DRONE TECHNOLOGY & ROBOTICS

DIPLOMA WALLAH

OPEN ELECTIVE

Jharkhand University Of Technology (JUT)

UNIT-III – Introduction to Drones

◆

Drones, formally known as Unmanned Aerial Vehicle (UAV)s, are aircraft systems that operate **without a human pilot onboard**. This expands into the broader concept of the Unmanned Aircraft System (UAS), which includes the UAV itself, the ground control station, the communications links, and supporting systems. A drone's evolution traces from early remote-controlled craft to modern autonomous vehicles enabled by miniaturised sensors, high-performance computing, advanced navigation, and communication networks. Understanding drones involves looking at their **history**, how they are **classified**, their **system composition**, and the many **applications** they serve.

Drones are integrated cyber-physical systems: they combine aerodynamics (lift, drag, propulsion), structural design (air-frame), embedded electronics (flight controller, sensors), software (autopilot algorithms, mission planning), power systems (batteries/fuel), and communications (telemetry, C2 links). They must work in real-world environments subject to weather, obstacles, airspace rules, and mission constraints. Their classification helps in matching drone type to task—size, weight, configuration, autonomy, range, take-off/landing method. System composition covers the hardware, sensors, actuators, power supply, autopilot software and ground-control infrastructure.

Applications now span from commercial (delivery, photography, inspection) to industrial (surveying, agriculture, infrastructure), public safety (search & rescue, disaster response), and military (reconnaissance, strike, swarm operations). Each application demands different trade-offs: endurance vs payload, agility vs stability, autonomy vs remote control. Regulations, safety and reliability are critical for operation in shared airspace and for public acceptance.

1. Introduction to UAS

Definition:
A UAS (Unmanned Aircraft System) includes not just the flying vehicle (the UAV) but also all supporting elements needed for safe & effective operation — ground control station, communication links, data/telemetry systems, payloads, mission management infrastructure. (Pilot Institute)

Importance:
Recognising drone operations as a full system (UAS) is crucial because:

- The vehicle alone isn't enough — you need command/control, communications, data links, sensors.
- Regulatory frameworks, safety standards and mission planning all hinge on seeing the whole system, not just the aircraft.
- For example, a drone used for inspection must integrate sensors, transmit data in real-time, and have ground-station support — it's more than just "fly & film".

Features:

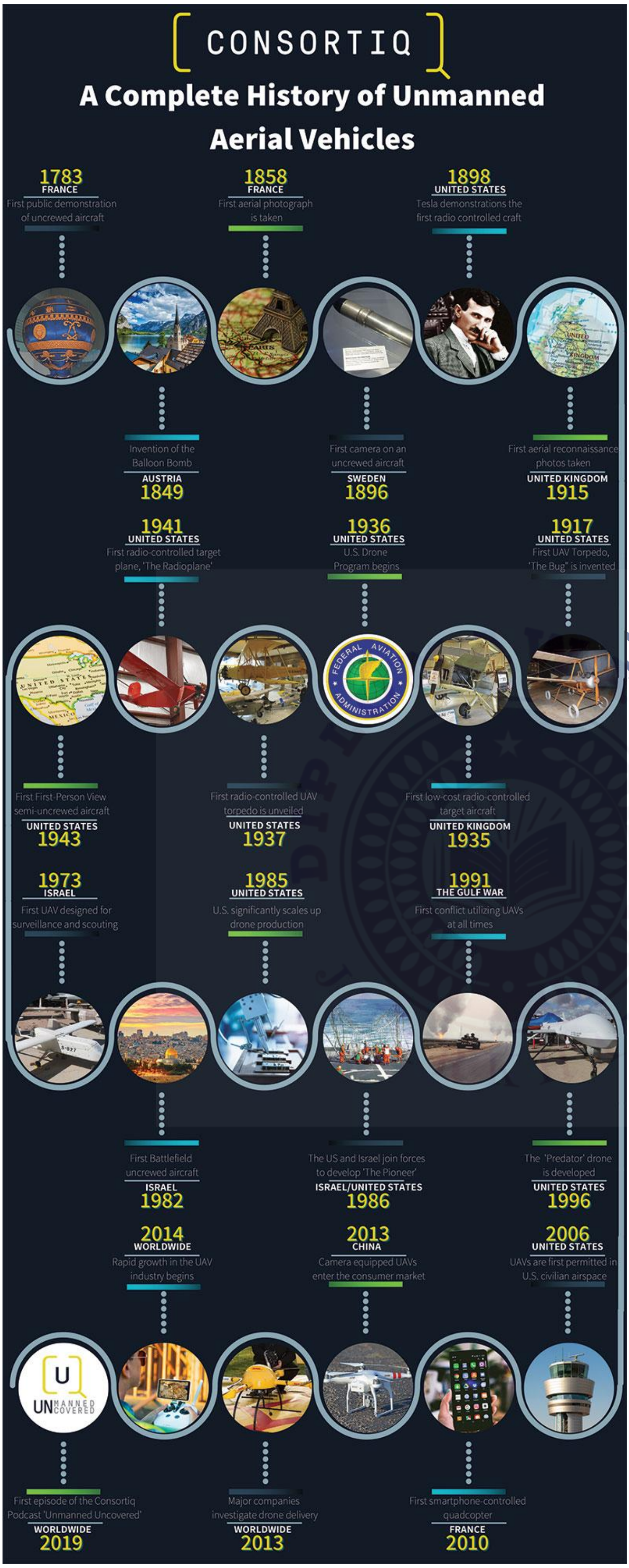
- Remote or autonomous operation: The pilot may be remote or the system fully automated. (Federal Aviation Administration)
- Sensor/actuator integration: The UAS must include sensors (camera, LiDAR, IMU) and actuators (rotors, control surfaces) tied into the system.
- Data links to ground station: Telemetry, command & control (C2) links enable monitoring and operation of the UAV.
- Mission management: From pre-flight planning, data collection, to post-processing and analysis, the UAS includes the full workflow.

