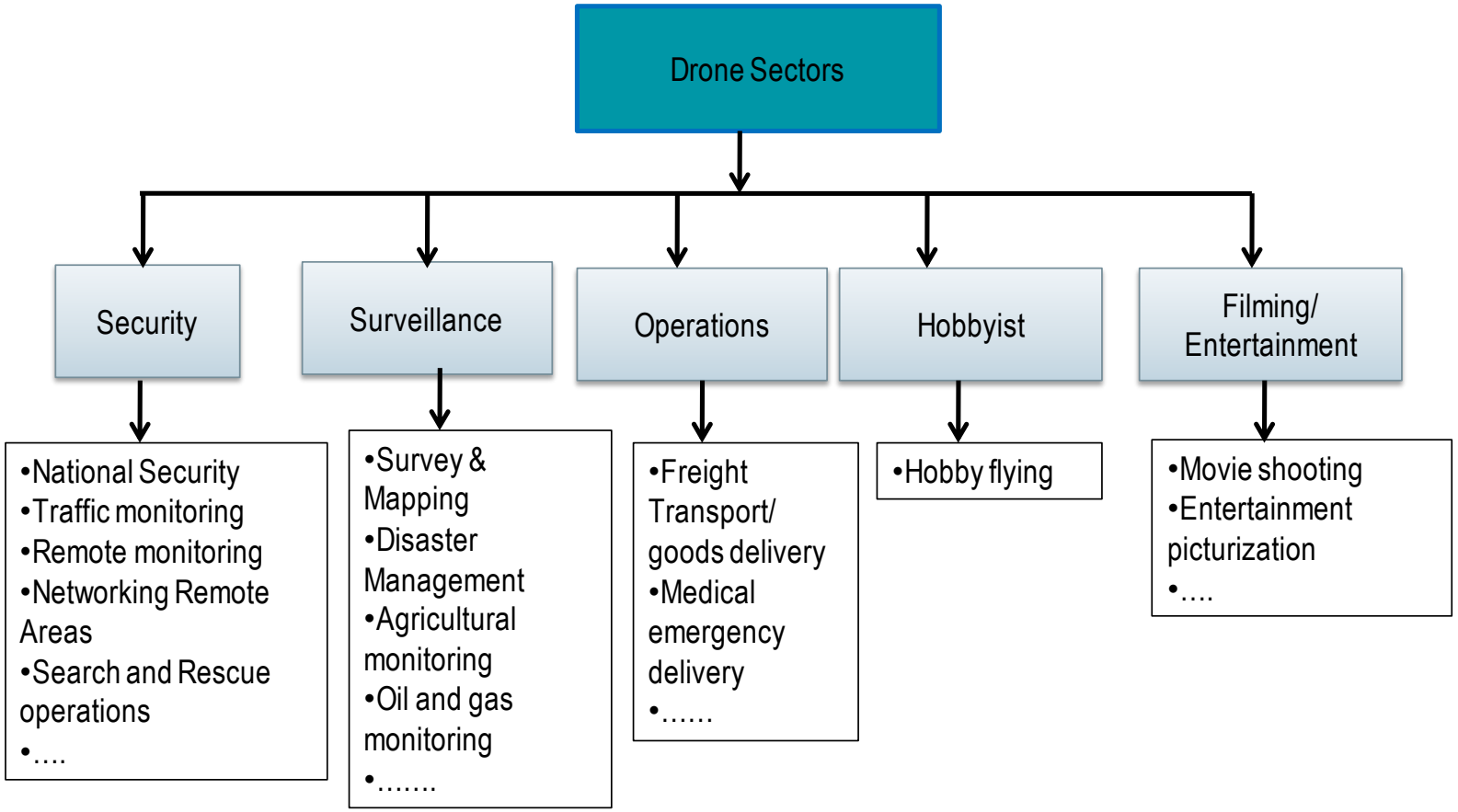
- Remotely operated Miniatured plane capable of flying and gathering information without a person on board.
- Operated with minimal human intervention
- Often the words (Aerial Vehicle), Unmanned Aerial System (UAS) and Drones are used interchangeably.

Hive Mind Swarming Autonomous Drones

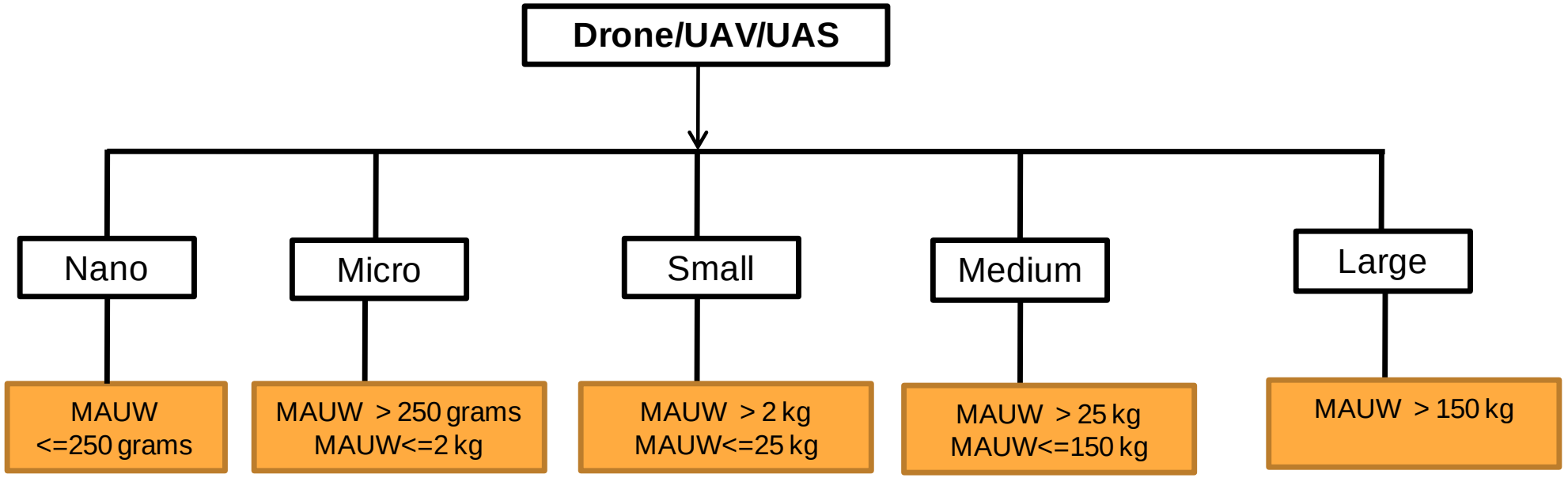
Intel – Swarm Drone Light Show : For Entertainment Applications

https://www.intel.in/content/www/in/en/technology-innovation/aerial-technology-light-show.html

