Autonomous Drone Project Documentation

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Any form of constructive suggestion or criticism is warmly welcomed and highly appreciated

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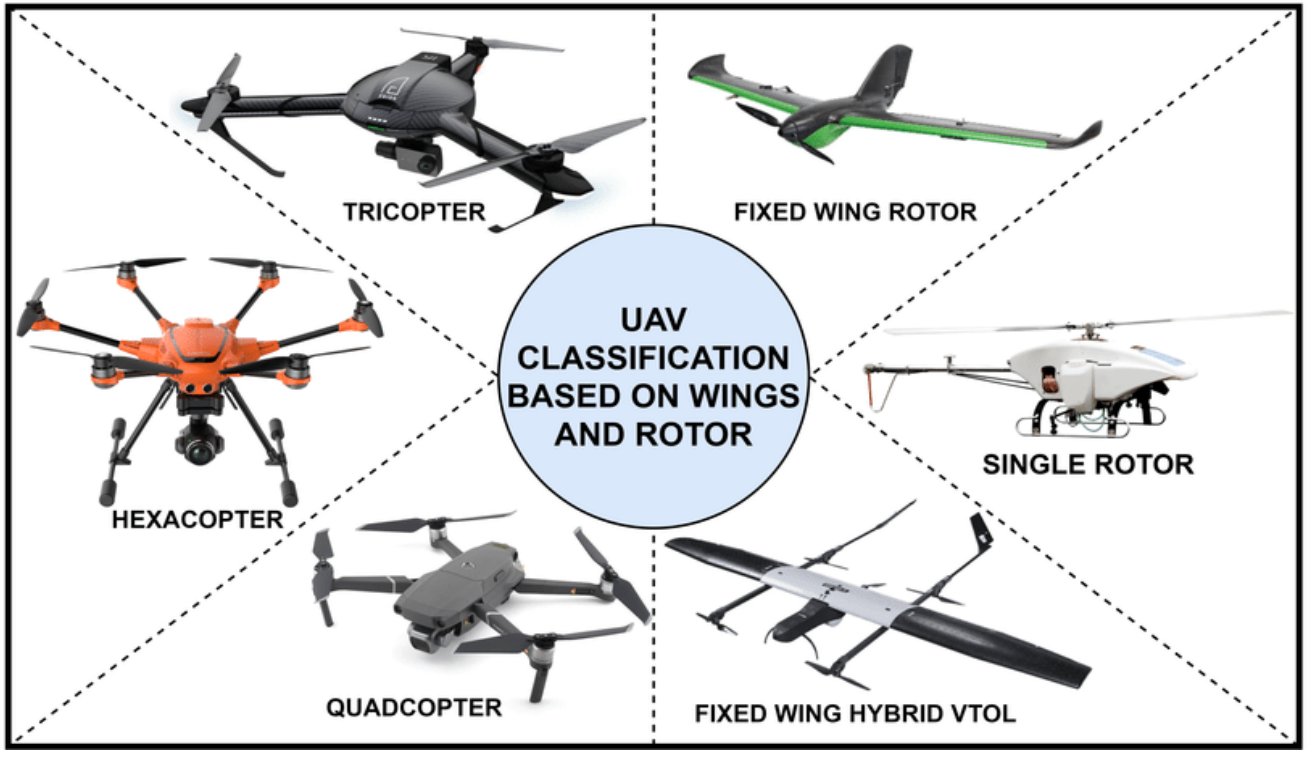
Introduction

Autonomous drones are unmanned aerial systems (UAS) capable of performing missions such as surveillance, mapping, inspection, and delivery without direct human control. This project aims to design, build, and test a fully autonomous quadcopter drone using the **Pixhawk flight controller** and **QGroundControl (QGC)** software.
<u>This documentation covers:</u>

Concepts of drones
Types of drones
Hardware required
Software required
Autopilot overview (Pixhawk)
QGroundControl configurations
Full calibration process
Step-by-step project workflow

Concept of a Drone (UAV)

A **drone** is an unmanned aerial vehicle controlled either remotely or autonomously using onboard sensors and autopilot systems.



Basic Concept

Lift: Generated by spinning propellers.

