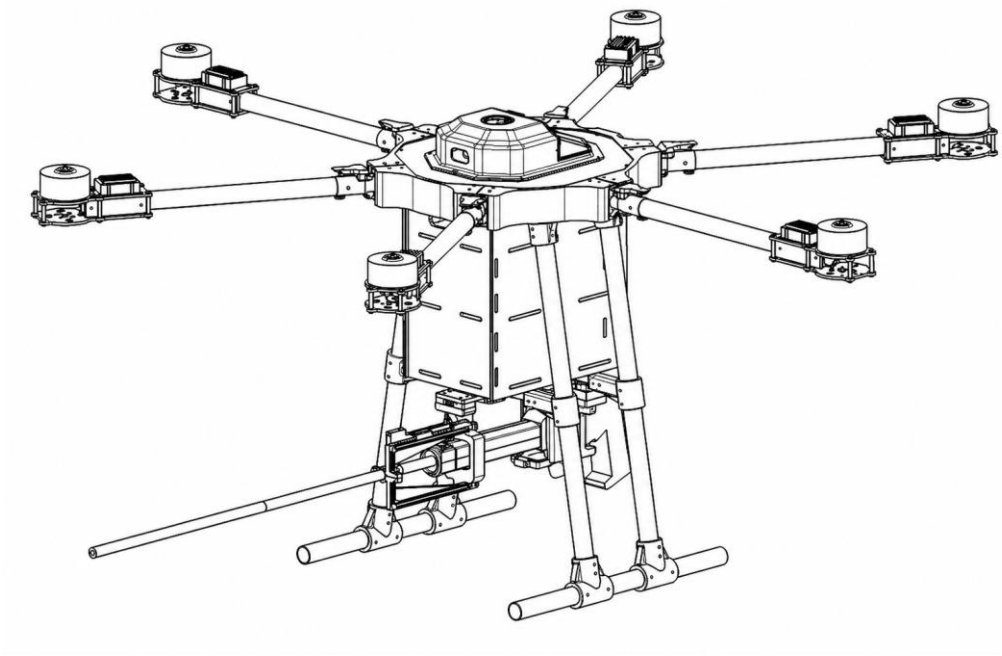
PROJECT SKYSCRUB

Operating Manual Version 1.0

July 2026



Project SkyScrub Website

Visit the official Project SkyScrub website to discover product features, technical documentation, project updates, and videos. The tutorials provide step-by-step guidance on system setup, calibration, flight operations, inspection, maintenance, and safety procedures.

To search for a specific section such as operating CrackScan or Calibration, press CTRL + F on windows or Command + F on mac

Additionally, navigation of this manual can be done through clicking on the designated section in the table of contents.

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1. Product Profile

This section briefly outlines the operation of the drone systems and what each component does.

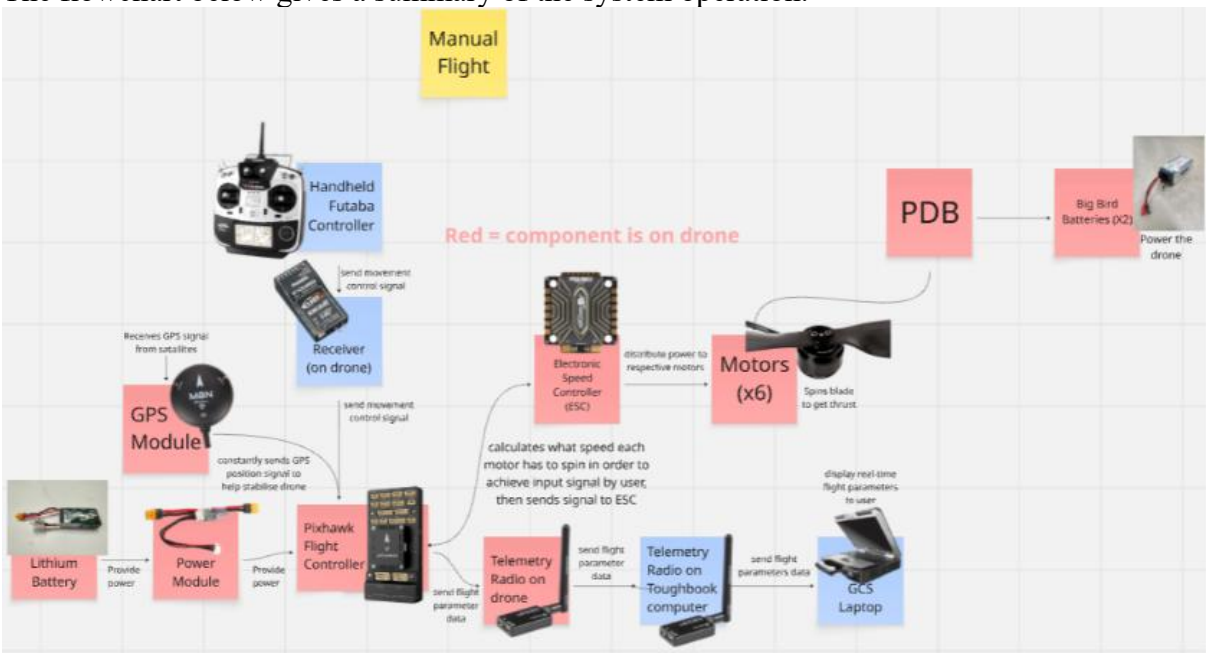
1.1 Operation Using Manual Control

The operation of the drone when using manual control is straightforward. The Lithium Polymer battery provides power to all the components through a connected power module. When a movement command is given by moving the joysticks on the Futaba remote controller, the signal is sent to the receiver on the drone wirelessly, which in turn sends it to the flight controller (which is essentially the brain of the drone). The flight controller calculates what changes each motor needs to make to its speed to fulfil the movement command, then sends the signal to each one via the electronic speed controller.