Drone Major Applications



Drone Classifications - DGCA

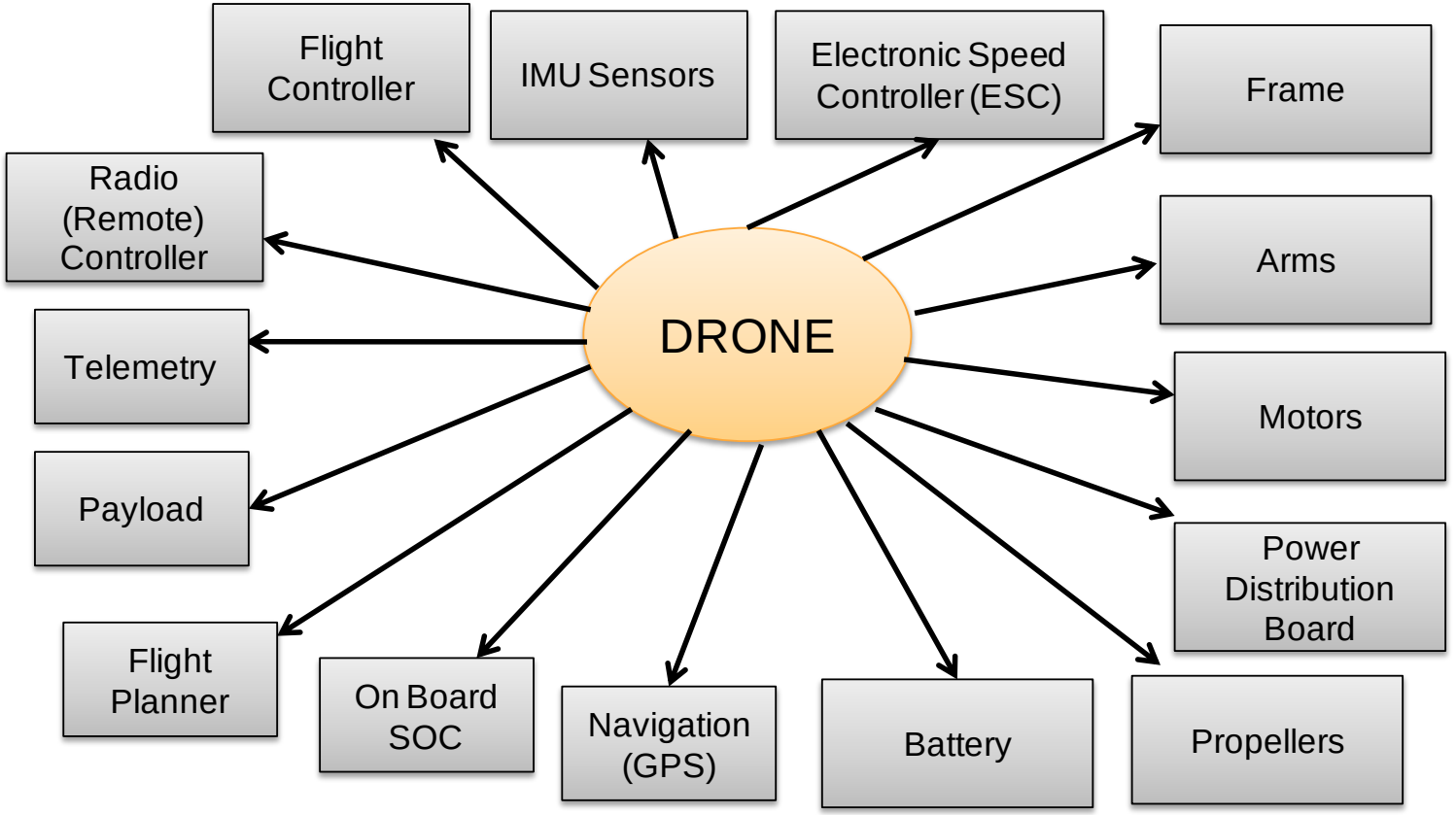


MAUW – **M**aximum **A**ll **U**p **W**eight

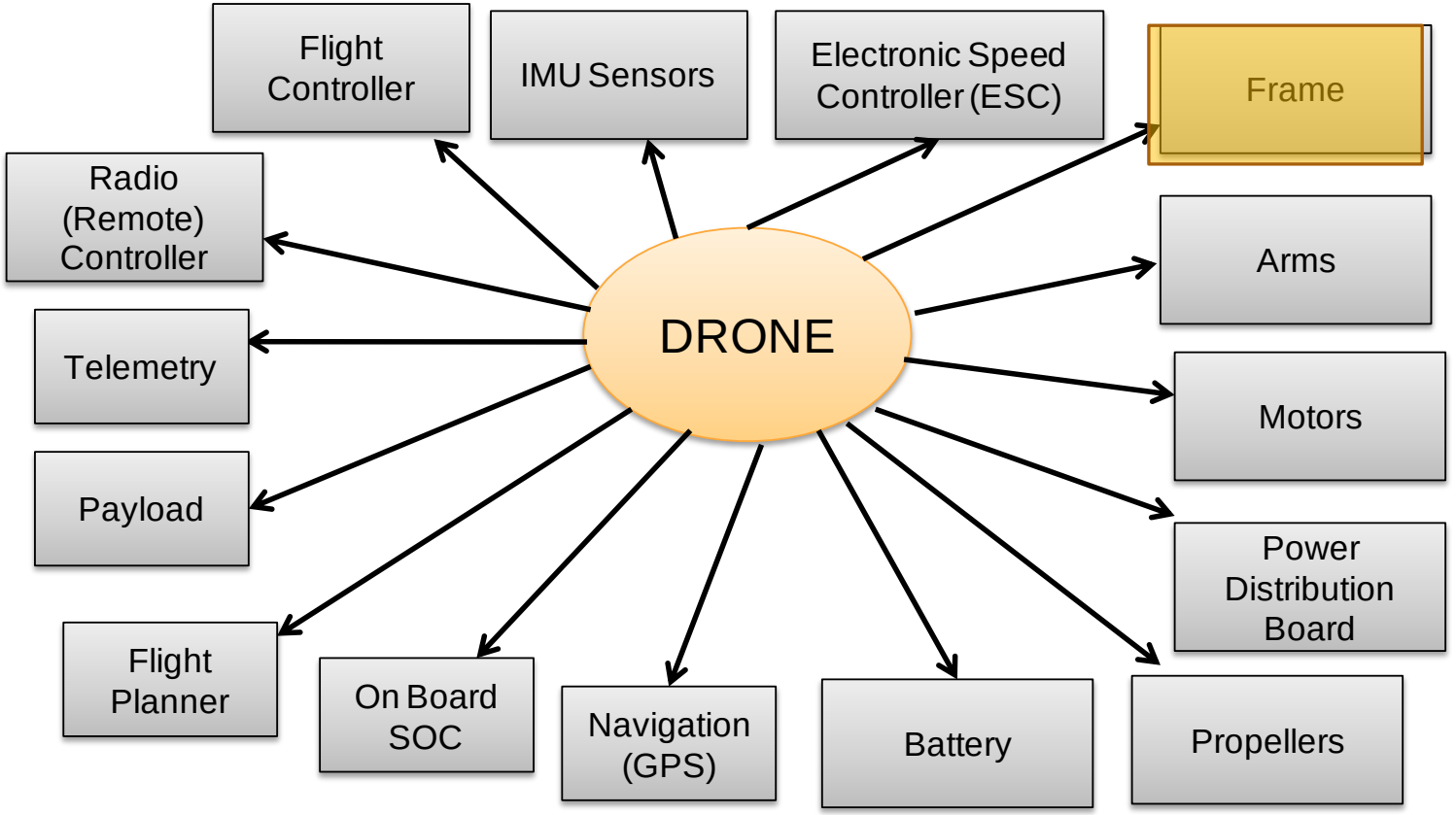
Topics

- **Components: Arms, motors, propellers, electronic speed controller (ESC), flight controller, Propulsion**

Anatomy of Drone



Anatomy of Drone



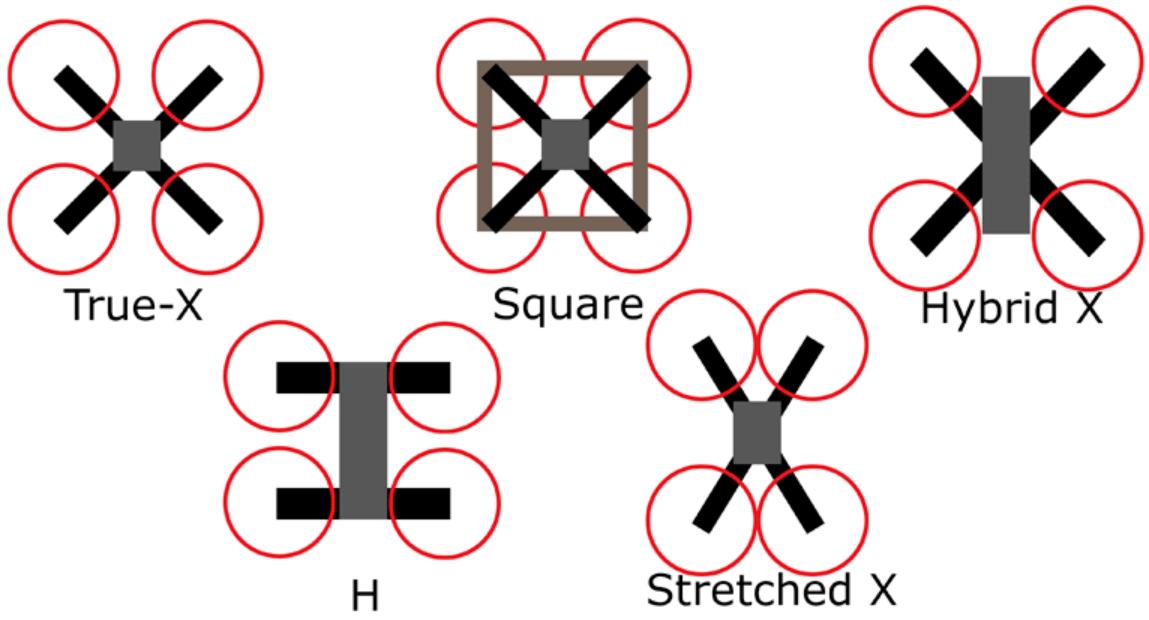
Frame

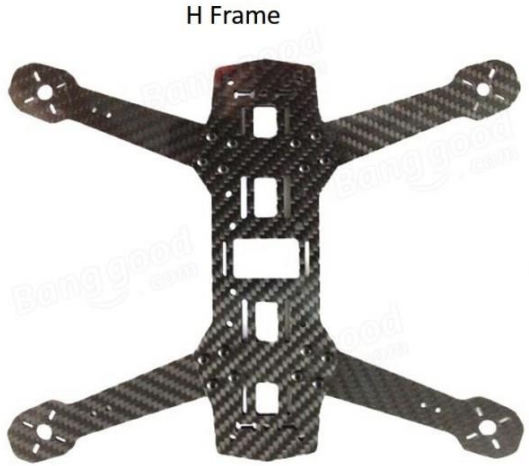
Frame

All the drone components are mounted to the frame. The frame should have sufficient place to mount all the components and should be very stable. Frames usually come in various shapes and sizes made with different material like plastic, foam, carbon fibre etc.