Thrust: Motor power used for flight and maneuvering

Weight: Total mass resisting lift.

Drag: Air resistance acting against motion.

Control: Achieved using motor RPM variations.

Types of Drones

Based on Structure

a. Multirotor Drones

Quadrotor (4 motors)

Hexacopter (6 motors)

Octocopter (8 motors)

b. Fixed-Wing Drones

Airplane-like, long endurance.

c. VTOL (Vertical Takeoff & Landing)

Hybrid of fixed-wing + multirotor.

Based on Control

Manual

Assisted (GPS hold, Loiter)

Fully Autonomous (Mission mode)

Hardware Requirements

Core Hardware Components

Pixhawk 4 Autopilot

GPS + Compass Module (e.g., Here2 / M8N)

Brushless Motors (4 units)

Electronic Speed Controllers (ESCs)

Propellers (CW + CCW pairs)

LiPo Battery (3S / 4S / 6S)

Power Distribution Board (PDB)

Battery Power Module (Voltage & Current se

Frame (450mm, 500mm, or custom)

Additional Components

Telemetry Radio (433 MHz / 915 MHz)

FPV Camera (optional)

ESC signal wires

XT60/XT90 connectors

Landing gear

GPS mast

Software Requirements

Ground Control Software

QGroundControl (QGC): For configuration, calibration, mission plann

Firmware

PX4 Autopilot Firmware (for Pixhawk)

Pixhawk 4 Autopilot Overview

Pixhawk is the brain of the drone. It handles:

Motor control

Sensors integration

GPS navigation

Flight stabilization

Autonomous mission execution

Sensors in Pixhawk

Accelerometer

Gyroscope

Magnetometer (external compass)

Barometer

GPS

Power monitoring

Inputs & Outputs

PWM outputs for ESCs

RC input

Telemetry ports

I2C for compass

CAN bus

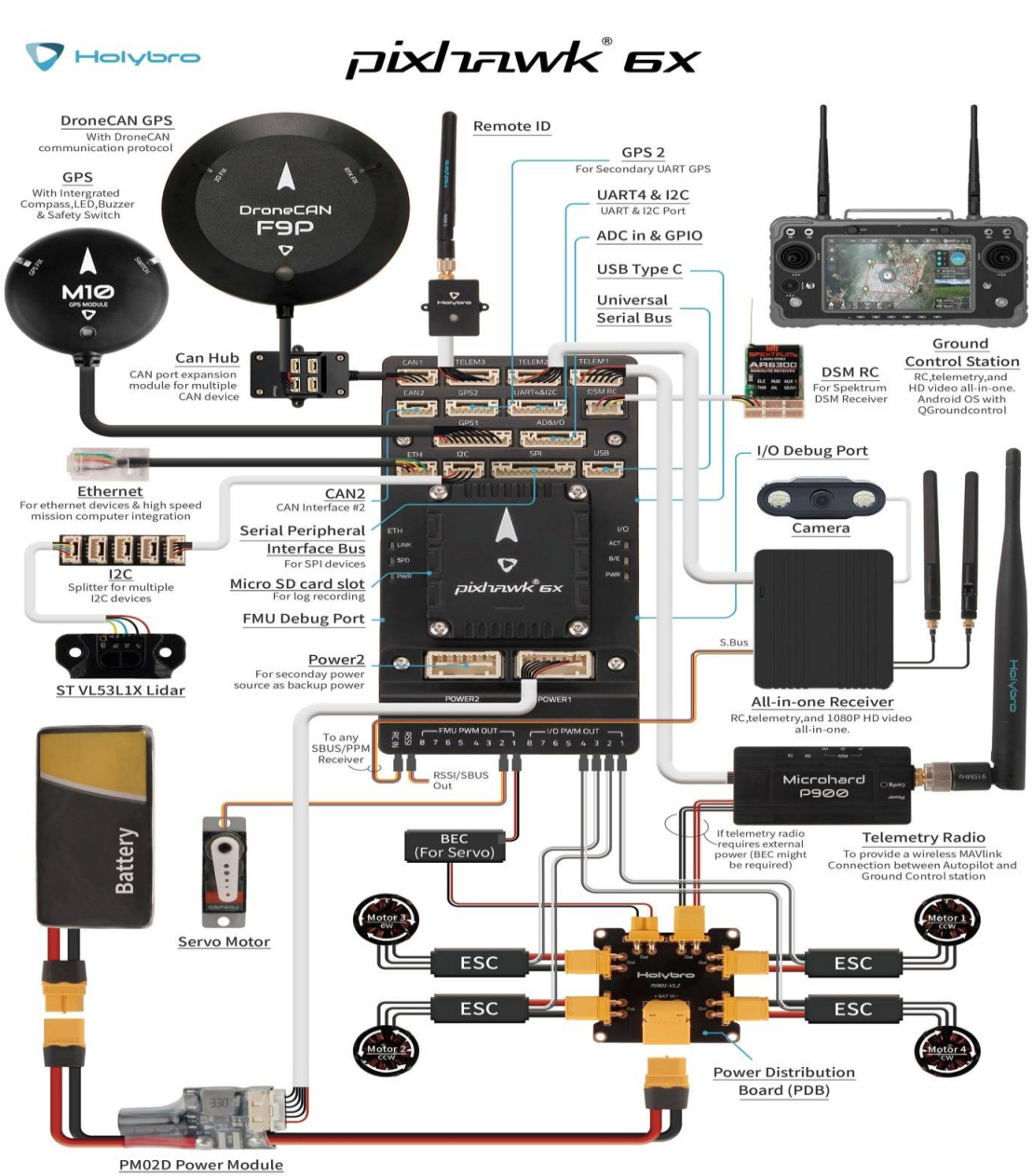
Connect to the Power Management Board using the 6-wire cable to direct power from your lithium polymer (LiPo) battery to the autopilot.