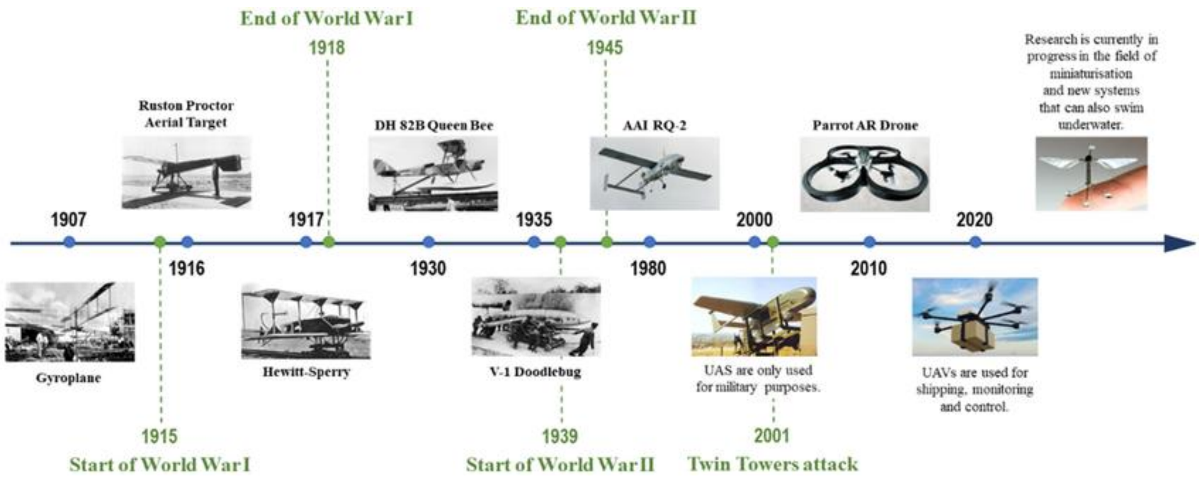
Deeper Insight:
Think of the UAS as a layered stack:

- Hardware layer: aircraft + sensors + actuators

- Communications layer: the links between UAV and ground/station or satellite
- Software/mission layer: autopilot, path planning, data processing
- Ground control/operations layer: the human or automated station that supervises flight, manages payloads and analyses outputs. This layered view helps in designing, regulating and integrating UAS into airspace, industry and infrastructure.