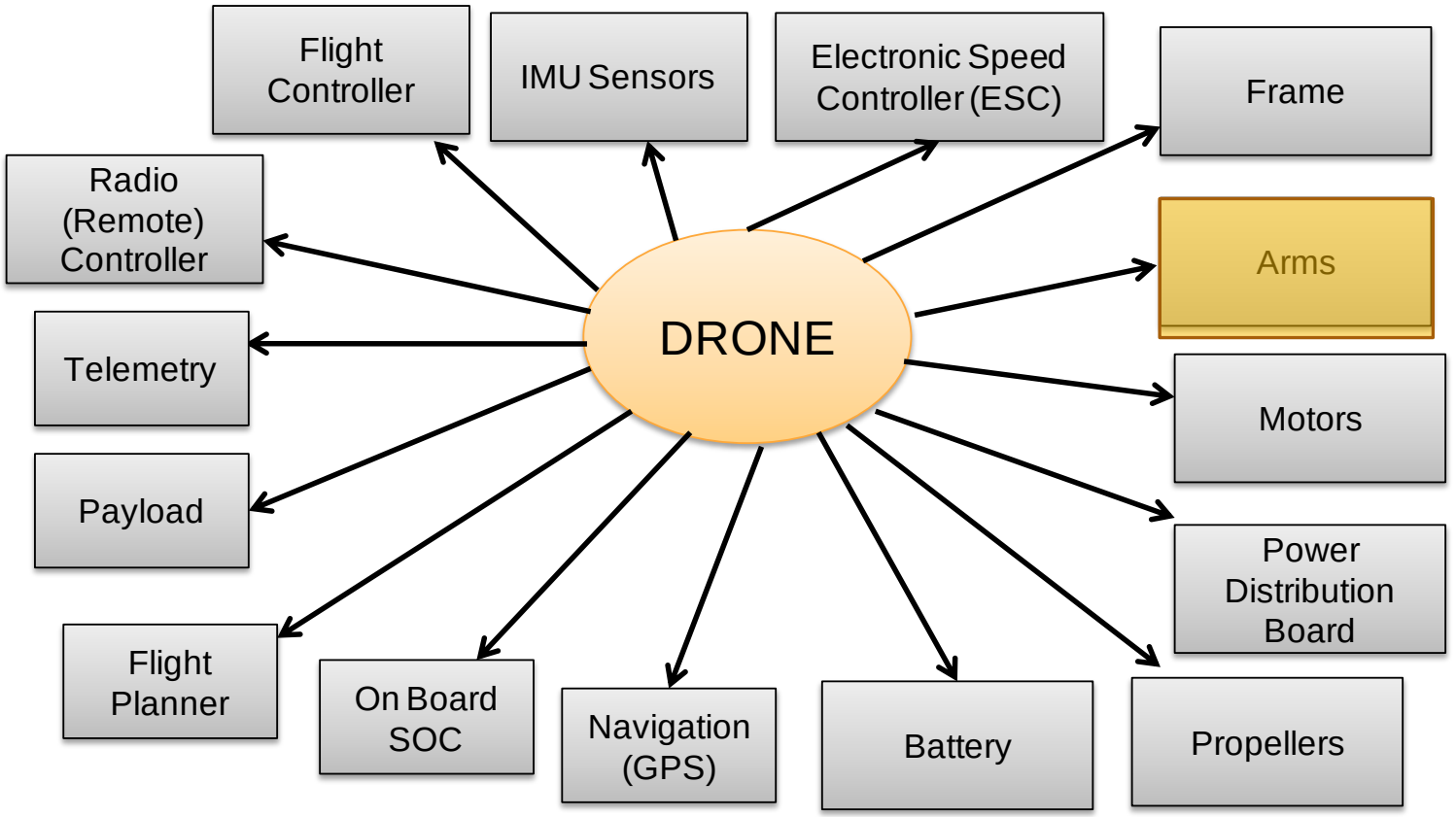
Drone Frame Types

FPV Frames:
Common Frame Shapes





Anatomy of Drone



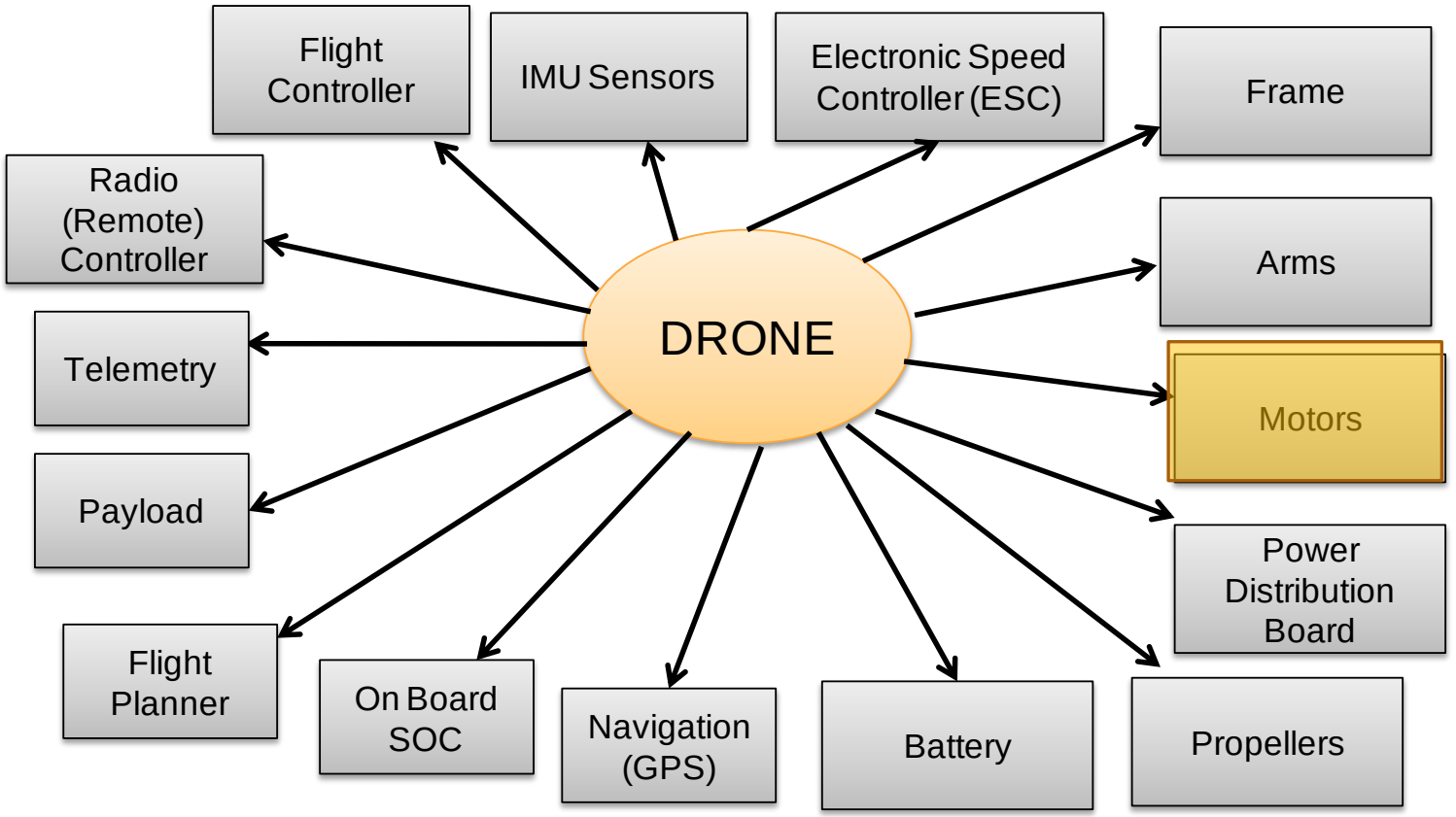
Arms

Arms — **Used to for mounting the motors. The arms are chosen such that there is very less vibration on the body to have very minimal blur during the imaging.**

Solid Arm Baseplate Frame

Separable Arm Frame

Anatomy of Drone

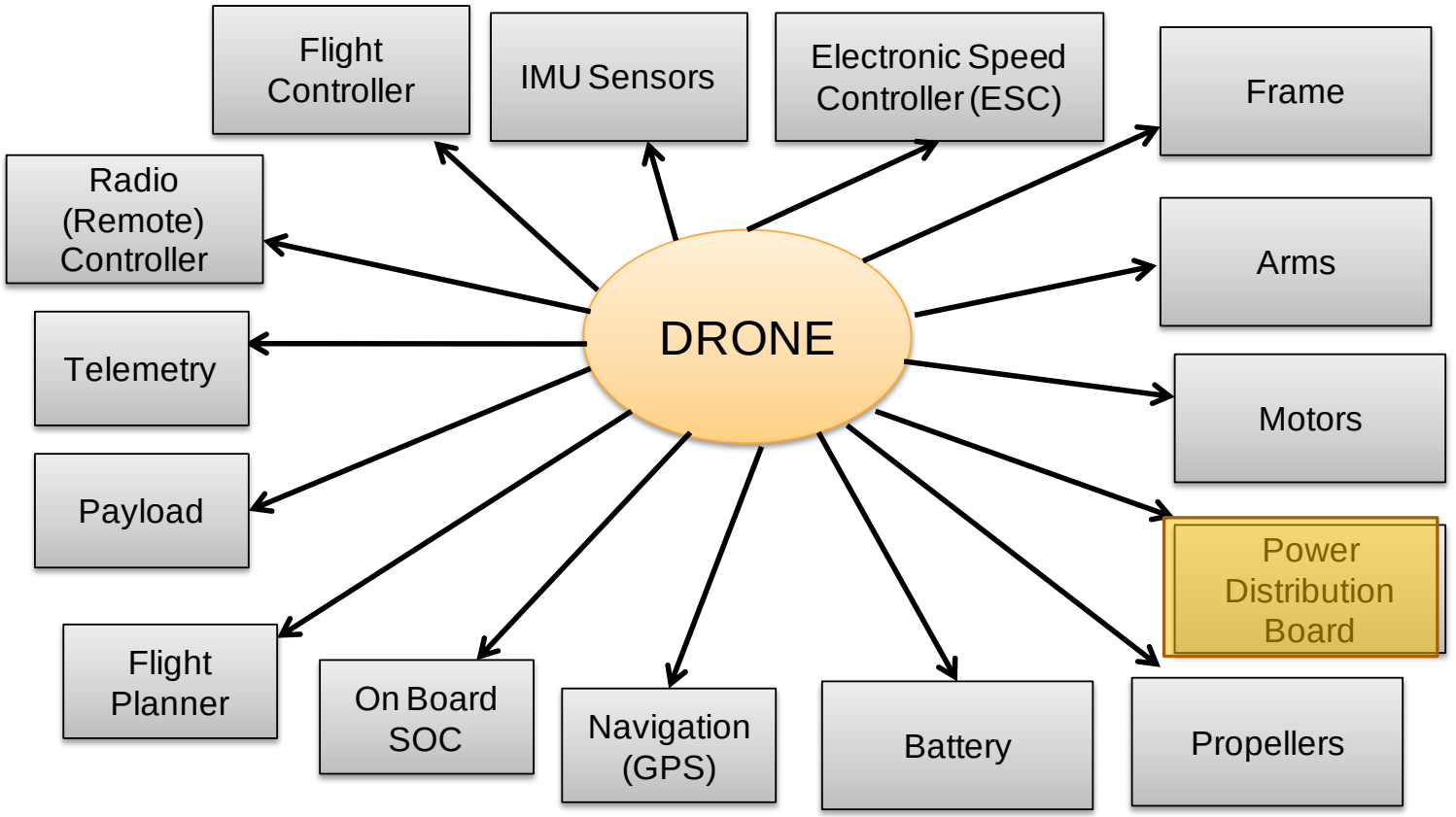


Motors

Motors

The motors are fitted to the arms. Usually Brushless DC motors (BLDC) which creates a minimal friction. A cylindrical shell of magnets rotates on precision bearings around a core of tightly and nearly coiled wire. The propeller is fastened atop. Motors are assigned various notations, the most consequential being the Kv rating, which indicates the revolutions per minute (RPM) while 1 V potential difference is applied.