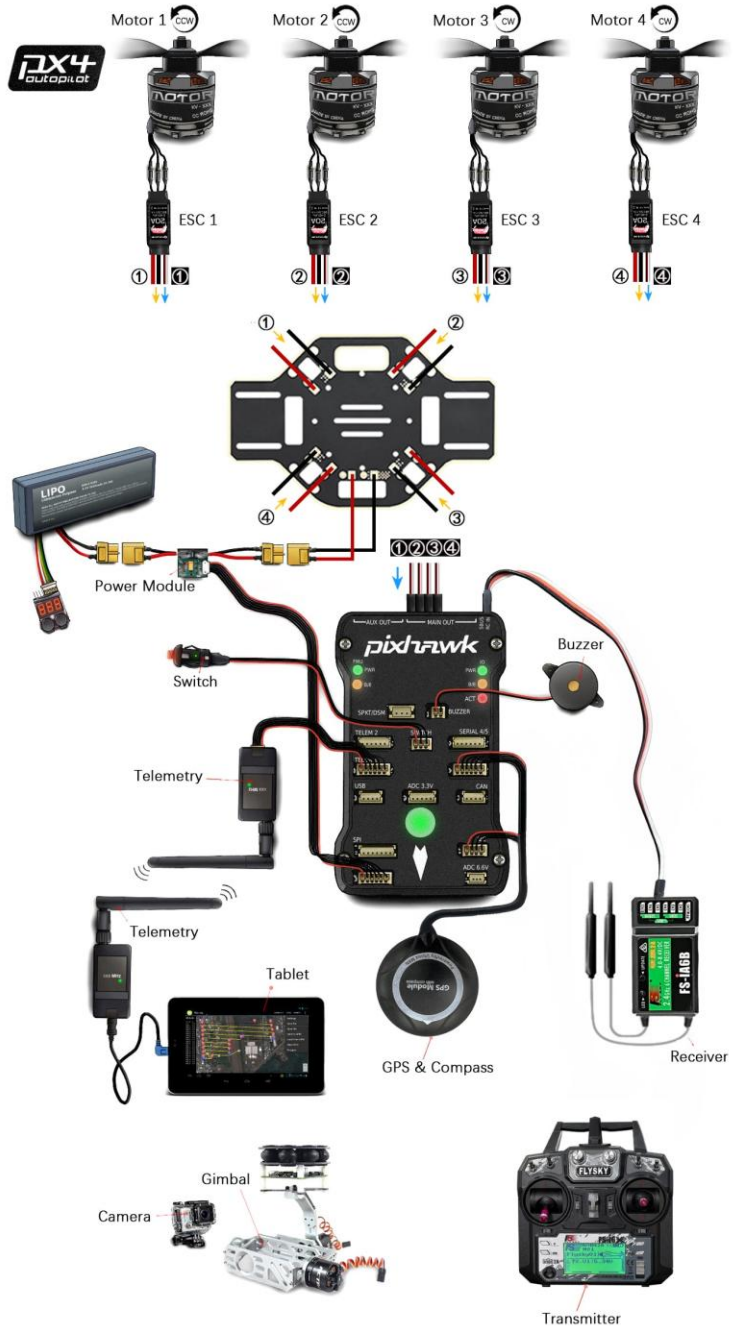
(Optional) Connect a Telemetry Radio to receive data in Ground Control Station and communicate with the autopilot in flight.

