

Indoor Line Following Drone Project Team 06

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Contents Page

1.	Safety	4
1.1	General Safety Warnings	4
1.2	Pre-Flight Safety Checklist	4
1.3	Operational Safety	4
1.4	Post Flight Safety	5
1.5	Emergency Action	5
1.6	Handling Hazardous Materials	5
1.7	Maintenance Safety	5
2.	Operation	5
2.1	Required Prior to First Use	5
2.2	Operational Steps	6
3.	Maintenance	7
3.1	Component Maintenance	7
3.2	Connection Maintenance	8

Indoor Line-Following Drone Operation and Maintenance Manual

1. Safety

1.1 General Safety Warnings

- **Prior to operating the drone, ensure you have thoroughly read and understood this manual.** This will reduce the risks of accidents and potential harm to the user, bystanders, the surroundings, and the drone itself. Retain this manual for future reference.
- **Indoor-use only:** This drone has been designed, built, and coded for indoor operation. Use of the drone in an outdoor environment is beyond the specifications of this drone. Issues that may arise include but are not limited to; signal loss, unstable flight due to wind, dust, dirt, or moisture accumulation in components leading to potential malfunctions, overheating, or permanent damage.
- **Avoid proximity to heat sources:** Keep the drone away from heat sources as exposure to high temperatures can damage components or cause overheating.
- **Avoid contact with water:** Ensure the drone is kept away from water and other liquids. Exposure to moisture can lead to malfunctions and increase the risk of a crash.
- **Do not touch operational drone:** Whilst the drone is in flight, do not touch the under any circumstances
- **14+:** This drone is intended for use by persons aged 14 years or older.
- **Keep drone within sight:** Do not allow drone to fly out of visible range.

1.2 Pre-Flight Safety Checklist

- **Battery Inspection:** Prior to each flight, inspect the drone battery. Ensure battery is fully charged and securely connected. Do not use a damaged, swollen, or leaking battery
- **Component functionality tests:** Run test codes for the flight controllers, microcontrollers, and sensors to confirm correct functionality.
- **E-Stop operation validations:** Verify the E-stop is functioning correctly and is accessible during flight. This enables immediate shutdown in the case of malfunction or unforeseen obstacles.
- **Inspect motor windings:** Verify that motor windings are clear of debris and appear undamaged.
- **Inspect propellers:** Verify that propellers are undamaged and that they are firmly attached to the motor shafts.

1.3 Operational Safety

- **Ensure flight area is free from unnecessary bystanders:** Avoid flying drone in area high crowded with bystanders.
- **Maintain a safe distance from operational drone:** Establish a safe distance between the operator and bystanders, and the drone. Do not operate the drone near one's face or eyes.

1.4 Post Flight Safety

- **Safely turn off the drone:** Upon flight completion (landed drone and stationary propellers) disconnect the battery.
- **Damage inspection:** After the drone has been safely depowered, inspect the drone for damage. Do not operate the drone if any part appears damaged or malfunctioning.
- **Safe battery storage:** Store the LiPo battery in an appropriately rated LiPo fireproof bag. Keep bag in a cool, dry location.
- **Safe battery charging:** Battery charging must be done under supervision and in a location out of reach of children. Allow battery to cool after use prior to charging. Do not charge a swollen or leaking battery.

1.5 Emergency Action

- **Fire:** If smoke or fire is present, do not handle the drone. Use a Carbon Dioxide Fire Extinguisher to extinguish flames.
- **Crash response:** In case of drone crash mid-flight, turn off the drone by disconnecting the battery prior to inspecting the drone for damage.

1.6 Handling Hazardous Materials

- **Safe battery disposal:** Do not dispose of the battery in curb side rubbish. Review your local disposal laws.
- **Avoid contact with leaking battery:** If battery leakage occurs, avoid contact with eyes or skin. If contact transpires, thoroughly wash exposed area with water and seek medical attention immediately.

1.7 Maintenance Safety

- **Disconnect battery during maintenance:** If maintenance works are to be performed on the drone, ensure battery is disconnected.
- **Use proper tools:** When changing or modifying drone parts, use only appropriate equipment and follow the manufacturer's instructions.