Anatomy of Drone

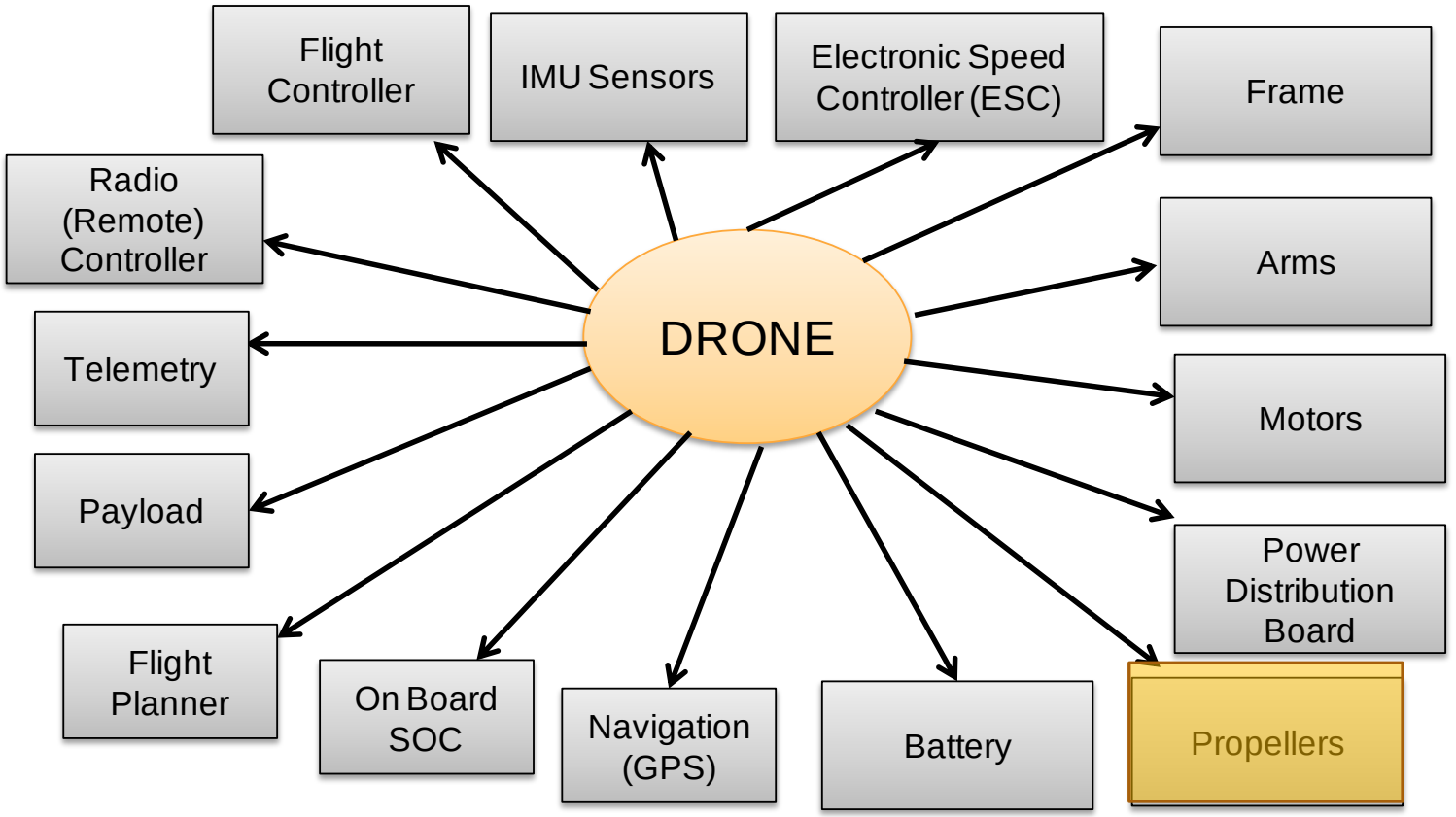


Power Distribution Board

Power Distribution Board (PDB)

Printed circuit board that is used to distribute the power from battery to all different components of the multi rotor. PDB distributes the power to the drone, and provides a neat and tidy way of connecting the battery to all Electronic Speed Controller (ESC) with enough copper points for soldering. PDB connects to the battery via power module to have the regulated supply from the battery

Anatomy of Drone

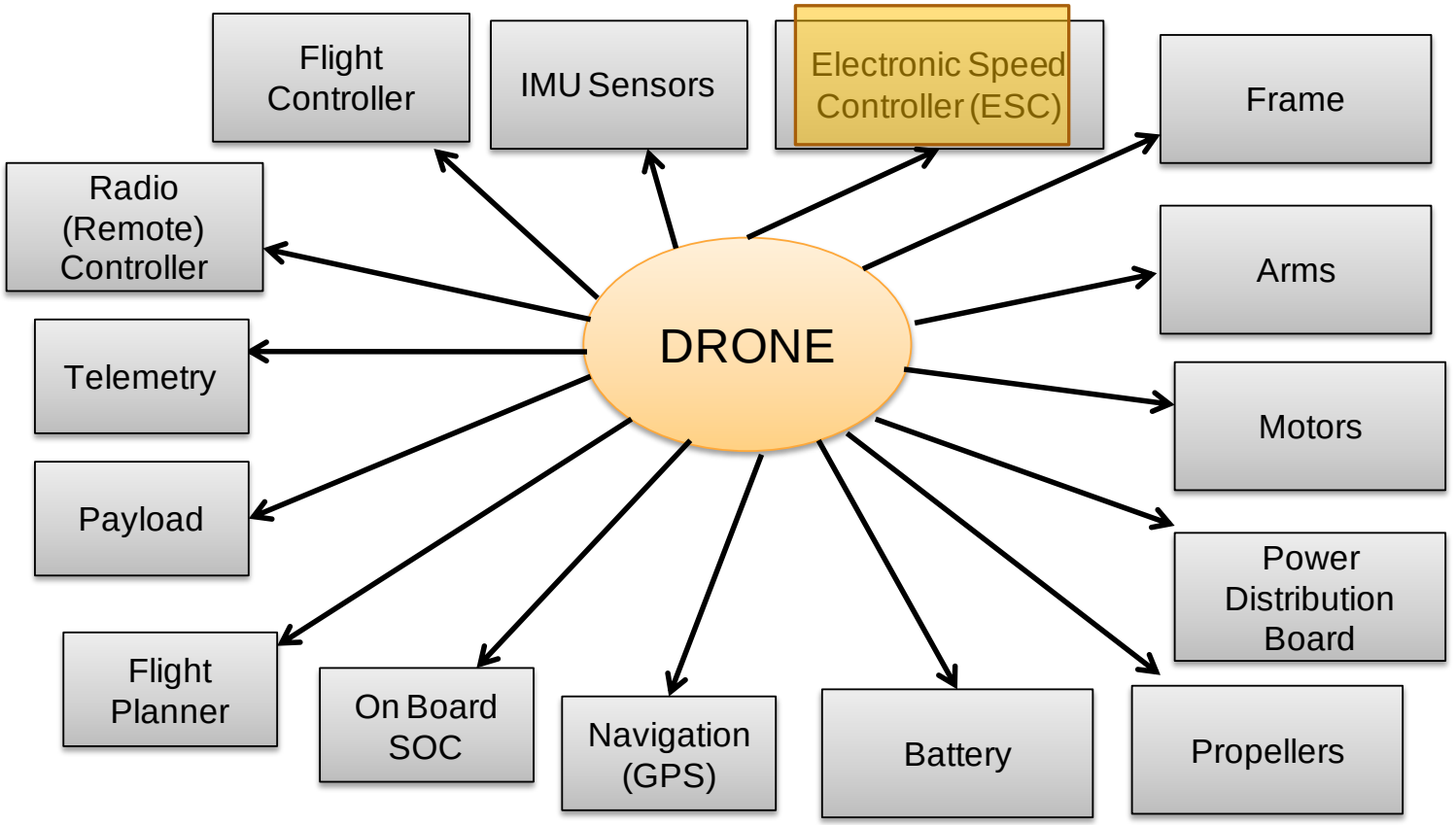


Propellers

Propeller

Propellers play a vital role in vertical lifting of the drone. The propellers are usually measured in inches. The smaller propellers are usually selected for higher Kv motor to have more speed, and larger propeller with correspondingly low Kv rating of the motor is used for nominal flight speed, which is generally suitable for imaging applications.

Anatomy of Drone

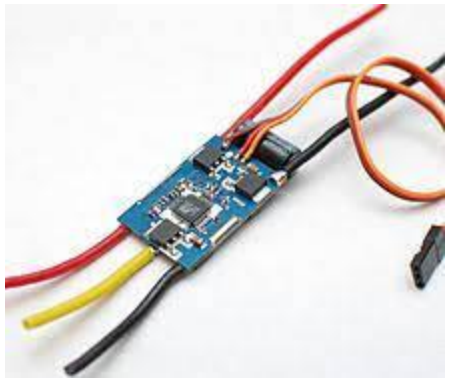


ESC (Electronic Speed Controller)

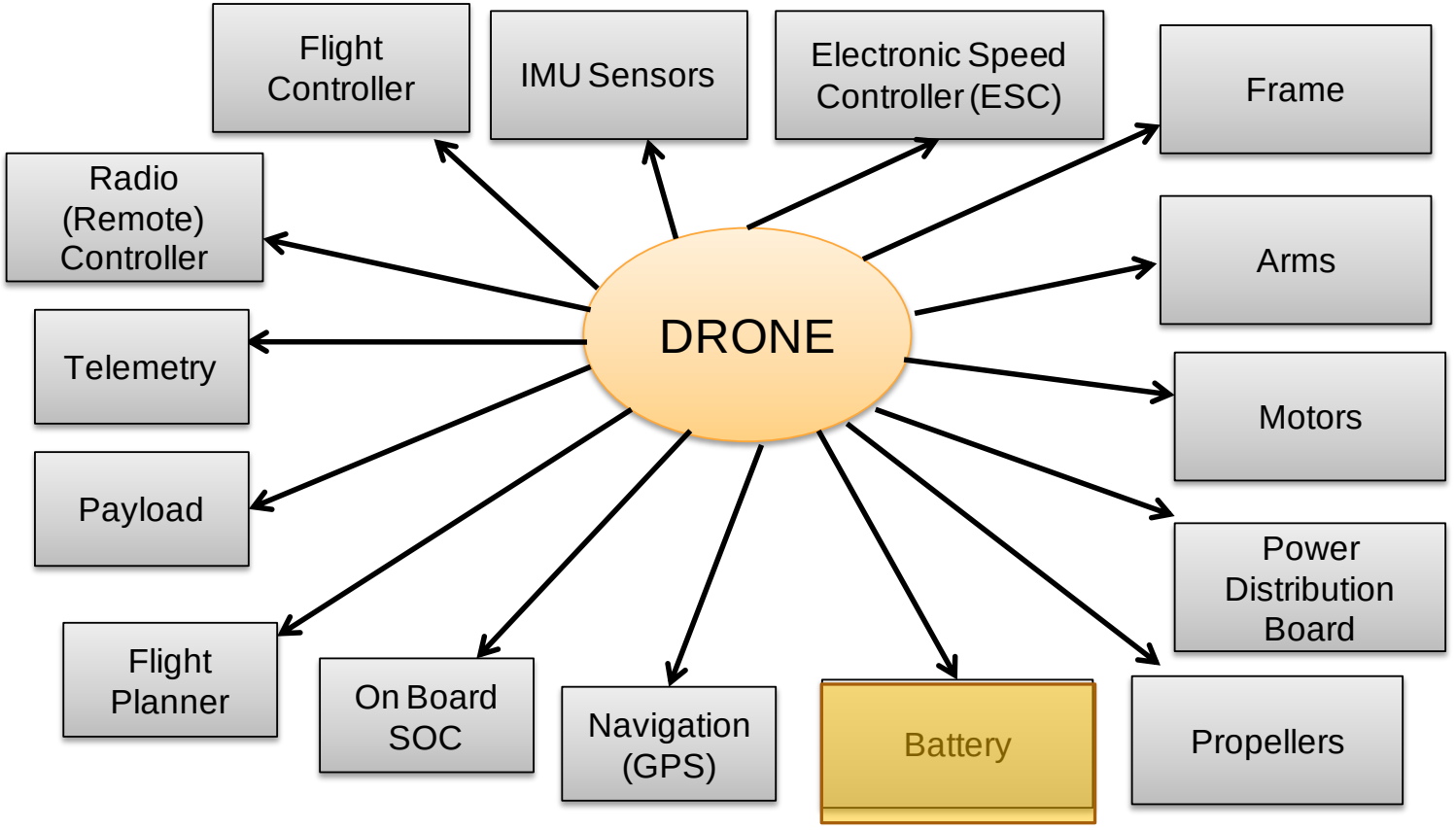
Electronic Speed Controller (ESC)

ESCs translate signal to electrical supply, with every motor connected to ESC to adjust its speed. The major factor for any ESC is the current rating the maximum it can draw, which should be more than the current drawing rate motor connected.