2. History of UAV / Drones


CONSORTIQ
A Complete History of Unmanned Aerial Vehicles
1783
FRANCE
First public demonstration of uncrewed aircraft
1858
FRANCE
First aerial photograph is taken
1898
UNITED STATES
Tesla demonstrates the first radio controlled craft
Invention of the Balloon Bomb
AUSTRIA
1849
First camera on an uncrewed aircraft
SWEDEN
1896
First aerial reconnaissance photos taken
UNITED KINGDOM
1915
1941
UNITED STATES
First radio-controlled target plane, 'The Radioplane'
1936
UNITED STATES
U.S. Drone Program begins
1917
UNITED STATES
First UAV Torpedo, 'The Bug' is invented
First First-Person View semi-uncrewed aircraft
UNITED STATES
1943
First radio-controlled UAV torpedo is unveiled
UNITED STATES
1937
First low-cost radio-controlled target aircraft
UNITED KINGDOM
1935
1973
ISRAEL
First UAV designed for surveillance and scouting
1985
UNITED STATES
U.S. significantly scales up drone production
1991
THE GULF WAR
First conflict utilizing UAVs at all times
First Battlefield uncrewed aircraft
ISRAEL
1982
The US and Israel join forces to develop 'The Pioneer'
ISRAEL/UNITED STATES
1986
The 'Predator' drone is developed
UNITED STATES
1996
2014
WORLDWIDE
Rapid growth in the UAV industry begins
2013
CHINA
Camera equipped UAVs enter the consumer market
2006
UNITED STATES
UAVs are first permitted in U.S. civilian airspace
First episode of the Consortiq Podcast 'Unmanned Uncovered'
WORLDWIDE
2019
Major companies investigate drone delivery
WORLDWIDE
2013
First smartphone-controlled quadcopter
FRANCE
2010



Early Beginnings:

- The concept of unmanned aircraft goes back to the late-18th and early-19th centuries: for example, unmanned balloons used in conflicts.
- Early 20th century: target drones (for anti-aircraft training) and reconnaissance UAVs began to appear.
- These early systems had limited autonomy and often required human operation, but they established the idea of aircraft without onboard pilots.

Mid-20th Century:

- During World Wars and the Cold War era, more advanced drones/UAVs were developed for reconnaissance, target practice and dangerous missions ("dull, dirty or dangerous"). (Wikipedia)
- The military demand drove innovation in sensors, remote control, and aviation systems.

Modern Era:

- The last few decades have seen rapid miniaturisation of sensors, advances in battery and propulsion systems, GPS navigation, communication links, and autonomous control.
- Consumer and commercial drones proliferated for photography, service, delivery, inspection.

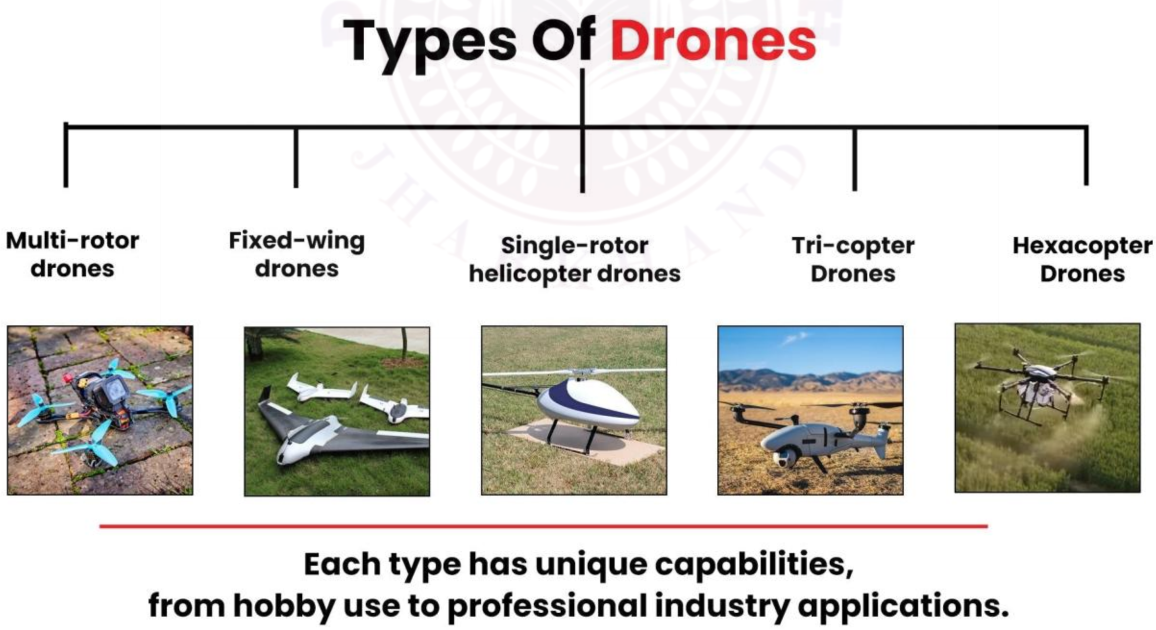
- Regulatory frameworks (e.g., by Federal Aviation Administration (FAA) in the U.S.) began to classify, regulate and integrate UAS into national airspace. (Federal Aviation Administration)
- Today's drones might have obstacle avoidance, swarm coordination, AI-based flight planning — far beyond early remote vehicles.