2. Operation

2.1 Required Prior to First Use

- **Phone/Tablet with IOS or android access:** To interact with the drone the user must download Raspcontroller, a free app which allows the user to remotely change GPIO pins.
- **Stable Wi-Fi/Hotspot:** To communicate with the Raspberry Pi, it must be connected to a local Wi-Fi
- **MicroUSB Reader:** In order for the Pi to operate in headless mode, the local Wi-Fi settings must be added to the bootup code. This is covered in Section 2.2.
- **Line requirements:** The line must be 8cm wide and be highly contrasting with the ground which itself cannot have complex patterns as this risks confusing the drone.

2.2 Operational Steps

1. **Connecting to new Wi-Fi:** For first use or when Wi-Fi settings have changed, complete the following steps.
 - a. Connect Raspberry Pi's SD card into a SD card reader
 - b. Create a file called *wpa_supplicant.conf*
 - c. Put the following code into the *wpa_supplicant.conf* file. Ensure the Country, SSID and PSK values are for your Wi-Fi settings.

```
country=AU
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1
network={
    ssid="Your_SSID"
    psk="Your_Password"
}
```

- d. Insert SD Card into Raspberry Pi
2. **Connect battery:** The 2S battery must be firmly connected to the flight controller via the power cables located at the back of the drone. Care must be taken in ensuring the correct polarity is followed (black – black and red – red).
3. **Ensure Power is reaching all components:** Once the battery is connected, ensure the lights on the flight controller, Arduino, and Raspberry Pi have been activated. If there are any issues please refer to 1.d in Maintenance.
4. **Wait for the Raspberry Pi light to stop flashing:** Once the light has stopped flashing the Raspberry Pi has completed booting meaning the user will be able to connect. If this is the first time connecting the Raspberry Pi, please move to step 5 if not skip to step 6
5. **First time Connection via Raspcontroller:** In the Rasp controller app press the plus button. This will allow the user to enter information to be able to connect to the drone. Please enter the following values:

<u>Device name:</u>	<i>drone</i>
<u>Host/IP Address:</u>	<i>drone.local</i>
<u>SSH Port:</u>	<i>22</i>
<u>Timeout (sec):</u>	<i>15</i>
<u>Username:</u>	<i>drone</i>
<u>Authentication:</u>	<i>Password</i>
<u>Password:</u>	<i>drone</i>

Once these values have been entered press connection test.

6. **Connection via Raspcontroller continued:** Once connected this app can allow the user to check the camera, monitor CPU and RAM functionality, and remotely control the GPIO pins.
7. **Connection via Raspcontroller continued – Remote GPIO:** Once on GPIO control, the user must add GPIO5, GPIO19, GPIO21, GPIO26. Once enabled ensure they are all set to OUT and 0.
8. **GPIO Functionality:** The following commands are linked to GPIO pins:

GPIO5:	Arming Drone
GPIO19:	Hovering Mode
GPIO21:	Line Following Mode
GPIO26:	E-stop

9. **Arming the Drone:** The user must set GPIO5 to 1 to arm the drone – without this pin activated the drone will not function.
10. **Launching the Drone:** Following all safety instructions and keeping a safe distance away, setting GPIO19 to 1 will launch the drone to a stable height. When in this mode the drone will hover at a specific height and await further instructions.
11. **Line Following:** Setting GPIO21 to 1 will enable the line following mode. Ensure the drone is able to see the path through the check camera functionality on Raspcontroller. If no line is detected the drone will not leave hovering mode. Once line following has begun no more direct inputs are needed. For Line functionality, if the user requires the drone to stop at a particular place on the route, please use a perpendicular line. This will cause the drone to hold for 30s.
12. **Emergency situations:** If at any time the drone is operating in an unplanned manner that can be dangerous or if the drone needs to urgently stopped, set GPIO26 to 1. This will enable the drone's failsafe mode causing it to land where it is.
13. **Notes:** Users should be aware that if the drone leaves Wi-Fi range for 30s the failsafe mode will also active.