During drone operation, the GPS module also helps to stabilise it by continuously receiving signals from various satellites, calculating its position, and sending it to the flight controller. This is crucial for stable flight, as the flight controller will know if the drone is drifting and make motor speed changes accordingly.

At the same time, the flight controller sends various flight parameters, such as roll, yaw, and pitch, as well as GPS signal stability, to the computer to let the user monitor them. This computer is also commonly known as the Ground Control System (GCS)

The flowchart below gives a summary of the system operation.



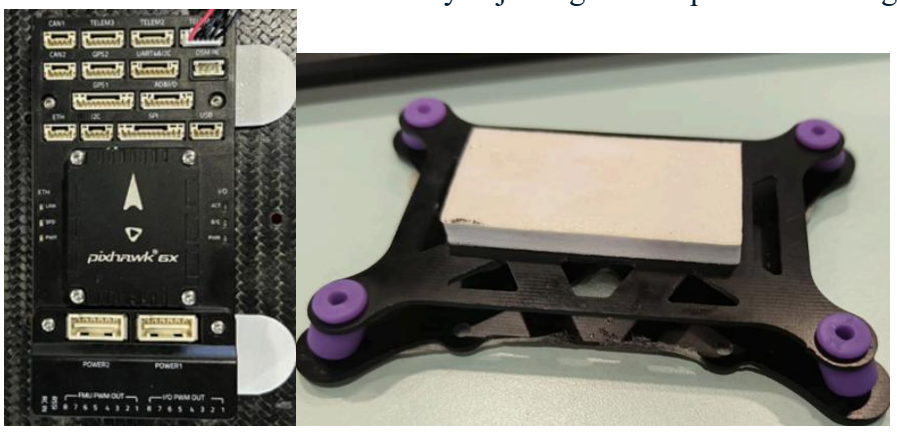
1.2. Drone Battery

Component Used: Big Bird (X2)
Purpose: Provide power to components used to fly the drone



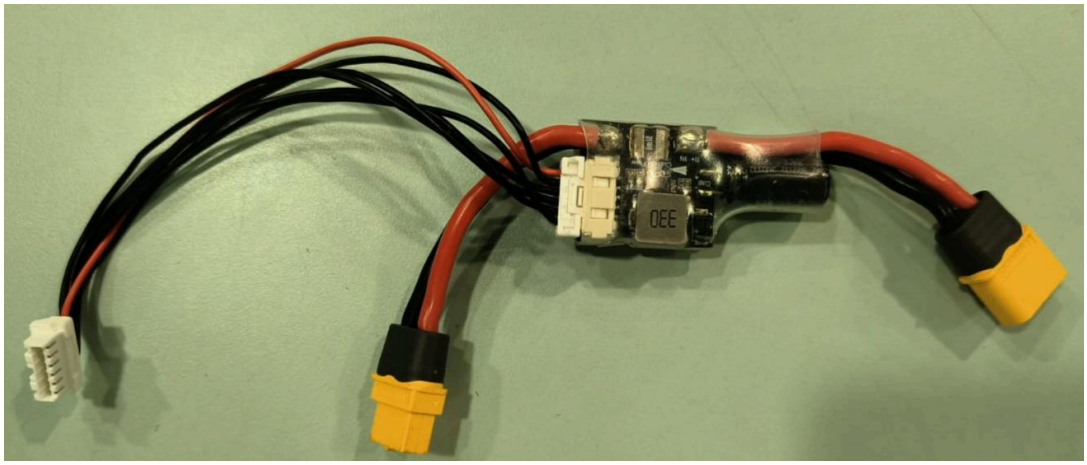
1.3 Flight Controller

Component Used: Pixhawk 6X (with damper to lessen vibration)
Purpose: Acts as the brain of the drone, processing sensor data and pilot commands to maintain stable flight and execute desired manoeuvres by adjusting motor speeds accordingly.



Pixhawk 6x Flight Controller, Dampener for Pixhawk

Component Used: PM02D power module
Purpose: Regulate power supply to the Pixhawk



PM02D power module

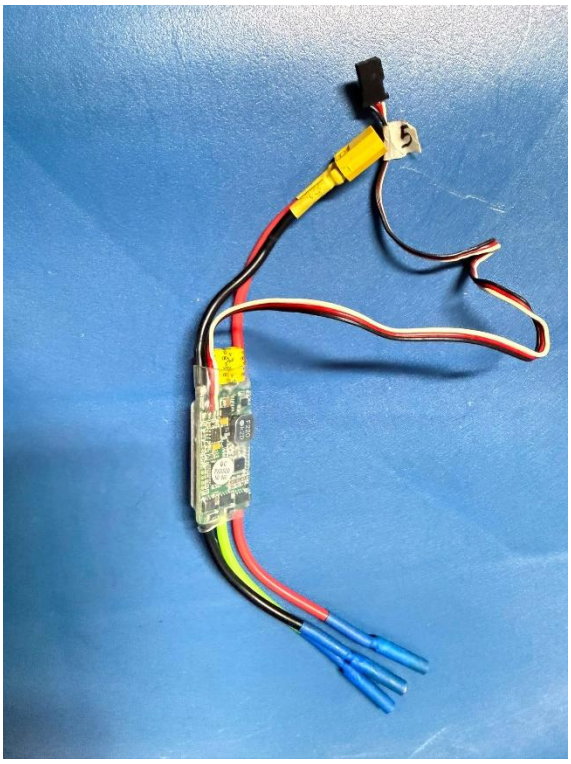
Component Used: 1000mAh-45C-11.1V-3S1P Battery
Purpose: Provides power to the Pixhawk