Generally, 30A for medium/large quads and 10 to 12 A for small quad is sufficient. A medium sized hexa copter can easily draw 40A.



Anatomy of Drone



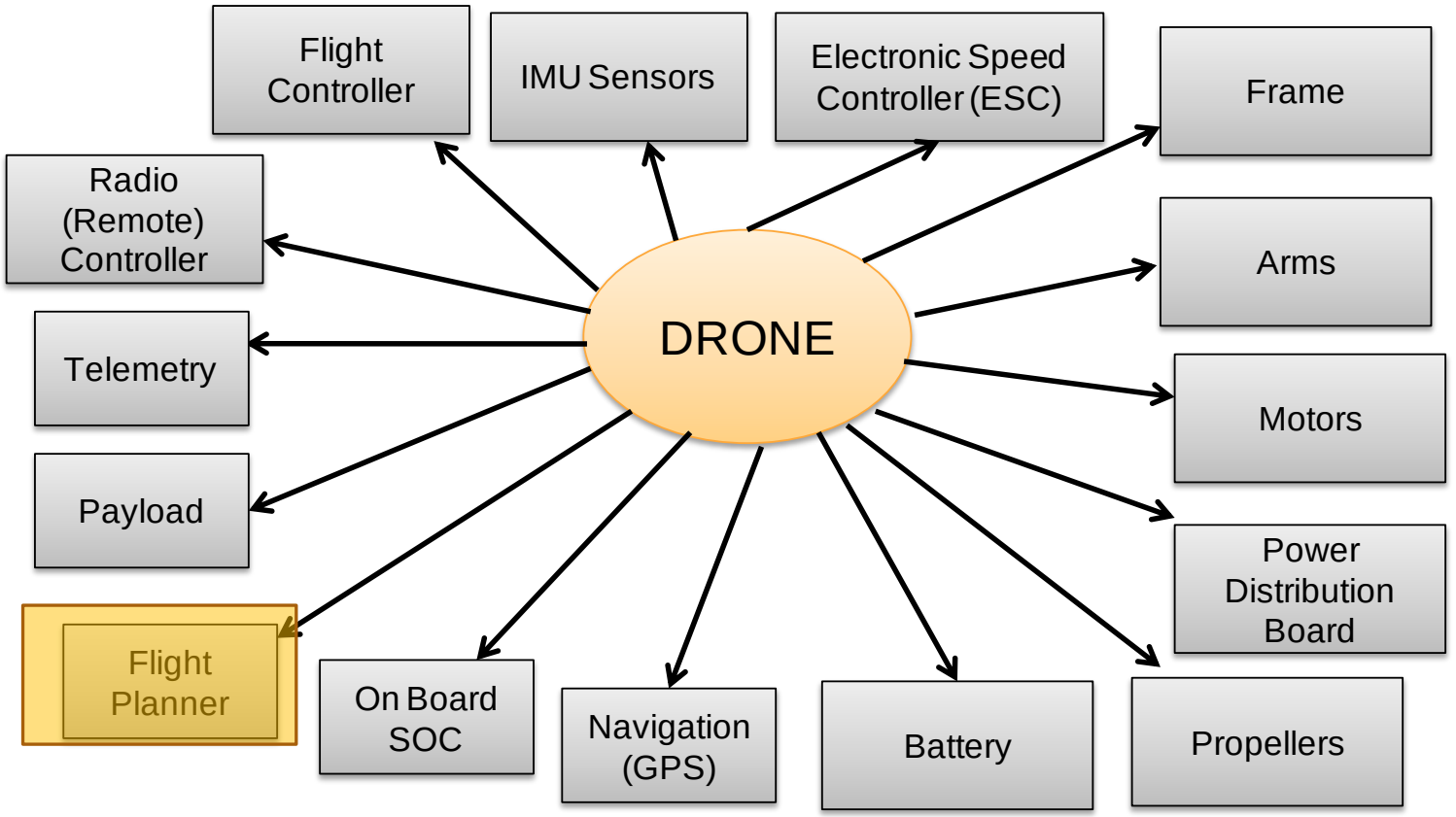
Propulsion/Battery

Battery

Drone batteries majorly used are Lithium Polymer (LiPO) or Lithium-ion type(Li-Io). Usually LiPO batteries are well suited for most of the drones due to their light weight, compact in size, and high discharge rate

Lithium-polymer (LiPO) batteries, relatively light weight, compact, and offering high discharge rates, LiPOs are well suited for multi-rotors.

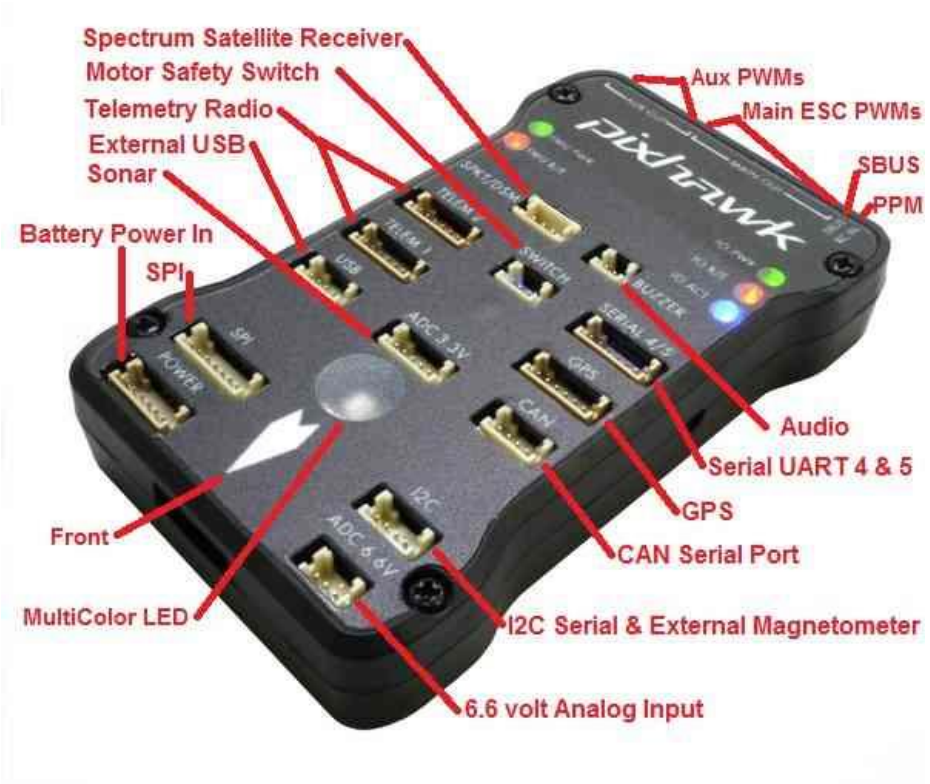
Anatomy of Drone

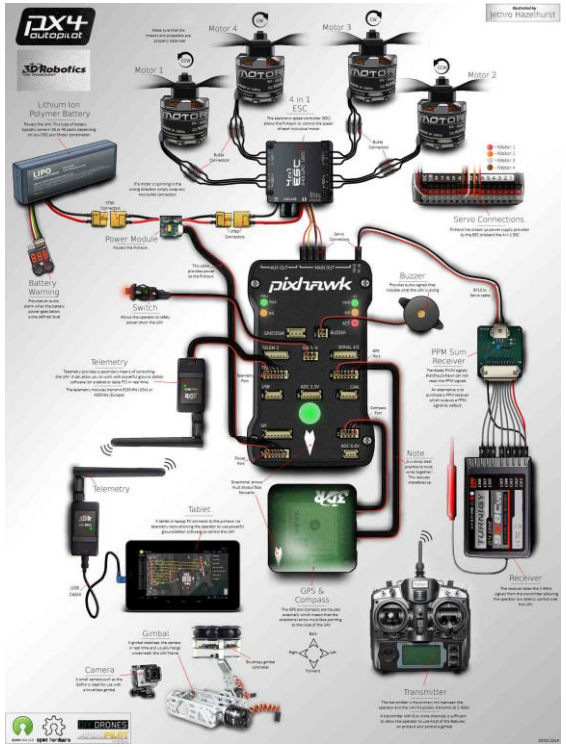


Flight Controller

Flight Controller

Flight Controller is a an important in the drone. Usually flight controller are microcontroller running Real Time operating System (RTOS) to operate the drone as they receive command from the operator. They contains IMU sensors and provides other interfaces to connect ESC, GPS, telemetry and RC flight modules etc.

