UNIT - III - DRONE FLYING AND OPERATION

Concept of operation for drone - Flight modes - Operate a small drone in a controlled environment - Drone controls Flight operations – management tool – Sensors – Onboard storage capacity - Removable storage devices - Linked mobile devices and applications

3.1 CONCEPT OF OPERATION FOR DRONE

A **Concept of Operation (CONOPS)** for **drone flying and operation** focuses specifically on the practical aspects of how the drone will be flown and operated to meet mission requirements. This document will describe the key aspects such as flight planning, operational controls, safety protocols, and mission execution.

Drone Flying and Operation CONOPS

1. Introduction

The Concept of Operation (CONOPS) for drone flying and operation provides a comprehensive description of how a drone will be flown, controlled, and managed during its mission. This includes pre-flight, in-flight, and post-flight procedures, safety protocols, and operator roles.

2. Mission Objectives

The primary goal is to ensure safe, efficient, and reliable drone operation for a variety of tasks, such as:

- Aerial surveillance and reconnaissance.
- Photography and videography.
- Data collection (e.g., environmental data, infrastructure inspection).
- Search and rescue support.

3. Flight Operations Overview

- **Operating Personnel**: A trained pilot/operator responsible for drone control and decision-making, supported by additional personnel for mission planning and data collection.
- **Flight Modes**: Manual, semi-autonomous (waypoint-based), and fully autonomous flight modes.
- **Flight Duration**: Dependent on drone capabilities (typically between 20 to 60 minutes per battery charge).

4. Pre-flight Operations

4.1 Flight Planning

- **Mission Briefing**: Operators review mission objectives, expected flight path, environmental conditions, and safety concerns.
- **Flight Path Design**: Pre-programmed or manual route, including take-off, waypoints, loiter zones, and landing. Tools like GPS and mapping software will be used.

- **Check Airspace Clearance**: Ensure legal compliance, check airspace restrictions, and obtain necessary permissions (e.g., from aviation authorities if operating in controlled airspace).
- **Weather Check**: Review real-time weather data to ensure it is safe to fly. Factors include wind speed, precipitation, and temperature.

4.2 Equipment Inspection

- **Drone Airframe**: Inspect for physical damage, loose parts, or structural issues.
- **Battery Status**: Ensure the battery is fully charged and functioning properly.
- **Sensors and Cameras**: Confirm proper functionality and calibration of all sensors (e.g., camera, LiDAR, thermal).
- **Control Systems**: Verify that the Ground Control Station (GCS) and drone communication links are operational.
- **Failsafe Systems**: Test the return-to-home and emergency landing protocols.

4.3 Operator Setup

- **GCS Setup**: Ensure proper connection to the drone and display all relevant telemetry (e.g., altitude, speed, battery status).
- **Communication Systems**: Establish reliable communication between the drone and GCS.
- **Calibration**: Perform necessary calibrations for the compass, accelerometer, and GPS before flight.

5. In-flight Operations

5.1 Take-off and Initial Climb

- **Manual Take-off**: Operator initiates take-off using a manual control or automated system depending on the environment.
- **Stabilization**: Once airborne, the operator ensures the drone is stable and adjusts for wind or other conditions.
- **Altitude and Path**: The drone climbs to the predefined altitude (generally between 30 to 150 meters based on mission needs).

5.2 Autonomous/Manual Navigation

- **Autonomous Flight Mode**: If pre-programmed, the drone follows GPS waypoints. Operator monitors but may intervene if necessary.
- **Manual Control**: In manual mode, the operator flies the drone directly using joysticks or a remote control system.
- **Sensor Usage**: During flight, onboard sensors (GPS, barometers, cameras) gather data in real-time.
- **Monitoring**: Continuous real-time monitoring of flight telemetry, including altitude, speed, distance from GCS, and battery levels.

5.3 Mid-flight Operations

- **Data Collection**: Cameras, sensors, or payloads gather necessary data (e.g., video, photographs, environmental metrics).
- **Course Adjustments**: The operator can adjust flight paths or altitudes as needed due to environmental changes or mission needs.
- **Obstacle Avoidance**: Use of onboard sensors to detect and avoid obstacles in real-time. Some drones may have advanced AI for collision avoidance.
- **Flight Log Recording**: All flight data (telemetry, video, GPS path) is logged for future analysis.