1.4. Electronic Speed Controller (ESC)

Component Used:

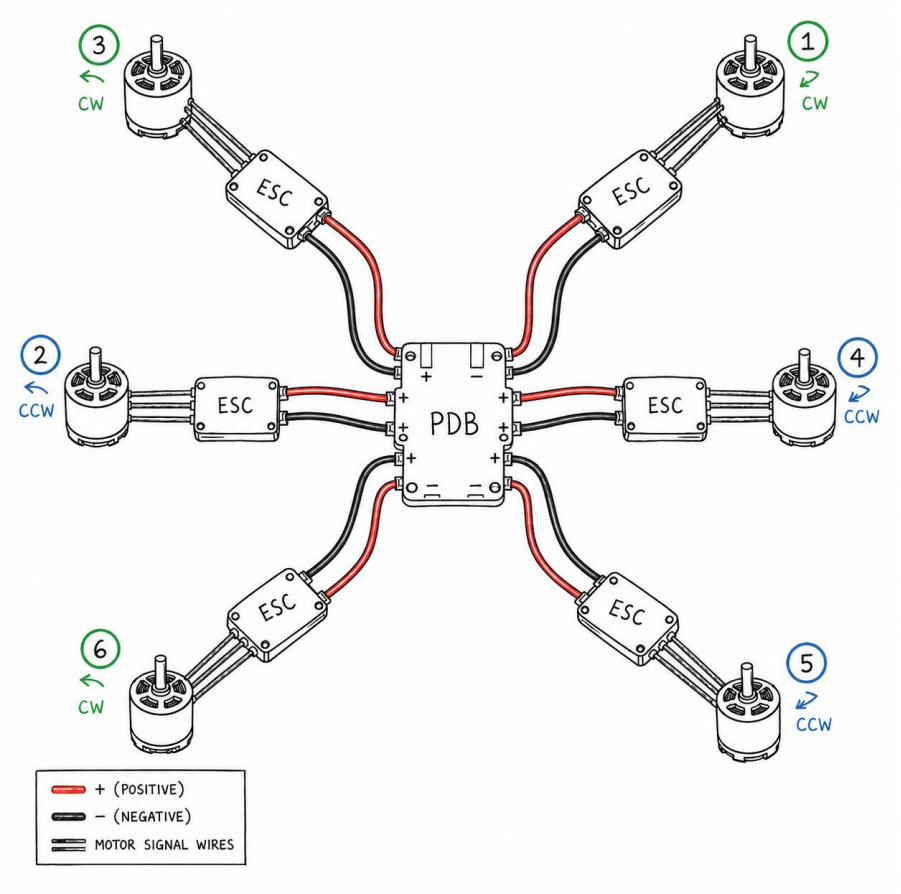
Purpose: Translates motor signals from the Pixhawk flight controller into precisely controlled power for the motors, enabling variable speed and rotation crucial for drone stability and manoeuvrability.



1.5. Motors and blades

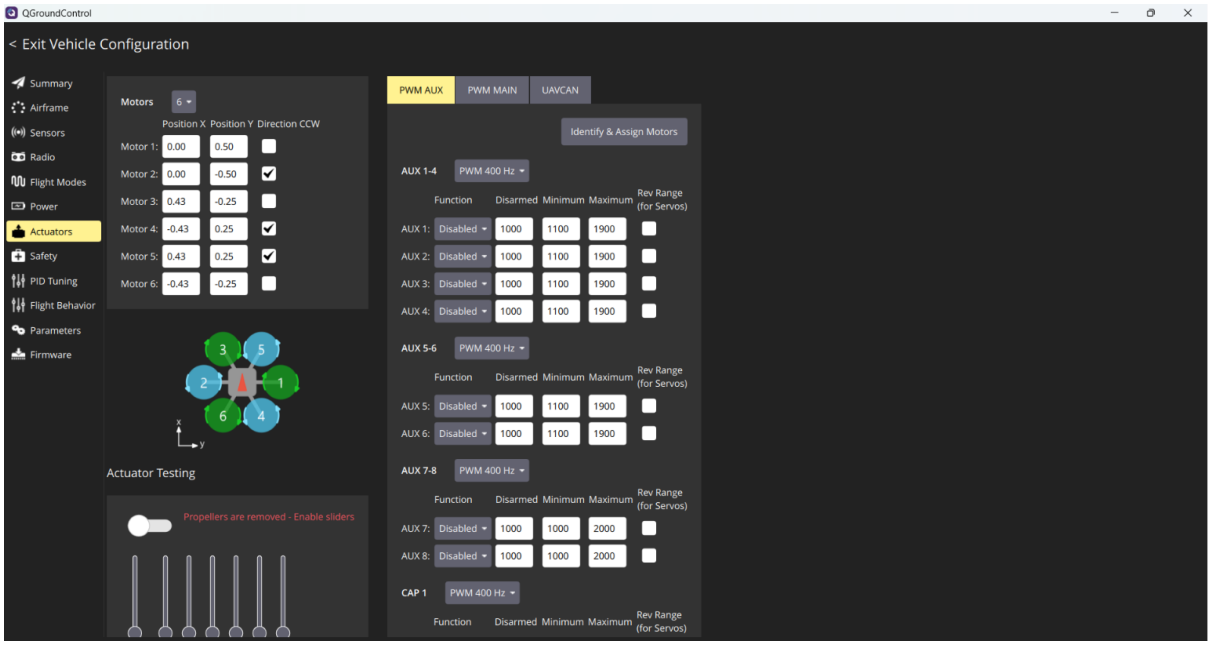
Component Used: T-Motors U3 700kv (x6)
Purpose: Receive power from the ESC and spin the blades attached to them to produce thrust

Note: For each motor, there are three wires with pin connectors. These male connectors are joined to the female connectors, which are soldered onto the ESC. The layout of connections is shown in the diagram below.