Connect to the Power Management Board using the 10 wire cable to send PWM signals to the motors.

Connect PPM, DSM or SBUS Radio Control receiver to provide the autopilot with RC input in manual and assisted flight modes.

Connect the provided GPS module (with integrated compass, safety switch and buzzer) to provide the autopilot with positioning data during flight.


Holybro
pixhawk® 6X
DroneCAN GPS
With DroneCAN communication protocol
GPS
With Intergrated Compass,LED,Buzzer & Safety Switch
DroneCAN F9P
M10 GPS MODULE
Remote ID
GPS 2
For Secondary UART GPS
UART4 & I2C
UART & I2C Port
ADC in & GPIO
USB Type C
Universal Serial Bus
Ground Control Station
RC,telemetry,and HD video all-in-one. Android OS with QGroundcontrol
DSM RC
For Spektrum DSM Receiver
Can Hub
CAN port expansion module for multiple CAN device
I/O Debug Port
Camera
Ethernet
For ethernet devices & high speed mission computer integration
CAN2
CAN Interface #2
Serial Peripheral Interface Bus
For SPI devices
Micro SD card slot
For log recording
FMU Debug Port
I2C
Splitter for multiple I2C devices
ST VL53L1X Lidar
Power2
For seconday power source as backup power
S.Bus
All-in-one Receiver
RC,telemetry,and 1080P HD video all-in-one.
To any SBUS/PPM Receiver
RSSI/SBUS Out
FMU PWM OUT
I/O PWM OUT
Microhard P900
If telemetry radio requires external power (BEC might be required)
Telemetry Radio
To provide a wireless MAVlink Connection between Autopilot and Ground Control station
Battery
Servo Motor
BEC (For Servo)
ESC
ESC
ESC
ESC
Motor 1 CCW
Motor 2 CW
Motor 3 CW
Motor 4 CW
Power Distribution Board (PDB)
PM02D Power Module


PX4 autopilot
Motor 1 CCW
Motor 2 CW
Motor 3 CW
Motor 4 CW
ESC 1
ESC 2
ESC 3
ESC 4
LIPO
Power Module
pixhawk
Buzzer
Switch
Telemetry
Telemetry
Tablet
GPS & Compass
Receiver
Gimbal
Camera
Transmitter

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY ORGANISED 1956 A.D.
INCORPORATED 1959 A.D.
KATHMANDU, NEPAL

FULL PIXHAWK CALIBRATION PROCEDURE (COMPLETE GUIDE)

✓ Motor order
✓ ESC calibration
✓ Radio calibration
✓ Motor direction
✓ PID tuning
✓ Sensor calibration
✓ Power calibration
✓ Flight mode setup
✓ Mission setup
→ All processes in one clean sequence

STEP 1 Prepare Hardware

✓ Remove propellers
✓ Connect ESC → Pixhawk MAIN OUT (1–4)
✓ Connect GPS + Compass
✓ Connect RC Receiver
✓ Power Pixhawk with USB

STEP 2 QGroundControl Connection

✓ Open QGC
✓ Connect Pixhawk via USB
✓ QGC detects the autopilot
✓ Go to Vehicle Setup