3. Maintenance

3.1 Component Maintenance

- a. **Propeller:** Propellers need to be regularly inspected before every flight to ensure that the propellers are not misshaped, discoloured, or fractured as these indicate that the propeller is worn/ old and needs replacement. Propellers should otherwise be replaced annually or after flying over 300 hours. Propellers should also be wiped down to clean off any foreign materials using a soft, dry cloth.
- b. **Motor:** Motors should be regularly cleaned to remove dust and debris using a soft brush or cloth. A lubricant can be applied to the shaft and bearings to reduce noise and friction. Motor windings should be rotated by hand to check for blockages or rubbing prior to usage. Motor windings can also be inspected for any visual deformations. Do not do any powered testing of the motor if blockage, rubbing, or deformation is discovered. Instead, clean or replace where necessary. If not discovered, briefly power the motor and listen for any unusual sounds as these may indicate issues with the motor bearings. To extend motor longevity, avoid overloading as this puts additional strain on the motors.
- c. **Camera:** Inspect the camera lense for any scratched, smudges, or foreign materials and ensure that the camera is firmly positioned before every flight. The camera lense can be wiped using a dust-free or microfibre cloth. If scratches are interfering with image-processing accuracy, camera replacement is necessary.
- d. **Battery:** To guarantee optimal drone battery performance and longevity, inspect the battery on a regular basis for any physical damage, swelling, or leaks. If any of these are discovered, replace and dispose of the damaged battery safely according to local rules. Use a balance charger to equally charge all cells, preventing

overcharging and extending battery life. Charge the battery to 50-60% capacity before storing it in a cool, dry location away from direct sunlight or harsh temperatures. If the battery is not in frequent use, cycle it every 1-2 months and avoid discharging it below 20% to prevent damage.

- e. **Frame:** Inspect the frame on a regular basis for visible cracks, particularly after hard landings or crashes, and repair any damaged components to maintain structural integrity. Periodically check and tighten screws, especially those near motor mounts and frame connections, as vibrations can cause loosening over time. Clean the frame with compressed air or a soft brush to remove dirt, dust, and debris, paying special attention to vital places like motor mounts and gimbals to maintain smooth operation and avoid performance difficulties.
- f. **Frame arms:** Inspect the frame arms on a regular basis for signs of warping, bending, or cracking, and replace any damaged arms as soon as possible. If weak areas or minor cracks emerge, consider strengthening them with epoxy or carbon fiber tape, however replacement is typically the best solution. Check that motor mounts are tightly attached, as loose screws might cause vibrations and performance concerns. Also, ensure that the propellers are balanced, since uneven propellers can put unnecessary strain on the frame arms, potentially causing damage over time.
- g. **Shrouds:** As the shrouds are 3D printed, inspect them before and after each flight for cracks, deformation, or wear, especially following impacts. Clean them regularly to remove debris that could affect aerodynamics. Replace any damaged shrouds immediately using the same 3D print shroud layout to maintain consistency. When replacing, verify the size, and if needed, smooth the edges with sandpaper to ensure a proper fit. Store the drone in a dry, cool place to prevent unnecessary wear or pressure on the shrouds.

3.2 Connection Maintenance

- a. **Screw condition:** Loose or worn screws can lead to mechanical failures or vibrations that reduce the drone's overall performance. After every flight, inspect all screws for tightness, especially those securing the motors, and other moving parts. Vibration during flight can cause screws to loosen over time. Replace screws that show signs of wear, such as stripped threads or rust. Corrosion can compromise structural integrity and make it difficult to tighten or remove screws when necessary. When replacing screws, ensure they are not over-tightened, especially those securing the motors, as excessive force can damage the motor windings and compromise motor functionality. Apply thread locker solution (a mild one) to screws that are prone to loosening. This will ensure that they stay secure during flights while still being removable for maintenance.
- b. **Soldering condition:** Soldered connections are crucial for maintaining electrical continuity in the power supply. Regularly inspect solder joints for cracks, cold joints, or oxidation, as weak points can lead to power loss or signal disruption. If any joint shows signs of wear, re-solder it immediately, taking proper precautions. When re-soldering, ensure no two connections are shorted and use a multimeter to verify continuity and detect any disconnections. Ensure cables and connectors are well-supported to avoid strain that could damage solder joints, especially those on

the flight controller. During routine maintenance, handle the drone with care to prevent accidental pulling on these connections.

- c. **Cable condition:** The condition of cables are crucial for power delivery and control signals. Ensure cables are neatly routed and secured with cable ties to prevent snagging and tangling, which can lead to disconnections or damage. Regularly inspect cables for fraying, exposed wires, or insulation damage, and replace any damaged cables immediately to avoid short circuits. Ensure that no wires cross the motor and propeller area to prevent cuts or entanglements, and handle the cable connection carefully especially the battery cable. Verify that all connectors are securely attached and free of corrosion or debris to maintain electrical continuity.