ESC connections layout

The wire order for each motor matters, as it will determine the direction of motor rotation. If the wires are connected as shown above, the motor will rotate clockwise by default. Since two motors are required to turn anticlockwise for the drone to fly, there are two ways to change the direction of rotation. The connections for the leftmost and rightmost wires of the motor can be switched. This will automatically reverse the rotation direction. Alternatively, if tweaking the hardware is not desired, the directions can be manually selected via the Vehicle Setup > Actuators module in QGroundControl installed on the ground control station.



QGroundControl actuators setup

After changing each motor to the desired spin direction, testing can be conducted to verify the changes using the "identify and assign motors" function. Ensure rotor blades are detached before testing for safety purposes.

Component Used: T-Motor Carbon Fibre Blades (x6)
Purpose: Provide thrust to lift drone

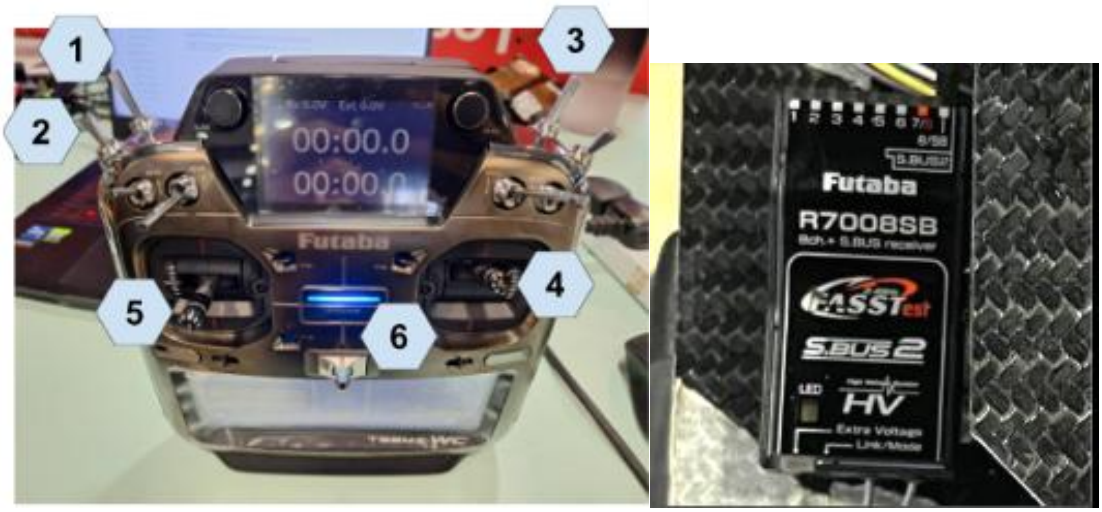


1.6. Drone Radios

Radios for Manual Control

Component Used: Futaba T32MZ-WC transmitter & R7008SB Receiver

Purpose: To manually operate the drone (for initial testing and in case manual control is required during operation).



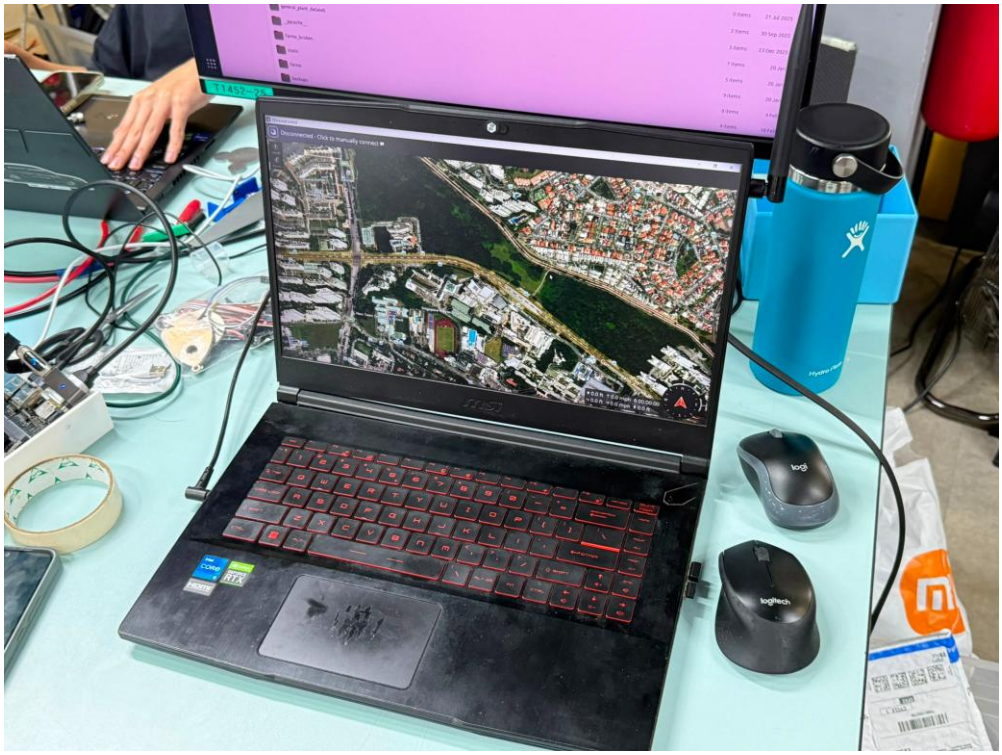
Futaba T32MZ-WC Transmitter, Futaba R7008SB Receiver