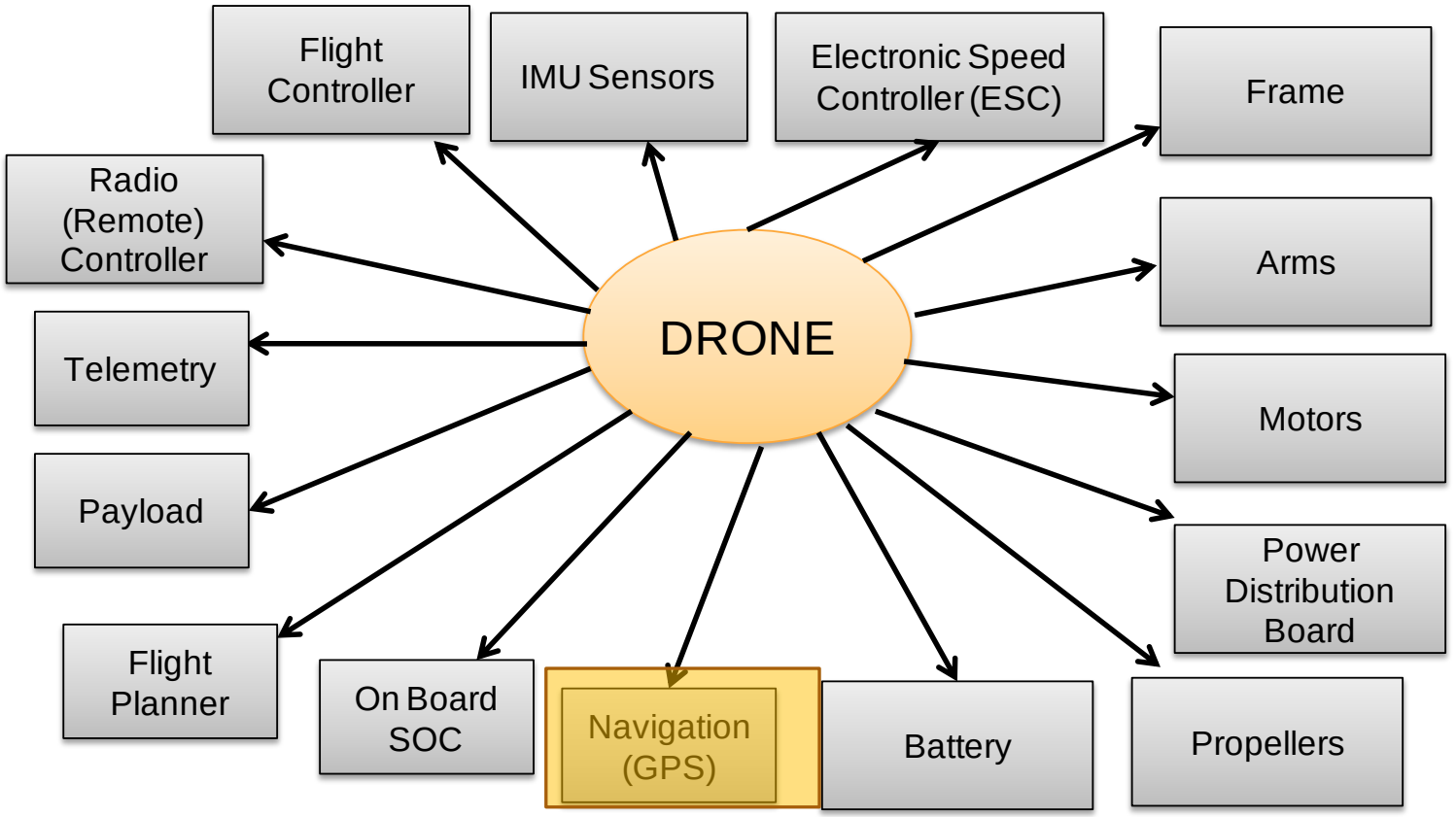




Topics

- **Sensors and Payloads: GPS, IMU**

Anatomy of Drone



Navigation and Guidance System

Navigation **Navigation sensor provides the position information to the drone, which is very essential for the drone to operate in auto flight mode.**

Compass **Compass offers the direction to the flight and other IMU sensors like gyro and barometer provides the movement and air pressures to the flight. IMU sensors are part of the Flight controller and GPS and compass is interfaced to the flight controller as an external interface.**

IMU **Inertia Measurement Unit(IMU) sensors like gyro and barometer provides the movement and air pressures to the flight. IMU sensors are part of the Flight controller and GPS and compass is interfaced to the flight controller as an external interface.**

Navigation System - UAV

- A **navigation system** is a computing system that helps to navigate/move.
- Navigation systems are in general on board UAV systems making use of radio or other signal transmission for controlling

Navigation systems – What for used?

Navigation systems may be capable of one or more of:

- Containing maps, which may be displayed in human-readable format via text or in a graphical format
- Determining a vehicle or vessel's location via sensors, maps, or information from external sources
- Providing suggested directions to a human in charge of a vehicle or vessel via text or speech
- Providing directions directly to an autonomous vehicle such as a robotic probe or guided missile
- Providing information on nearby vehicles or vessels, or other hazards or obstacles
- Providing information on traffic conditions and suggesting alternative directions
- Simultaneous localization and mapping
- Acoustic positioning for underwater navigation

Types of Navigation Systems

- **Satellite navigation system**
  - **Global Positioning System, a group of satellites and computers that can provide information on any person, vessel, or vehicle's location via a GPS receiver**
    - **GPS navigation device, a device that can receive GPS signals for the purpose of determining the device's location and possibly to suggest or give directions**
  - **GLONASS, satellite navigation system run by Russia**
  - **Galileo global navigation satellite system**
  - **IRNSS, regional satellite system run by India.**
- **Automotive navigation system - Uses satellite navigation system**
- **Marine navigation systems using sonar (** Sonar is a technique that uses sound propagation to navigate, measure distances, communicate with or detect objects on or under the surface of the water)
- **Surgical navigation system, a system that determines the position of surgical instruments in relation to patient images such as CT or MRI scans.**
- **Inertial guidance system, a system which continuously determines the position, orientation, and velocity (direction and speed of movement) of a moving object without the need for external reference**
- **Robotic mapping, the methods and equipment by which an autonomous robot is able to construct (or use) a map or floor plan and to localize itself within it**
- **XNAV for deep space navigation**

UAV / Drone Navigation – Satellite based

•A group of satellites and computers that can provide information on any person, vessel, or vehicle's location via receiver: a device that can receive signals for the purpose of determining the device's location and possibly to suggest or give directions

- Global Positioning System (GPS): Run by USA
- GLONASS, satellite navigation system run by Russia
- Galileo global navigation satellite system by Europe
- BeiDou: China’s Satellite Navigation System
- IRNSS, Regional satellite system run by India.
- GAGAN : GPS Aided Navigation system by India.

Drone/UAV use : GPS

The Global Positioning System (GPS) is a U.S.-owned utility that provides users with positioning, navigation, and timing (PNT) services. This system consists of three segments: the space segment, the control segment, and the user segment. The U.S. Space Force develops, maintains, and operates the space and control segments.

Space Segment consists of a nominal constellation of 24 operating satellites that transmit one way signals that give the current GPS satellite position and time

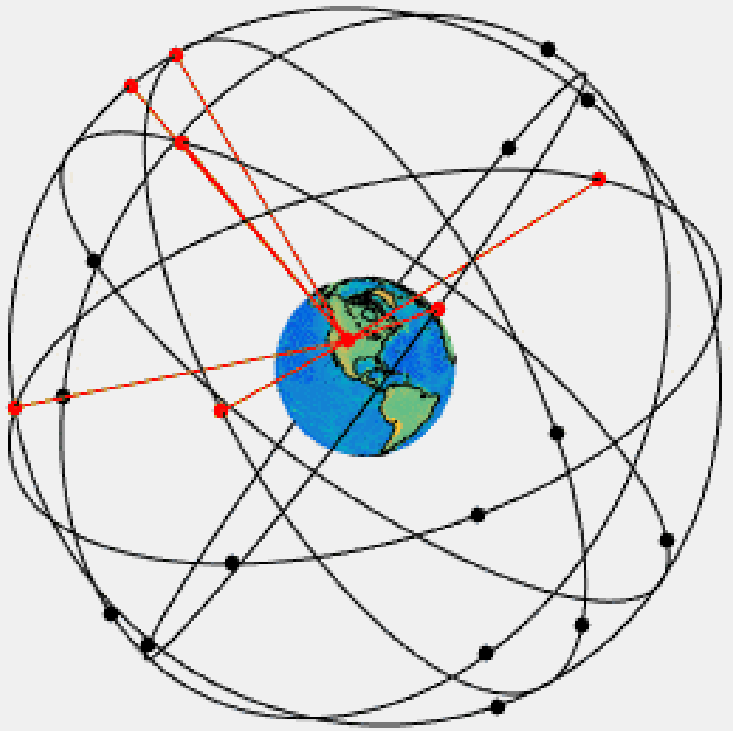
Control segment: consists of world wide monitor and control stations that maintain the satellites in their proper orbits through occasional command maneuvers, and adjust the satellite clocks. It tracks the GPS satellites, uploads the updated navigational data, and maintains health and status of satellite constellation.

User segment: consists the GPS receiver equipment, which receives the signals from the GPS satellites and uses the transmitted information to calculate the users' three dimensional position and time.

GPS Constellation

A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth. Each satellite continually transmits messages that include the time the message was transmitted and the satellite position at the time of message transmission.

The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite using the velocity of light. This measured distance is called pseudorange. Because of errors in receiver clock, the pseudorange has many errors. Since this error is equal for all observations, the effect of that can be destroyed. The calculation of distance should be done for at least four satellites.

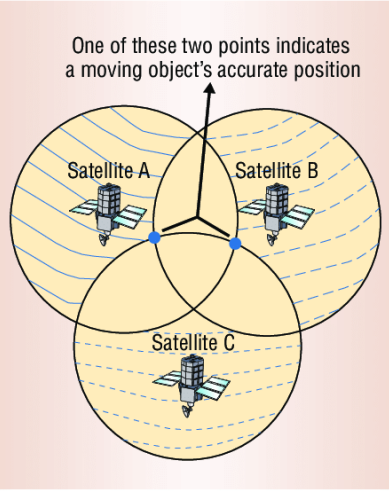


How to find position using GPS

Orbiting the Earth are a number of Global Positioning System (GPS) satellites that can help determine your location on the planet. The concepts behind GPS positioning are very simple, but the application and implementation require amazing precision.