Deeper Insight:
Understanding history helps:

- Recognise how design constraints (weight, range, sensor capability) improved over time.
- See why older military capabilities trickle into civilian market (e.g., GPS, LiDAR, autonomous navigation).
- Appreciate regulatory and airspace integration challenges that stem from legacy aviation rules built for manned craft.

---

3. Classification of Drones



Classification helps match drones to tasks and design constraints. Here are detailed breakdowns:

By Configuration / Air-frame

- **Multi-rotor** (quadcopters, hexacopters, octocopters): multiple rotors provide vertical lift, hover capability, agility. (AUAV)
- **Single-rotor helicopters**: one large rotor plus tail rotor (like helicopter), longer endurance than some multi-rotors, higher complexity. (AUAV)
- **Fixed-wing**: airplane-style wings, cannot hover in place, efficient forward flight, longer range and endurance. (AUAV)
- **Hybrid VTOL (Vertical Take-Off and Landing)**: combines rotors (for vertical lift) with fixed wings (for forward flight) — best of both worlds but more complex. (AUAV)

By Size / Weight / Endurance

- Classifications vary by region/agency. Example: size from very small (nano) up to large tactical UAVs. (JOUAV)
- Example scheme: Nano (< 0.2 kg), Small (up to ~20 kg), Medium/Large (> 20 kg) etc. (Botlink)
- Endurance/trade-offs: heavier drones carry more payload but often have shorter flight time or need stronger power systems.

By Take-Off / Landing Method

- **Conventional fixed wing with runway**: needs runway or catapult to launch.
- **VTOL**: take-off and land vertically (rotors) — useful in constrained spaces, urban areas.
- **Hybrid**: vertical launch then transition to winged forward flight.