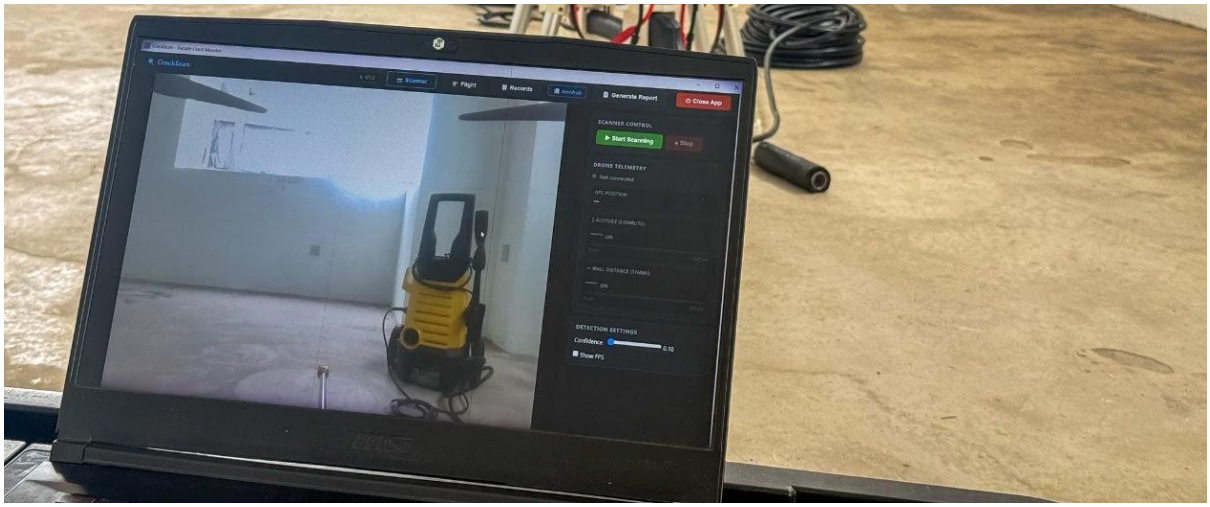
Transmitter Switches:
1: Arming Switch
2: Flight Mode Switch
3: Emergency Kill Switch
4: Throttle and Roll Control
5: Pitch and Yaw Control
6: Power on/off switch: press to turn on, press and hold, then tap ‘yes’ on screen to power off
The switches and functions are explained in greater detail in a later section.

1.7. Ground Control Station

Component Used: MSI GF63 Thin 11UC + 433MHz 100mW telemetry radios (x2)

Purpose: To track and monitor flight data and parameters in real time. QGroundControl is installed to interface with the drone's flight controller in addition to the CrackScan software that enables real-time crack detection, defect logging, and inspection reporting during flight as well as displaying additional parameters. It also allows the ground control station (GCS) to continue monitoring flight data in real-time wirelessly. One is connected to the GCS via USB connection.





1.8. GPS Module

Component Used: Holybro M8N GPS Module

Purpose: To link the drone to GPS satellites to allow various functions (eg., geofencing, altitude hovering, navigation, and provide data for CrackScan elevation map) it is connected to the GPS1 port of the Flight Controller



Holybro M8N GPS Module on drone

1.9. Distance Detection

Component Used: LIDAR-Lite v3

Purpose: Detect the vertical distance (altitude) of the drone using the light reflection principle



LIDAR-Lite v3

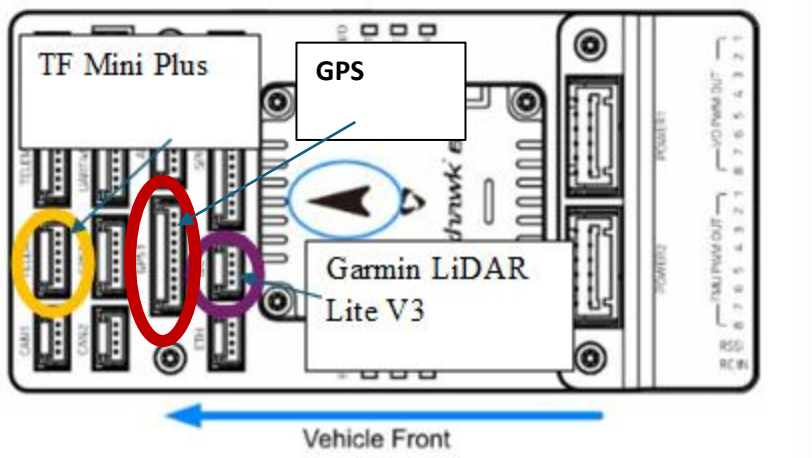
It is connected to the flight controller via the I2C (Inter-Integrated Circuit) port.

Component Used: TF Mini UART Plus
Purpose: Detect the horizontal distance between the drone and the facade using the light reflection principle



It is connected to the flight controller through the TELEM3 (Telemetry 3) port

A guide to the connections for the hardware and telemetry to the Pixhawk flight controller



1.10 Detection Pod

Component Used: 3D printed pod (designed and printed in-house)

Purpose: To house all the components needed for autonomous flight & Crack Detection in a single unit



Camera for detection

Component Used: Intel RealSense D435i camera

Purpose: Provides real-time data of cracks



Intel RealSense D435i

Computer

Component Used: NVIDIA Jetson Orin Nano

Purpose: Process data from the camera, run the code for autonomous flying and communicate with the Pixhawk to execute the required manoeuvre.



