User Manual

Autonomous Indoor Line-Following Drone

Team02

Project Partners

UWA Aviation Labs (UWAAL)
Australian National Fabrication Facility (ANFF)

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Practical Class

Tuesday, 10-11am

Contents

1. Safety Statement

The operator must contact their supervisor should they have any questions regarding this document and must not progress further and only operate the drone in the Lycopodium laboratory.

Under the Civil Aviation Safety Authority's (CASA) rules regarding microdones, the drone must not be operated within 30 meters of another who is not part of the project. The operator must strictly adhere to the no-fly zones around government buildings such as hospitals, airports, national parks and police stations.

1.1. Competency Requirements

This document is intended for an operator with at least a bachelor's degree in engineering or an equivalent licence. The operator must have sufficient computer skills, programming skills and a basic understanding of electrical systems. The operator must complete UWA Non-Staff Safety and Health Induction and Lycopodium Site-Specific Induction. The operator must complete all required documentation and obtain access to the Lycopodium laboratory.

1.2. Potential Hazards

Hazards	Cautionary Actions
Electrocution 	Exposed wires must not be touched when system is powered. Do not touch leads of electronic speed controller capacitor as it may retain significant charge after use.
Flammable 	Battery must be charged following appropriate instructions and stored in LiPo safe bag. Battery should never be disassembled or undergo physical impact. Hazardous substance handling training is required before use.
Slip, Trip, Fall 	Keep the workspace clear of obstructions. Ensure cables, wires and tools are correctly stored.
Entanglement 	Propellors must never be spun when long hair, jewellery or other loose clothing / accessories are present. Never insert anything including tools or fingers into propellors when they are spinning.
Flying Objects 	Drone must always be tightly assembled before flight All fragile objects and unnecessary personnel must be removed from flight area before take-off
High Noise Level 	Wear hearing protection when in close vicinity with the drone in operating state.

1.3. PPE


Safety Glasses


Gloves


Long Sleeve Clothes


Hearing Protection

1.4. Equipment

See Table 1 for the list of equipment that is essential in performing successful operations and Maintenance Activities.

Table 1: Required Equipment to perform Operation and Maintenance Activities

Equipment	Quantity
Laptop with Windows 7 or newer	1
USB C cable supporting power and data transfer	1
Multimeter with test probes	1
M3 Bolts x 16mm Hex Head Style	4
M2 Bolts x 16mm Phillips Head Style	4
Breadboard Wires – Male to Male Ends	2
5V Phone Charger or Equivalent supporting USB Type A	1

2. Installation Manual

This manual will guide the user through the necessary set-up, operation and maintenance of the drone. The drone uses a custom Python script to control the drone, utilising Dronekit and curses library.

2.1. System Requirements:

1. Drone Hardware: a MAVLink-compatible Drone
2. Software: Python 2.7 or below installed on a laptop with a keyboard that is able to connect to the drone via USB or WIFI.
3. Additional Requirements: Dronekit and curses library installed on the laptop.

3. Setup:

Flight Controller Setup:

1. First, ensure that Mission Planner is installed. To install Mission Planner, click on the following link and follow the on-screen instructions to complete the installation: https://ardupilot.org/planner/docs/mission-planner-installation.html

Library Installation:

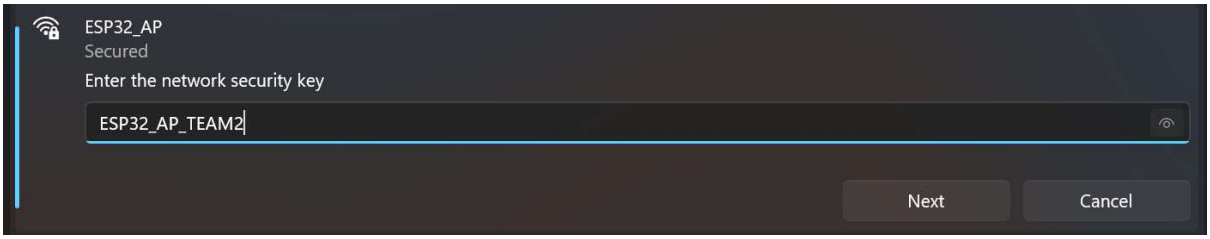
1. Ensure that Python is installed on your control laptop. If not installed, click on the following link and download a ***Python version 2.7 or later*** : https://www.python.org/downloads/

2. Once Python is downloaded, open the command prompt or terminal on the laptop and install the necessary Python libraries. Type the following command to do this:

```
pip install dronekit
```

Connection to Drone:

1. Go to the Wi-Fi settings of the user laptop and connect to WIFI "***ESP32_AP***".



2. Enter password "ESP32_AP_TEAM2" to connect to the drone.

4. Operating Manual

4.1. Pre-Flight Checklist:

1. Battery Check: Ensure that the battery is fully charged and secured to the drone body before flight.
2. Propellor check: Check that the propellors are secured to the drone frame properly and that the propellor guards are screwed on.
3. Safety Check: Ensure that the operating area is clear of any obstacles that could pose any danger and that conditions are suitable for flying.