By Autonomy & Application

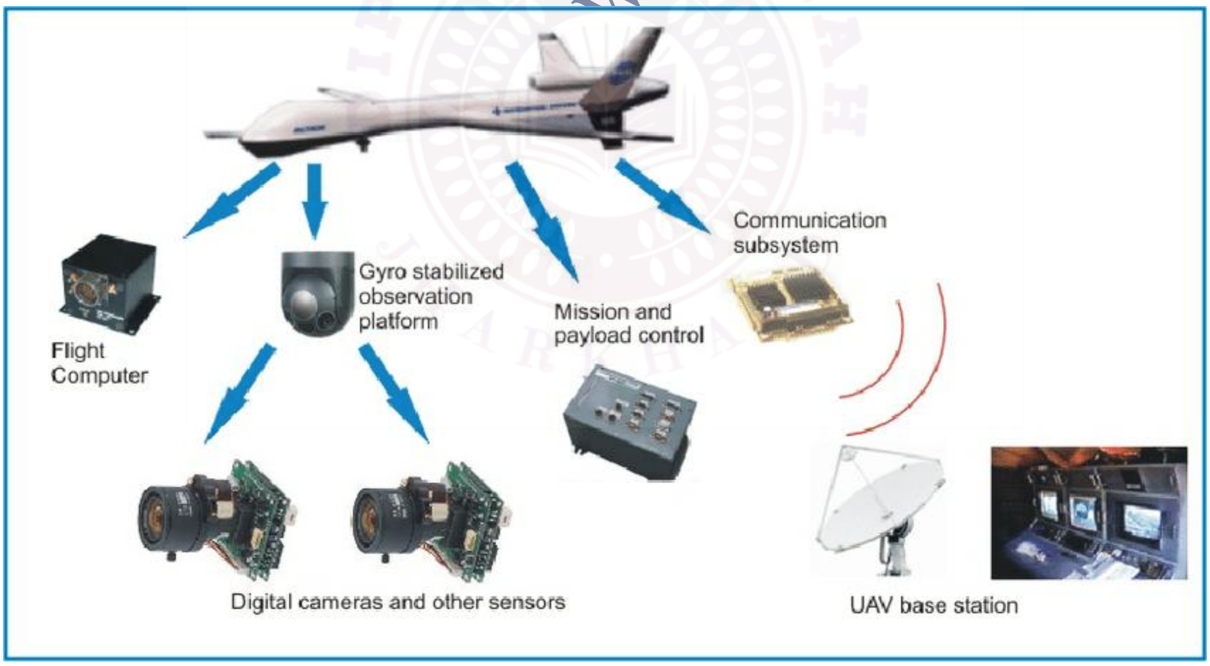
- **Manual/remote-controlled (RC)**: pilot directly controls flight.
- **Semi-autonomous**: autopilot helps with some tasks (hover, follow-me) but human intervenes.
- **Fully autonomous**: drone plans route, avoids obstacles, completes mission without human pilot.

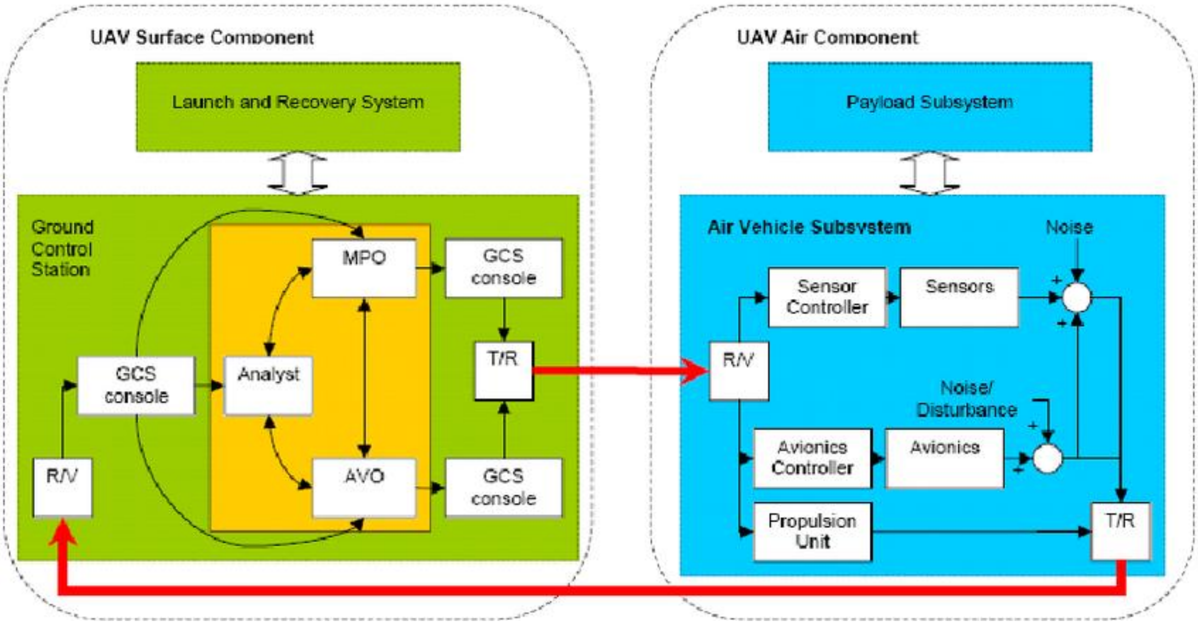
- **By application domain**: recreational, commercial (inspection, photography), industrial (surveying, agriculture), military (recon, strike). (Javier Gómiz)