5.4 Emergency Procedures

- **Low Battery Warning**: The system alerts the operator when battery power is critically low. The drone will either land or initiate a return-to-home (RTH) sequence.
- **Signal Loss**: If communication with the GCS is lost, the drone will automatically return to the launch point or perform an emergency landing based on the failsafe configuration.
- **Manual Override**: The operator has the ability to manually control the drone at any time, overriding autonomous functions if necessary for safety.

6. Post-flight Operations

6.1 Landing

- **Automated Landing**: The drone can autonomously return to the launch site or designated landing area using pre-programmed instructions.
- **Manual Landing**: The operator may take manual control for precise landing, especially in congested or hazardous environments.
- **Shutdown**: Upon landing, the drone's systems are powered down safely to avoid damage to the electronics or battery.

6.2 Post-flight Inspection

- **Airframe Check**: Inspect the drone for any damage or wear sustained during the flight.
- **Battery Recharging**: Disconnect and recharge the batteries for future missions.
- **Data Retrieval**: Download collected data (images, telemetry, sensor readings) from onboard storage or the GCS for analysis.
- **Flight Log Review**: Review the flight log for any abnormalities or important operational details that need to be reported.

6.3 Maintenance and Storage

- **Routine Maintenance**: Perform regular maintenance such as motor checks, software updates, sensor calibration, and part replacement.
- **Storage**: Store the drone and all related equipment in a secure and dry environment to protect from environmental damage.

7. Safety and Risk Management

- **Pre-flight Risk Assessment**: Evaluate all potential risks, including weather conditions, nearby obstacles, and airspace restrictions.

- **Safety Zones**: Establish no-fly zones and safe operating altitudes to prevent collisions or violations of privacy.
- **Emergency Protocols**: Establish clear emergency procedures in case of equipment failure or adverse conditions.
- **Pilot Training**: Ensure that all operators are fully trained on both manual and autonomous drone operation, including emergency response.

8. Regulatory Compliance

- **Airspace Laws**: Adhere to local, national, or international regulations (such as FAA, EASA, or DGCA) for drone operations.
- **Operational Limits**: Respect altitude, range, and flight area limitations imposed by regulatory authorities.
- **Privacy Laws**: Ensure all operations comply with local privacy regulations when conducting surveillance or data collection in populated areas.

3.2 FLIGHT MODES

Drones offer a variety of flight modes to cater to different skill levels and operational needs. Here are some common flight modes:

1. **GPS Mode**: Utilizes GPS for stable hovering and navigation. It helps maintain position and altitude, making it ideal for beginners.
2. **Altitude Hold Mode**: Keeps the drone at a constant altitude, allowing the pilot to focus on directional control.
3. **Manual Mode (Acro Mode)**: Offers full control over the drone without any stabilization, suitable for experienced pilots who want to perform advanced maneuvers.
4. **Headless Mode**: Simplifies control by allowing the pilot to maneuver the drone relative to their own position, regardless of the drone's orientation.
5. **Follow Me Mode**: The drone autonomously follows the pilot, using GPS or visual tracking, great for capturing action shots.
6. **Waypoint Navigation**: Allows the pilot to set predefined GPS waypoints for the drone to follow autonomously.
7. **Return to Home (RTH)**: Automatically returns the drone to its takeoff point if the battery is low or if it loses connection.
8. **Sport Mode**: Increases speed and responsiveness, often used for racing or agile maneuvers.
9. **Cinewhoop Mode**: A stabilized mode for capturing smooth, cinematic shots, particularly useful for filming.
10. **Orbit Mode**: The drone circles around a specific point while maintaining a set distance, ideal for dynamic shots.

3.3 OPERATE A SMALL DRONE IN A CONTROLLED ENVIRONMENT

Operating a small drone in a controlled environment can be a great way to gain experience and practice your skills. Here's a step-by-step guide to help you get started:

1. Choose the Right Location

- **Indoor Space**: Use a large gym, warehouse, or open area free of obstacles.

- **Outdoor Space**: Find a clear, open area away from people, buildings, and trees, like a park or sports field.

2. Check the Weather

- Ensure that wind speeds are low and visibility is good if flying outdoors. Calm conditions are best for beginners.

3. Pre-Flight Checklist

- **Battery Check**: Ensure both the drone and controller batteries are fully charged.
- **Calibration**: Calibrate the drone's compass and sensors according to the manufacturer's instructions.
- **Firmware Updates**: Check for any firmware updates for the drone and controller.

4. Familiarize Yourself with Controls

- **Throttle**: Controls altitude.
- **Yaw**: Rotates the drone left or right.
- **Pitch**: Tilts the drone forward or backward.
- **Roll**: Tilts the drone left or right.