4.2. Operating Instructions:

Uploading Python script to Flight Controller:

1. First ensure that the laptop is connected to the ESP32_AP Wi-Fi.
2. Ensure that the code includes the following in its connection string:
   - UDP connection
   - Port configuration is set to 14550 to listen for incoming MAVLink messages
   - Wi-Fi IP address is 192.168.4.1

The following should be pre-implemented in the Python script but is mentioned as a precaution.

```
# Connect to the drone over Wi-Fi using the specified IP address and port
vehicle = connect('udp:192.168.4.1:14550', wait_ready=True)
```

Take-off:

1. Ensure that the drone is on a flat surface before taking off. Run the script. This will arm the drone and switch it into “GUIDED” mode for manual control flight.

Flight Commands:

- **Movement Controls:** Use the keyboard keys (W, A, S, D,) to control the drone’s movement.
- **Altitude Control:** Use the up and down keys
- **Yaw Controls:** Use the Left and Right Arrow keys to adjust the drone’s yaw.
- **Landing:** Press the “**L”** key to initiate landing. Please note that the user shall observe the surroundings and confirm it is safe for landing before initiating the landing.

5. Safeguards:

Communications Failure:

During flight, if the Flight controller Wi-Fi fails to connect to the laptop, the drone is automatically programmed to land the drone if communications is lost for 30 seconds.

6. Maintenance Manual

6.1. Post-Flight Inspection

After each flight the drone should be inspected to ensure its condition matches that displayed in Figure 1. The following checks should be performed:

1. 4 M3 bolts must be secured in each corner of the mounting plate.
2. 4 M2 bolts must be secured in each corner of the main body such that they are. inserted from the top of the propellor guards, go through the main body and screw into the top of the landing strut.
3. Each propellor should be secured to a motor using 2 of the supplied motor bolts.
4. The battery should be securely attached to the top of the mounting plate using the attached Velcro strip.
5. The obstacle avoidance sensor should be securely attached to in its holder on the front propellor guard.
6. All 3D printed parts should be without breakage or deformation. Otherwise, see section 4.3 on repairing the frame.
7. No wires should be loose and disconnected. Secure loose wires before next take-off. Reconnect unplugged wires where appropriate,

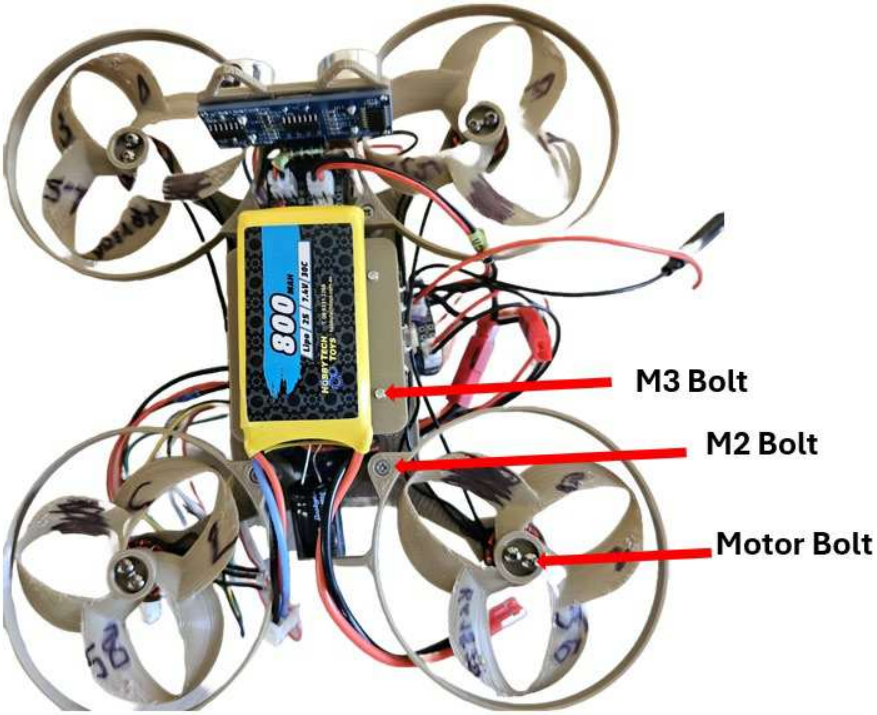


Figure 1: Assembled Drone Without Damage

6.2. Battery Maintenance

Precautions

- Do not over-discharge the battery under 3.5V or overcharge the battery above 7.5V.
- The battery will drain within 3 minutes of continuous use with the motors running.
- The LEDs on the charger don't work properly. Please ignore them.
- If the battery swells and does not cool down within 15 mins after use: DISCONTINUE USE IMMEDIATELY. Place the battery in a LiPo safe bag and dispose of it according to local council battery disposal laws.