GPS positioning works on two basic mathematical concepts. The first is called trilateration, which literally means positioning from three distances. The second concept is the relationship between distance traveled, rate (speed) of travel and amount of time spent traveling, or:

Distance = Rate × Time



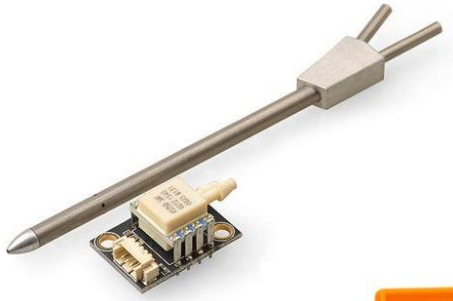
UAV : GPS Receivers

https://www.indexpro.net/en/Category/772

IMU Sensors

GPS & Compass

Airspeed



Distance

Tachometer

https://docs.px4.io/v1.12/en/getting_started/sensor_selection.html

Topics

- **Data Link System**

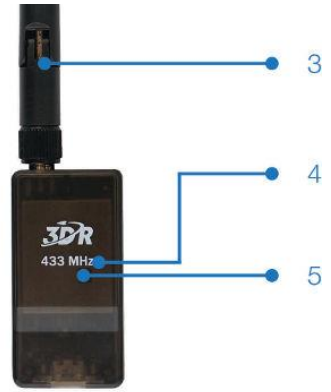
Data Link System

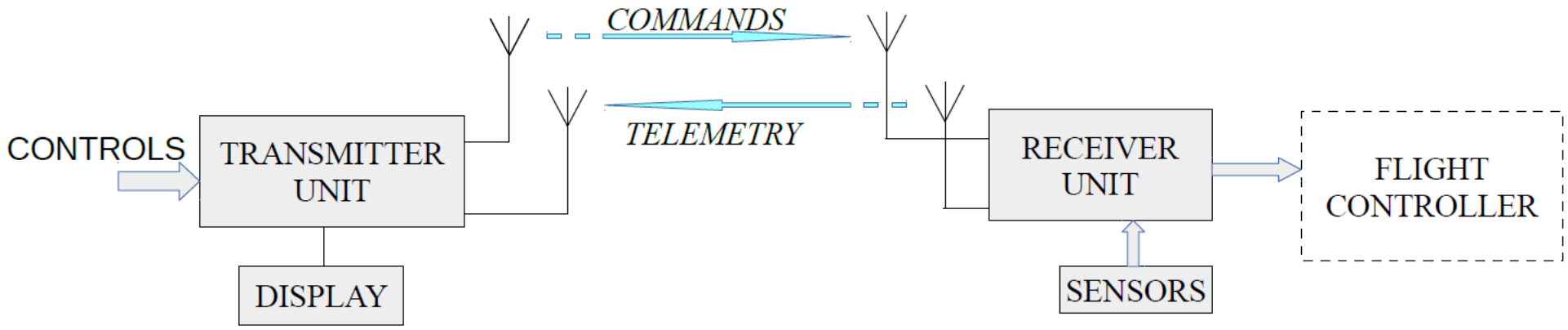
Provides Communication among Air and Ground Modules

Types of communication:

- UHF/VHF
- C Band
- Ku band
- LTE

1 Micro-USB port
2 DF13 six-position port
3 Antenna
4 Frequency
5 LED indicator





Topics

- **Classification of payload based on applications; Hyper-spectral sensors; Laser Detection and Range (LiDAR); Synthetic Aperture Radar (SAR); Thermal cameras; ultra-sonic detectors; Case study on payloads. Introduction to Navigation systems and types of guidance**

Cameras – RGB, Thermal and Hyper Spectral

Drones uses several imaging cameras for data collection

RGB : Red, Green and Blue Filter Cameras to capture Multi spectral Data

Thermal Cameras: for Day and Night Operations

Hyper Spectral Cameras: For Detailed Study and analysis with narrow spectral bandwidth range.

https://www.flir.in/browse/home-amp-outdoor/drone-cameras/

Benefits/Advantages

- Controlled and Owned by users themselves, unlike more expensive satellite and aerial imagery.
- Provides opportunities to produce **timely, high quality and cloud free very high resolution imagery** for mapping applications and thus allowing quick decision making.

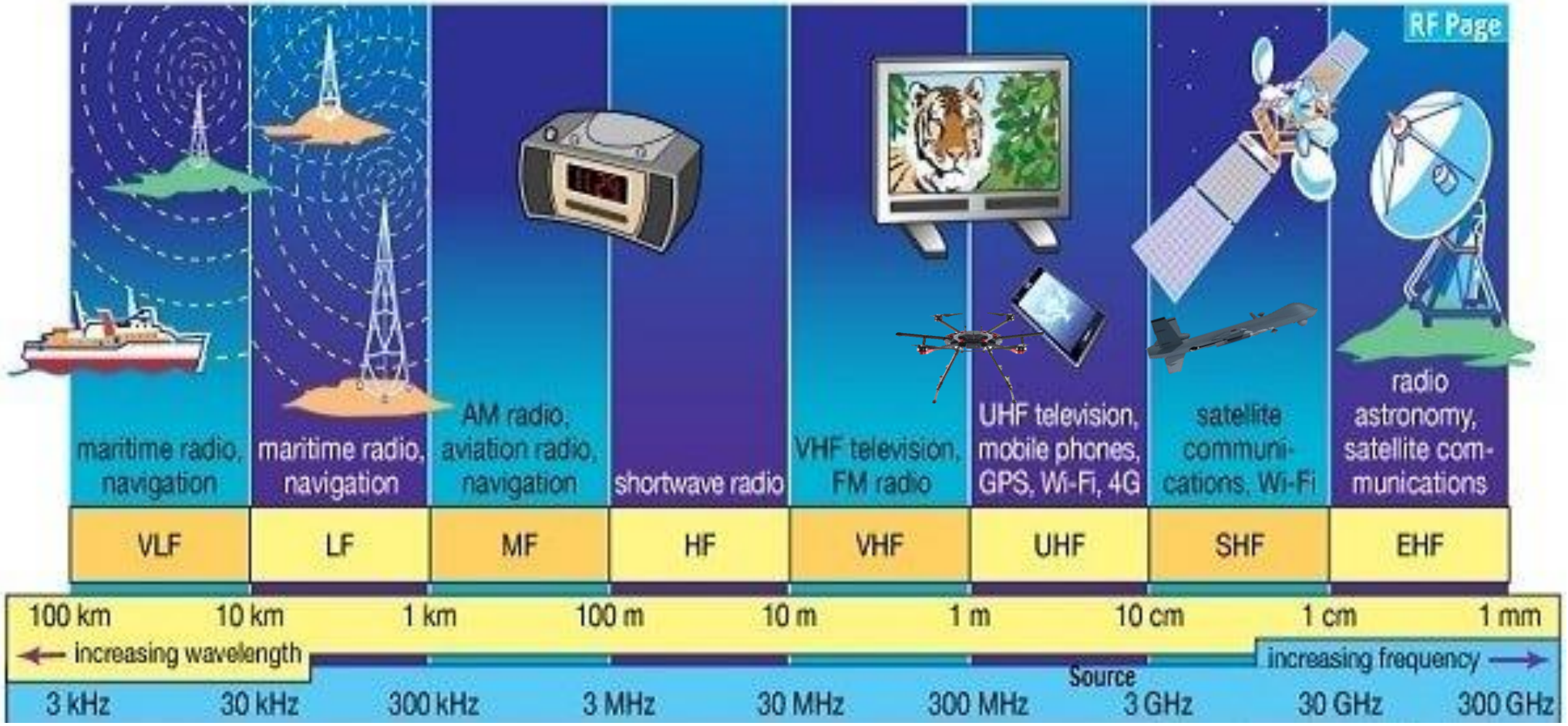
Drone Applications

- **General purpose Applications**
  - Corridor Mapping
  - Surveillance
  - High scale mapping
  - Sporadic Event Monitoring and Management
  - Ad Hoc Communication network
  - Entertainment: Movies, Hobbies [some pictures]
  - Disaster Management
- **Tactical missions**
  - Secure and Surveillance Monitoring
  - Swam Flying

Radio Range

- Radio signals travel primarily LOS(line-of-sight) from the transmitter to the receiver, passing through different obstructions along the path from the transmitter to the receiver.
- Signal strength diminishes with the square of distance
  - If you move twice as far away, the signal is ¼ the signal strength.
  - If you are 3 times as far, the signal is reduced to 1/9th of the signal.
- There is another loss due to the frequency which increases with higher frequency.
- The effects of radio propagation are different for each band.
- Since radio coverage is essential, the consideration of propagation characteristics of the different frequency bands must be taken into account when choosing a radio system.

Radio Frequency Spectrum

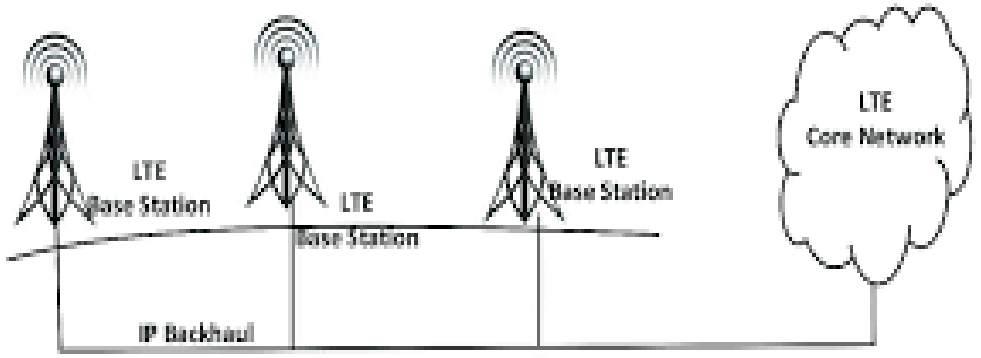


UHF – Ultra High Frequency

- Ultra high frequency (UHF) is the ITU designation for radio frequencies in the range between 300 megahertz (MHz) and 3 gigahertz (GHz),
- It also known as the decimetre band as the wavelengths range from one meter to one tenth of a meter (one decimeter).
- UHF radio waves propagate mainly by line of sight; they are blocked by hills and large buildings although the transmission through building walls is strong enough for indoor reception. They are used for television broadcasting, cell phones, satellite communication including GPS, personal radio services including Wi-Fi and Bluetooth, walkie-talkies, cordless phones, and numerous other applications.

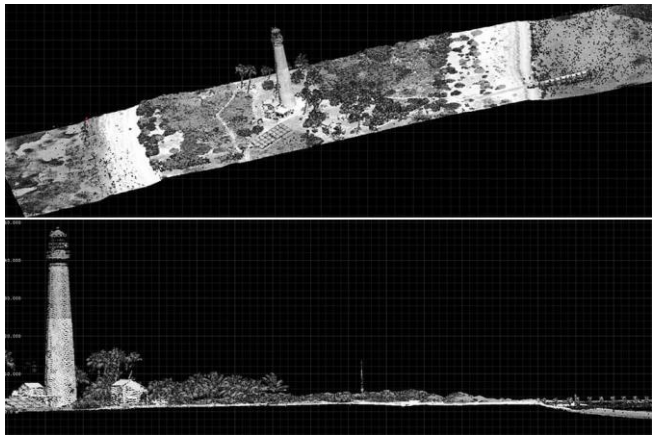
LTE Communication

- 4G LTE is an alternative to the radio control system that can eliminate the short distances limitation of a drone.
- In terms of using a drone for search and rescue missions, the 4G network allows a drone to fly several miles away from the controller or pilot.
- The distance improvement, in turn, improves the efficiency of drone applications.
- Replacing the standard radio control feature of drones with a 4G LTE network connection has several advantages in terms of long range communication using cellular networks, higher bandwidth etc.
- Also, the standard security protocols for communication can be used similar to Adhoc communication.