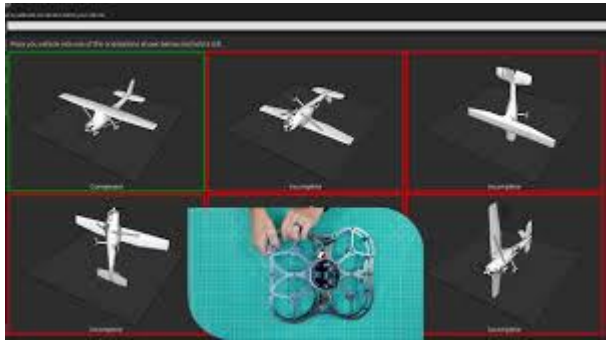
STEP 3 Firmware & Airframe Setup

✓ Vehicle Setup → Firmware
✓ Install PX4 firmware
✓ Reboot
✓ Go to Airframe
✓ Select Quadrotor X
✓ Apply → Reboot

STEP 4 —Sensor Calibration (ALL MUST BE DONE)

Accelerometer Calibration

✓ Vehicle Setup → **Sensors → Accelerometer**
✓ Keep drone level
✓ Follow steps (6 orientations)
✓ Save

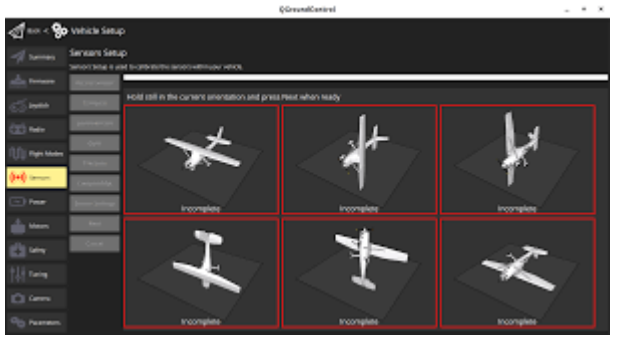


Gyroscope Calibration

✓ Keep drone still
✓ QGC calibrates automatically
✓ Save

Compass Calibration

✓ Sensors → **Compass**
✓ Rotate drone in all directions
✓ Complete → Save
✓ Make sure no magnetic interference



Level Horizon

✓ Place drone on a flat surface
✓ Press **Level Horizon**
✓ This completes sensor calibration.

STEP 5 — Radio Calibration

✓ Vehicle Setup → **Radio**

✓ Move sticks fully:

- Throttle
- Yaw
- Pitch
- Roll

✓ Move all switches

✓ QGC detects max/min PWM

✓ Save

✓ Set a dedicated **ARM switch** (important)

STEP 6 — Power Module Calibration

✓ Vehicle Setup → **Power**

✓ Select battery type (3S, 4S, 6S)

✓ Select sensor type (usually: *Analog Voltage & Current*)

✓ Enter correct:

- Voltage divider
- Amperes per volt

✓ Connect battery

✓ Make sure QGC shows correct real voltage

✓ Save

STEP 7 — ESC Calibration

METHOD — Full Automatic (Recommended)

✓ Go to **Power**

✓ Click **"Calibrate ESC"**

✓ Remove battery

✓ QGC says: *“Plug in battery now”*

✓ Connect battery

✓ ESC beeps (max throttle detected)

✓ ESC beeps again (min throttle saved)

✓ Calibration done

✓ This sets equal throttle range for all ESCs.

✓ Front

STEP 8 — Motor Order & Test

✓ Correct Quad-X Motor Order

Front
↑

1 2
CW CCW

4 3
CCW CW

↓
Back

✓ Motor Test in QGC

✓ Vehicle Setup → **Motors**

✓ Check safety box

✓ Test each motor A–D

✓ Confirm:

- ✓ Motor spins in correct order
- ✓ Direction is correct

If motor spins wrong direction:

✓ Swap any 2 ESC wires (no need to re-program)

STEP 9 — PID Tuning (Basic)

✓ Go to **PID Tuning** in QGC

Recommended starting values:

Roll/Pitch P: 6–8

Roll/Pitch I: 0.2–0.4

Roll/Pitch D: 0.002–0.004

Yaw:

Yaw P: 4–6

Yaw I: 0.1–0.3

Rules:

✓ Fast vibration → D too high

✓ Slow oscillation → P too high

Drift → Increase I

STEP 10 — Flight Modes Setup

✓ Go to **Flight Modes**

✓ Set at least 3:

Stabilized – Manual backup

Position Hold – GPS stabilized

Mission / Auto Mode – Fully autonomous

✓ Assign switches to each mode.