NVIDIA Jetson Orin Nano

Power Source

Component Used: Xiaomi

Purpose: Provide power to run the Jetson Nano (which runs the camera)



Jetson Power Source



USB C to Barrel Jack Adaptor

Part 2: Using QGroundControl

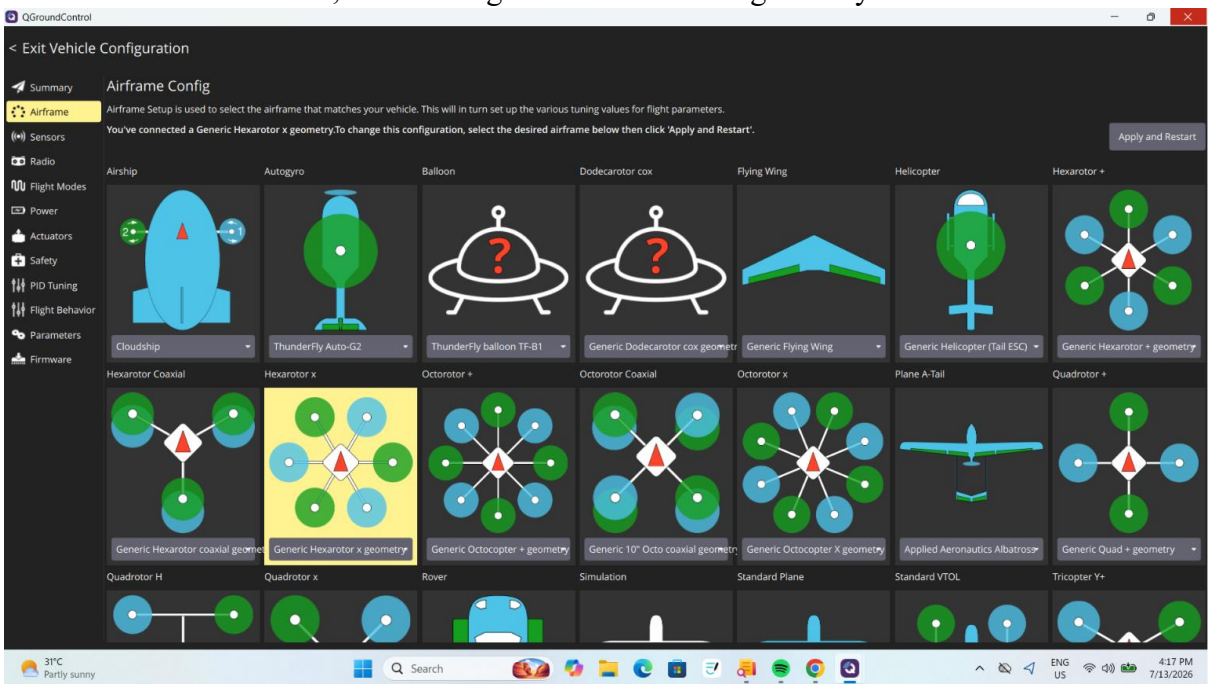
This section outlines briefly how to use the QGroundControl software installed on the ground control station (MSI GF63).

2.1. Setup and Calibration

On first use or after any changes to the drone's physical setup, calibration must be done on QGroundControl before flight. If calibration was done previously, the following points can serve as a checklist to ensure all settings are correct. Launch QGroundControl and click on the "Q" logo in the top left corner. Select "Vehicle Setup" to access these settings.

Airframe Selection

Under the "Airframe" tab, ensure the generic Hexarotor x geometry is selected



Airframe Selection

Calibrating Sensors

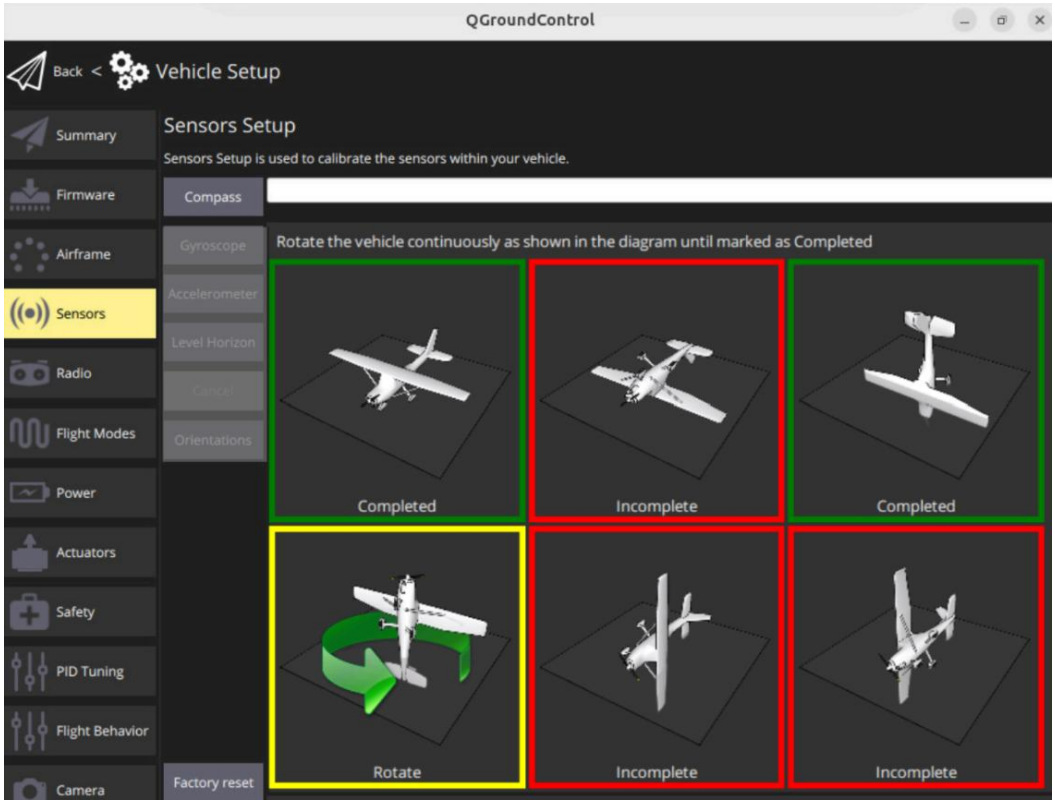
Pixhawk flight controller requires calibration for the following sensors:

Compass: Requires calibration during first setup, as well as follow-up calibration when testing the drone in areas with high magnetic fields. (Project Centre has many other devices/tools which affect the magnetic field)

Gyroscope: Requires calibration during first setup; calibration ensures Pixhawk attitude is correct.

Accelerometer: Requires calibration during first setup or if the flight controller orientation changes. Calibration of the accelerometer ensures correct velocity estimations.

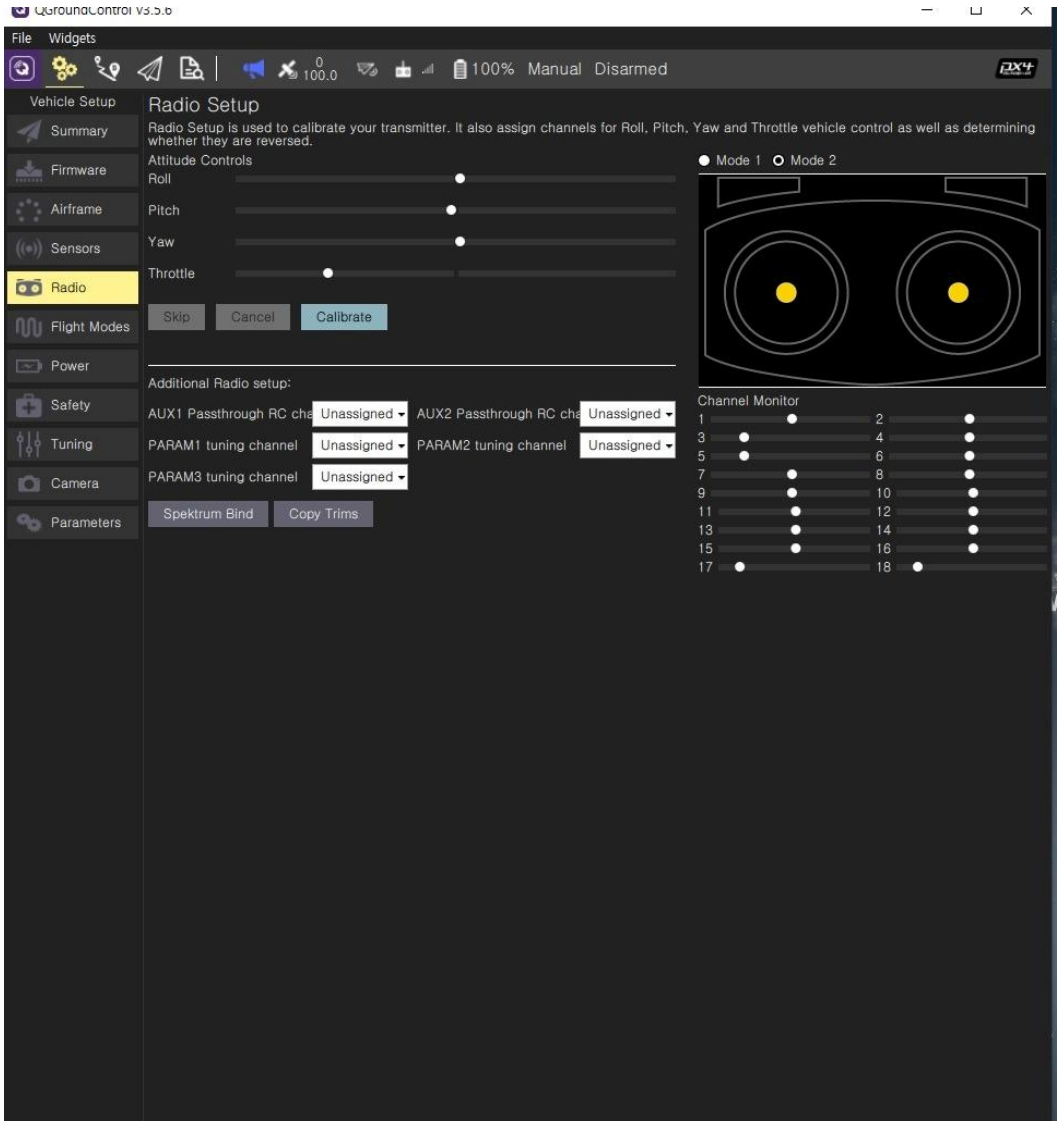
Under the "Sensors" tab, follow the on-screen instructions when calibrating. You will be required to rotate the drone when calibrating the compass and accelerometer. Ensure the flight controller is the pivot point when rotating.