Charging Procedure:

Please refer to Figure 2 regarding the following charging procedure:

1. Connect a male-to-male breadboard wire in the positive output of the battery's red connector. Do likewise with a separate breadboard wire for the negative output.
2. Ensure multimeter is set to measure voltage and probes are plugged in correctly.
3. Use the multimeter to measure the battery voltage by touching the black probe to the exposed end of the breadboard wire coming from the negative battery output. Do likewise with the red multimeter probe for the positive battery output.
4. If the measured voltage is under 7.3V then the battery requires charging.
5. Plug battery charger into any standard 5V phone charger or similar.
6. Plug 3 pin battery connector into charger.
7. Check the battery voltage every 15-30 mins and only do another 15-30 mins if more charge is needed by re-measuring the batter voltage with the multimeter as per steps 2-4.

Figure 2: The charger (LEFT). The Battery (RIGHT)

6.3. Frame Repair

All parts of the frame are 3D printed, except for the bolts and threaded inserts. If a piece of the frame breaks the steps to take are as follows:

1. Identify the broken piece as per Figure 3.The descriptions in Figure 3 match the names of the Fusion 360 and STL files corresponding to each piece. These files are in 05.3D Modelling\00. Fusion 360 Files and 05.3D Modelling\01.STLs for 3D Printing of the design outputs folder respectively.
2. Use the Fusion 360 files if the parts need to be altered. New STL files can then be exported from Fusion 360. Use the STL files if needing to 3D print a replacement.
3. To 3D print a new part, upload the relevant STL to any slicing software compatible with the 3D printer being used. The parts can be printed on any standard FDM 3D printer.
4. Use the slicer, as per the software distributor's instructions, to slice the desired STL file into gcode.
5. Upload the gcode to an appropriate FDM 3D printer and initalise the print as per the 3D printer manufacturer's instructions.
6. Once the required part has been printed, remove from the 3D printer build plate and remove support structures if necessary. If printing each piece flat, then no supports should be necessary to add.
7. If the part being replaced is the landing strut, then a M2 threaded heat insert will need to be added at the top of each of the 4 landing strut pillars.
8. Threaded inserts can be applied by placing heat inserts carefully onto the end of a soldering iron and then setting the iron to 150°C. Once hot, the inserts can be pressed gently into the required spot on the frame.
9. Once all parts have cooled to room temperature, they are ready to be attached to the overall drone.

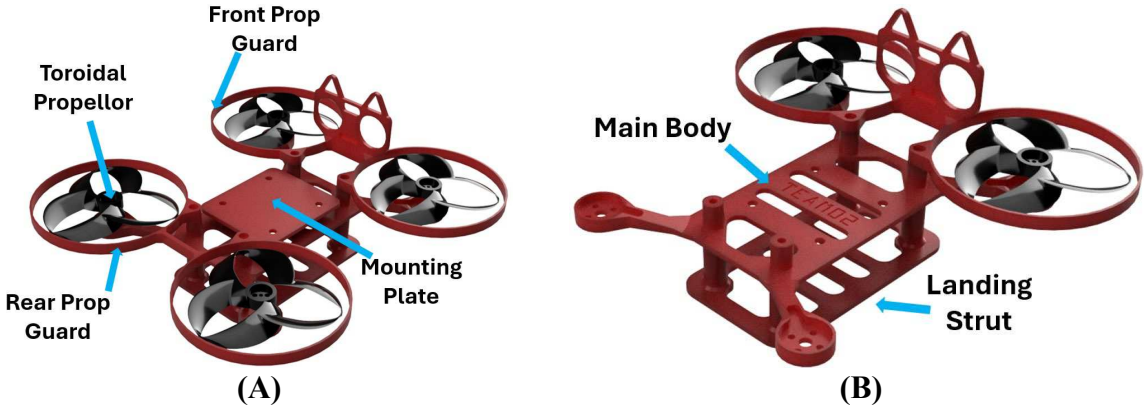


Figure 3: (A) Assembled Frame. (B) Frame with Mounting Plate and Rear Components Removed