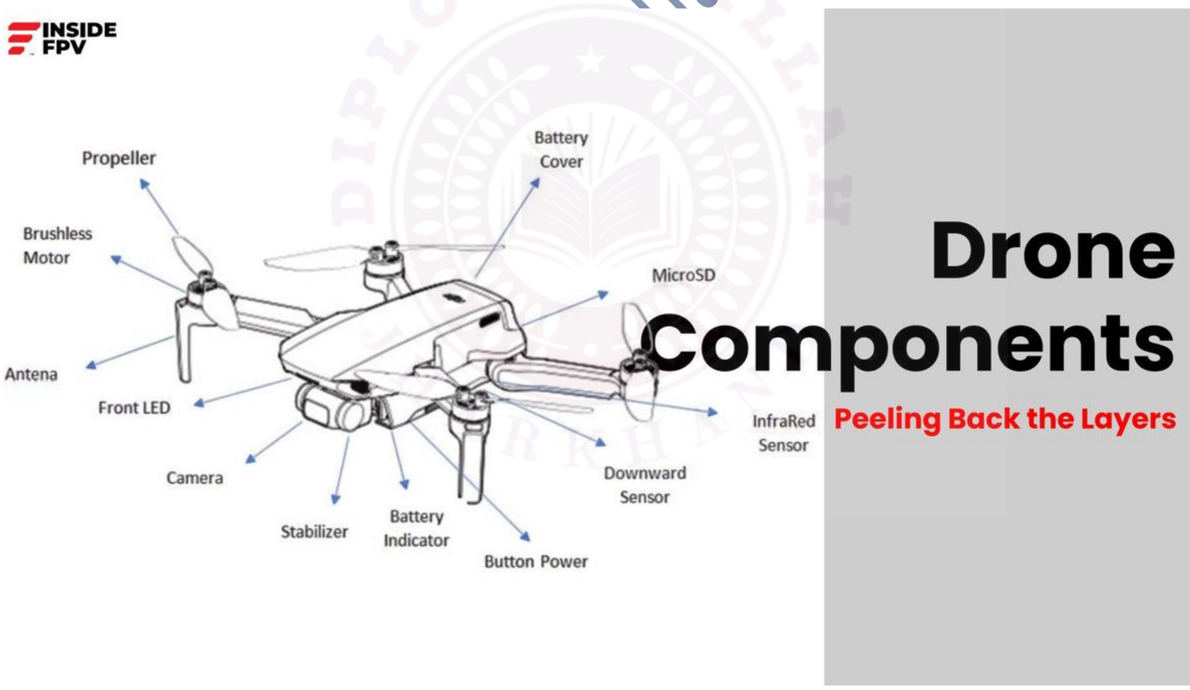
Deeper Insight: Why classification matters

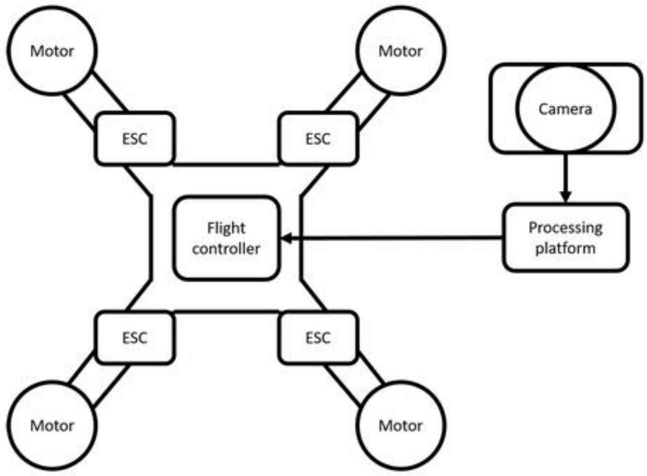
- Enables selecting a drone type best suited for your task: for example, crop surveying over large fields → fixed-wing; high-resolution video in urban environment → multi-rotor.
- Helps in regulatory compliance: weight categories influence licensing, operational zones, airspace restrictions. (Congress.gov)
- Design trade-offs: hover capability vs endurance, agility vs range, complexity vs reliability.
- Logistics & cost: heavier or complex drones cost more, require bigger infrastructure, maintenance.