5. Takeoff

- Start with the drone on a flat, stable surface.
- Gradually increase the throttle until the drone lifts off. Practice hovering at a low altitude.

6. Practice Basic Maneuvers

- **Hovering**: Maintain a stable hover at a set altitude.
- **Forward/Backward Flight**: Move the drone forward and backward while maintaining altitude.
- **Sideward Flight**: Practice moving left and right.
- **Turning**: Rotate the drone in place using yaw controls.

7. Advanced Maneuvers (When Comfortable)

- **Figure Eights**: Fly in a figure-eight pattern to practice coordination.
- **Ascend and Descend**: Practice changing altitude while moving.
- **Landings**: Focus on smooth landings by gradually reducing throttle.

8. Emergency Procedures

- Familiarize yourself with the emergency shut-off procedures and how to activate return-to-home (RTH) if available.

9. Post-Flight

- **Inspect the Drone**: Check for any damage or issues.
- **Battery Management**: Properly store and charge batteries.

10. Follow Regulations

- Always adhere to local laws and regulations regarding drone operation, including any altitude limits and no-fly zones.

Tips for Success:

- **Practice Regularly**: Consistency will help improve your skills.
- **Use Simulators**: Consider using drone flight simulators to practice without risk.
- **Join a Community**: Engage with local drone clubs or online forums for tips and support.

3.4 DRONE CONTROLS FLIGHT OPERATIONS

Drone flight operations involve several key aspects of control, including the use of hardware and software components to maneuver the drone effectively. Here's a breakdown of how drone flight operations work and the types of controls involved:

1. Types of Drone Controls

- **Manual Control:**
  - This is typically done via a remote controller, which uses joysticks and buttons to control the drone's movement in real time.
  - Movements include throttle (up/down), pitch (forward/backward), roll (left/right), and yaw (rotation).
- **Semi-Autonomous Control:**
  - The drone follows pre-defined instructions or waypoints while the pilot oversees operations. The pilot may intervene when necessary.
- **Fully Autonomous Control:**
  - In this mode, drones are pre-programmed to carry out a full mission without human intervention, using GPS and sensors for navigation.

2. Basic Movements and Operations

- **Takeoff and Landing:**
  - Most drones have assisted or automated takeoff and landing functions.
  - Manual takeoff involves increasing throttle, while landing requires reducing throttle smoothly.
- **Hovering:**
  - Keeping the drone stable at a fixed altitude, which requires adjustments in throttle and fine-tuning with pitch, roll, and yaw.
- **Maneuvering:**
  - **Pitch (forward/backward)**: Controls the forward and backward tilt of the drone, causing it to move forward or backward.
  - **Roll (left/right)**: Controls the side-to-side tilt of the drone, making it move to the left or right.

o **Yaw (rotate)**: Adjusts the rotational direction of the drone, allowing it to rotate clockwise or counterclockwise.

3. Flight Modes

- **GPS Mode:**
  - o Drones use GPS to hold their position and altitude. This is a standard mode for stable and easy flying.
- **Attitude Mode:**
  - o The drone maintains a level attitude but doesn't hold its position or altitude. This requires more manual control.
- **Sport/Manual Mode:**
  - o This is a high-performance mode where the drone's response is faster, and there is no stabilization from GPS. It requires advanced piloting skills.
- **Waypoint Mode:**
  - o Pilots can program waypoints in a map interface, allowing the drone to fly autonomously between designated points.

4. Navigation and Sensors

- **GPS/GLONASS:**
  - o Global navigation satellite systems help in positioning, allowing precise control, waypoint following, and return-to-home functions.
- **IMU (Inertial Measurement Unit):**
  - o Measures acceleration and angular velocity, helping maintain drone orientation and stability.
- **Barometer:**
  - o Measures atmospheric pressure to maintain and control altitude.
- **Obstacle Detection and Avoidance:**
  - o Uses cameras, ultrasonic sensors, and lidar to detect and avoid objects.

5. Communication Systems

- **Radio Frequency (RF):**
  - o Drones are controlled wirelessly via RF signals, typically in the 2.4GHz or 5.8GHz range.
- **Telemetry:**
  - o The drone sends data back to the controller, such as altitude, speed, and battery status.
- **FPV (First-Person View):**
  - o Allows the pilot to see a live feed from the drone's camera, often used for racing drones or precise filming.

6. Pre-Flight and Post-Flight Checks

- **Pre-Flight:**
  - o Checking the battery, props, camera, and connectivity.
  - o Verifying no-fly zones and weather conditions.
- **Post-Flight:**