STEP 12 — Autonomous Mission Planning

✓ Go to **Plan** tab

Add:

- ✓ Takeoff command
- ✓ Multiple waypoints
- ✓ Land command

Set:

- ✓ Altitude
- ✓ Speed

✓ Upload mission to Pixhawk

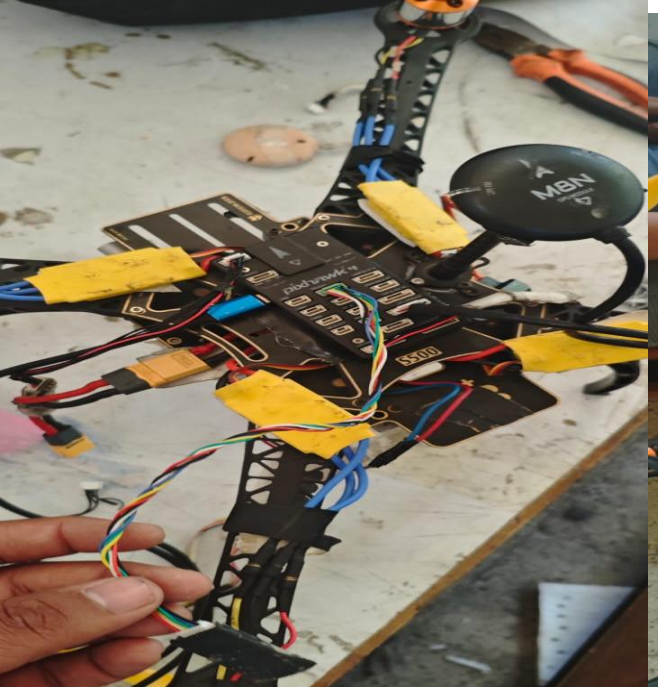
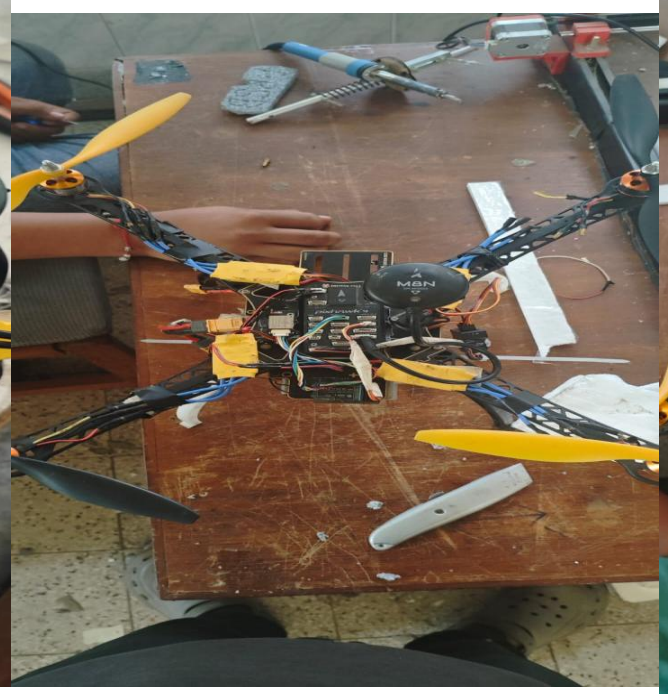
.

STEP 13 — Pre-flight Checklist

✓ GPS locked (HDOP < 1.5)
✓ Compass OK
✓ Accelerometer OK
✓ RC connected
✓ Battery full
✓ Motor test completed
✓ No vibration
✓ Flight modes mapped

STEP 14 — Arming & Test Hover

✓ Arm using switch
✓ Lift slowly
✓ Check:
    Stability
    Yaw hold
    GPS position hold
✓ If stable → proceed to autonomous

STEP 15 — Autonomous Flight

✓ Switch to **Mission Mode (AUTO)**
✓ Drone will:
    Takeoff
    Follow all waypoints
    Land automatically