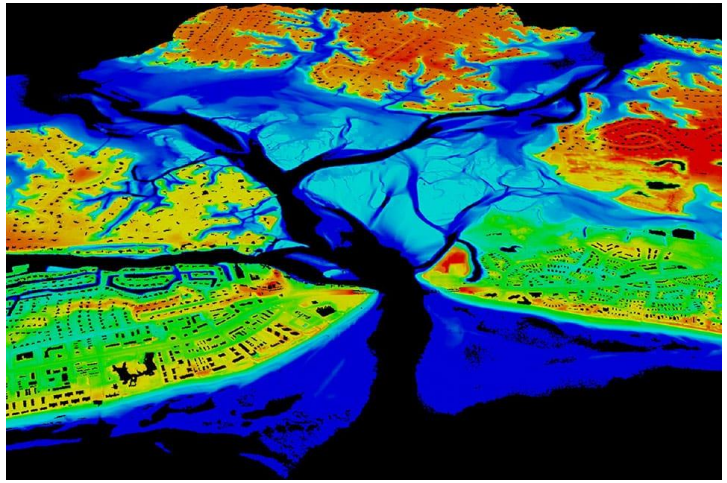
LiDAR (Light Detection And Ranging)

Lidar — Light Detection and Ranging — is **a remote sensing method** used to examine the surface of the Earth.



Lidar, which stands for *Light Detection and Ranging,* is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses—combined with other data recorded by the airborne system — generate precise, three-dimensional information about the shape of the Earth and its surface characteristics.

A lidar instrument principally consists of a laser, a scanner, and a specialized GPS receiver. Airplanes and helicopters are the most commonly used platforms for acquiring lidar data over broad areas. Two types of lidar are topographic and bathymetric. Topographic lidar typically uses a near-infrared laser to map the land, while bathymetric lidar uses water-penetrating green light to also measure seafloor and riverbed elevations.



Topics

- **Mission Planning and Control.**

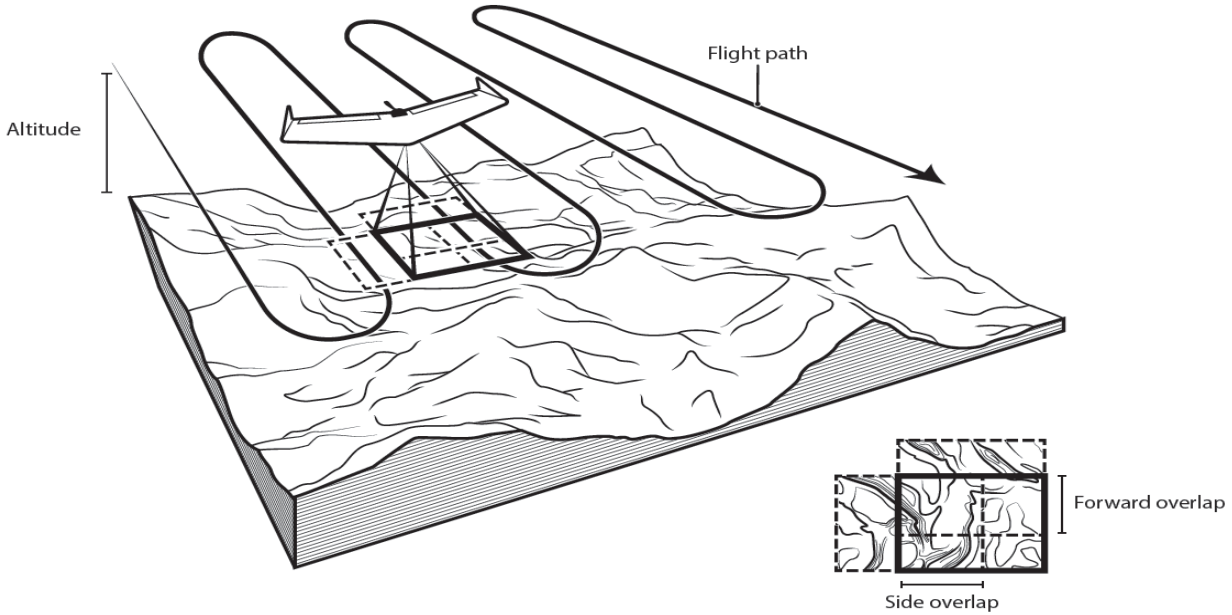
Drone Flight mission – Open Source and COTS

- Ardupilot https://ardupilot.org/planner/
- QGround Control http://qgroundcontrol.com/
- Drone Code / Drone kit
- Flytbase https://flytbase.com/

Mission Planning

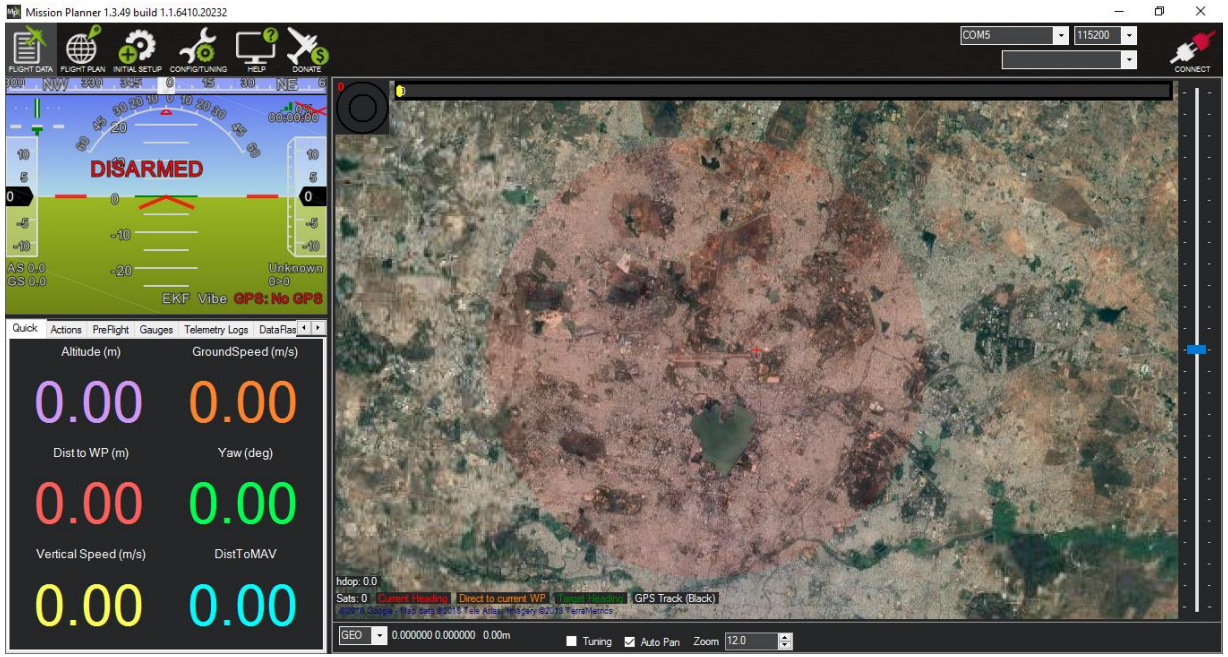
- Flight Planning
  - Manual control is generally useful for inspections(say beneath a bridge) that aim to react to information in real time, while autonomous control, more useful when one is trying to fly in a systematic pattern to create a map.
  - Decision to be made for the flight is in autonomous control between GPS/GAGAN waypoints or will be controlled manually.
- The majority of UAV mappers use autonomous control.

UAV should remain within the line of sight (LOS) of pilots unless the pilots have sufficient experience, specific need, and regulatory approval to fly beyond their line of sight.

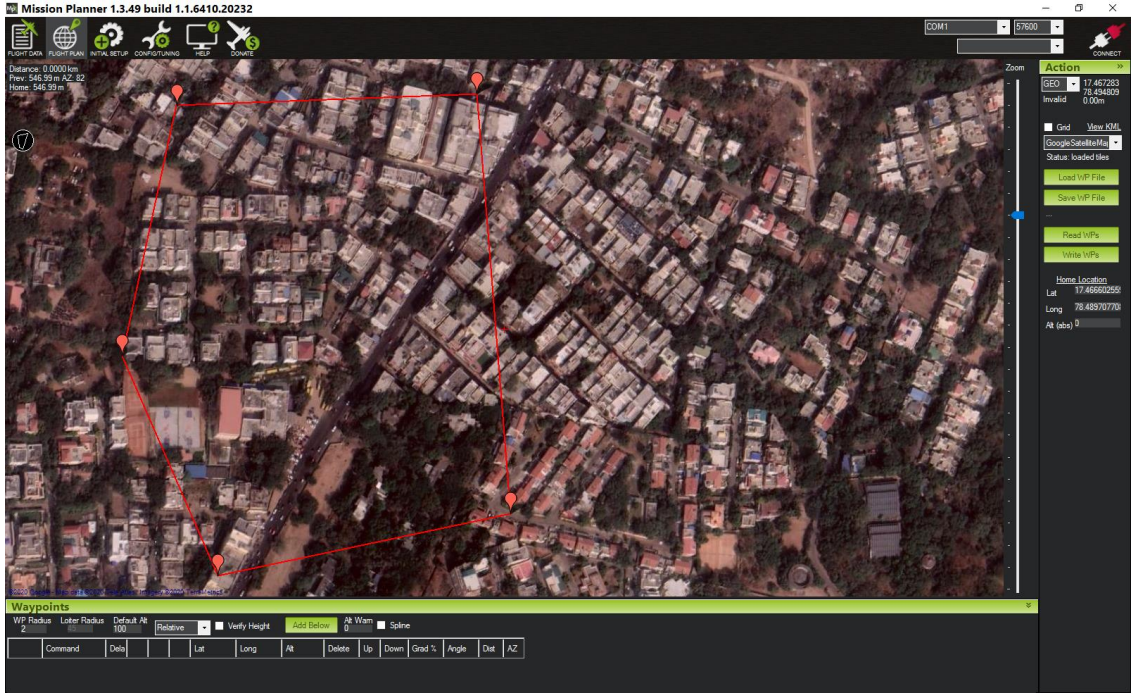


Planning is to ensure each image has adequate overlap with the subsequent images, making it possible for processing software to merge the images.

Ardupilot – for mission planning in auto pilot mode



Mission Planner Software



Flight Planning

THANK YOU