4. System Composition




UAV Surface Component
Launch and Recovery System
Ground Control Station
MPO
GCS console
GCS console
Analyst
T/R
R/V
AVO
GCS console
UAV Air Component
Payload Subsystem
Air Vehicle Subsystem
Noise
Sensor Controller
Sensors
R/V
Noise/ Disturbance
Avionics Controller
Avionics
Propulsion Unit
T/R


INSIDE FPV
Propeller
Battery Cover
Brushless Motor
MicroSD
Antena
Front LED
InfraRed Sensor
Camera
Downward Sensor
Stabilizer
Battery Indicator
Button Power
Drone Components
Peeling Back the Layers



- Air-frame & Propulsion: Frame shape (rotors, wings), motors/engines, propellers, design for payload + endurance.
- Flight Controller & Autopilot: IMU (accelerometer, gyroscope, magnetometer), GPS, barometer, flight control algorithms (PID, MAVLink systems).
- Sensors & Payloads: Cameras (visible, IR), LiDAR, thermal sensors, multispectral sensors for agriculture.
- Communications & Ground Control: Telemetry/data-link, remote pilot station (GCS), satellite or RF links.
- Power System: Batteries (Li-Po), hybrid fuel systems, energy management for flight time.
- Software & Autonomy: Mission planning, obstacle avoidance, navigation, swarm coordination.
- Trade-offs: Payload vs endurance, complexity vs reliability, cost vs performance.

5. Applications

- Commercial/industrial: infrastructure inspection (bridges, pipelines), survey/mapping, agriculture monitoring/dusting.
- Delivery/logistics: medical supply drops, last-mile delivery in remote areas.
- Public safety: search & rescue, fire monitoring, disaster response.

- Military & defence: reconnaissance, strike missions, swarm drone tactics.
- Research & environment: wildlife tracking, atmospheric sensing, environmental monitoring.

◆ Key Points

1. Drone (UAV/UAS) = Aircraft + remote ground station + communication links.
2. History shows progression from simple remote craft to advanced autonomous systems.
3. Classification helps choose correct type for task (multi-rotor vs fixed-wing etc).
4. System composition covers hardware, sensors, control, communications, power.
5. Trade-offs matter: e.g., heavier payload reduces endurance.
6. Applications wide-ranging across sectors.
7. Autonomy and navigation (GPS, IMU, vision) are increasingly important.
8. Regulations, safety, and reliability are essential for real-world use.
9. Emerging trends: hybrid VTOL, delivery drones, swarm systems.
10. Understanding full system (UAS) not just flying machine is key.

◆ Real-Life Example

Imagine a **hybrid VTOL drone** used for medical supply delivery to remote villages. It takes off vertically from a small landing pad (VTOL), then transitions to forward fixed-wing mode to cover long range efficiently. Its system integrates: rotors + wing (configuration), onboard flight controller with IMU/GPS, sensors for obstacle detection, communication link to ground station, battery or hybrid power. It carries a medical kit (payload), navigates autonomously using GPS waypoints and vision-based obstacle avoidance, communicates status back to base. On arrival, it lands vertically near clinic, drops off kit, returns. This real-life example illustrates classification (hybrid VTOL), system composition (air-frame, controller, sensors, comms), application (delivery/logistics), and uses modern autonomy and navigation.

◆ Summary in Hinglish

Drone matlab unmanned aircraft system -- jisme pilot board mein nahi hota.
UAS ka matlab hai poora system: drone + ground station + communication.
Drone ka itihaas simple remote craft se shuru hua aur ab advanced autonomous systems tak pahucha.
Types alag-alagh: multi-rotor (quad), fixed-wing (plane type), hybrid VTOL.
System me aate hain: frame, motors, sensors (IMU, GPS), flight controller, communication link, power supply.
Use-case bahut bade hain: inspection, delivery, agriculture, rescue, defence.
Trade-offs ke saath design karna padta hai — jaisa payload vs flight time.
Rules, safety aur reliability bahut maine rakhte hain.
Simple: *"Drone = flying robot system without a human pilot, integrating sensors, control, communication, mission."*

Diploma Wallah

Made with 💗 by Sangam