Calibrating Compass

Calibrating Radio

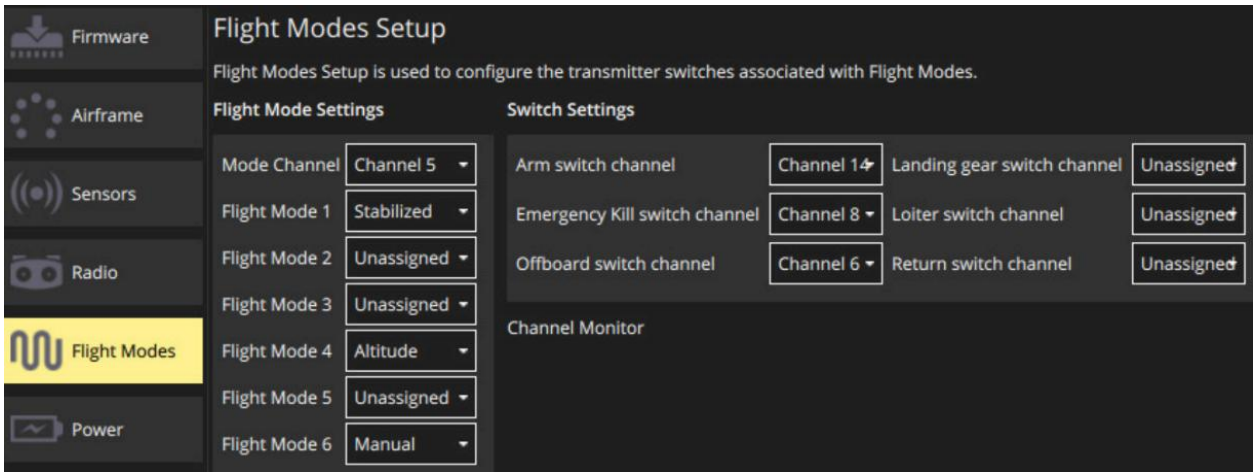
Calibrating the remote control can be done if errors are suspected or to verify the radio is working normally. Under the “Radio” tab, follow the instructions on screen to calibrate the radio.



Calibrating Radio

Flight Modes

Customisation can be done in the “Flight Modes” tab to configure which switches do what on the radio controller. Check whether the settings match the figure below.



Flight Modes Configuration

The table below outlines the various functions of the switches used for this project.

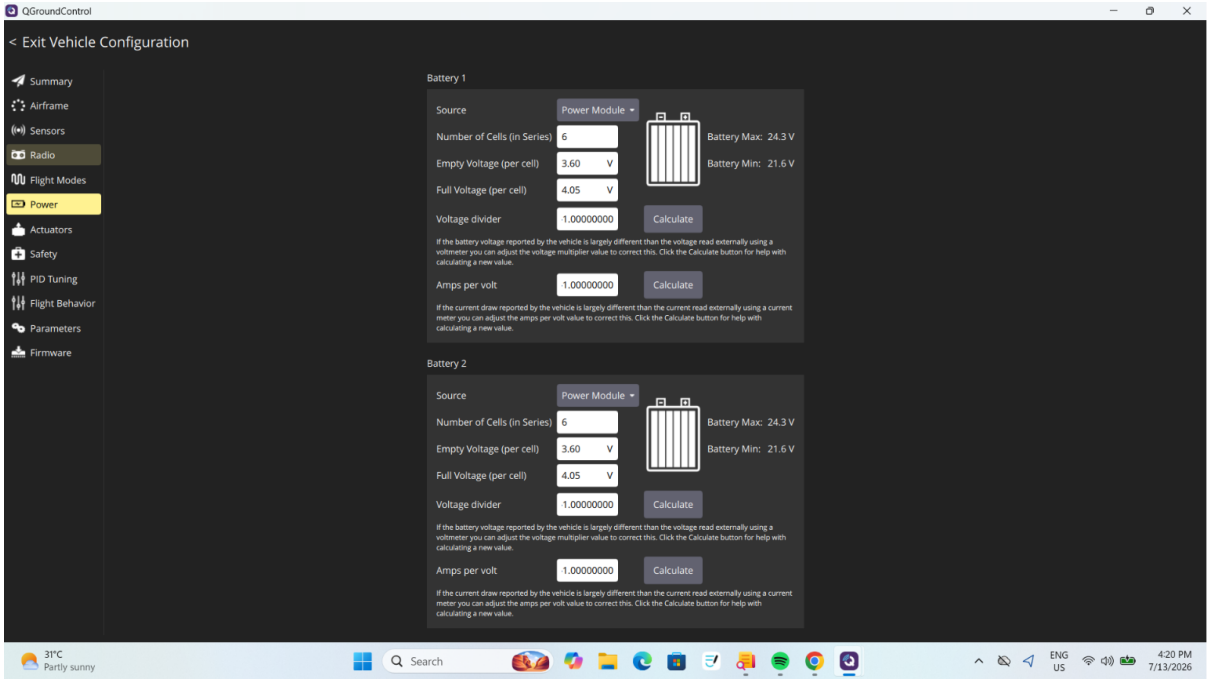
Channel Number	Assigned Setting	Setting Purpose	Type/Location on Futaba Transmitter
Channel 14	Arm Switch Channel	The switch manually arms the drone before takeoff, and disarms the drone after landing	A maintained contact switch located at the top left
Channel 8	Emergency kill switch channel	During unexpected issues mid-flight, the kill switch channel can be activated to stop the drone immediately	A momentary switch located at the top right
Channel 6	Offboard switch channel	Gives the onboard computers (Jetson Nano) control of the drone. The offboard switch starts the code running on the Jetson computer, making the drone fly autonomously. The switch can also be	A sliding switch located at the top right at the back

		switched off to return to manual mode if needed.	
Channel 5	Flight Modes 1, 4 and 6	Flight mode 1 - Stabilize Flight mode 4 - Altitude Flight mode 6 - Manual Manual flight enables regular drone control using radio transmitters. Altitude mode enables drone hover using Lidarlite	A 3-way selection switch located at the top left

Switch allocation and functions

Power Setup

The type of power supplied to the drone and the power source can be updated in the “Power” tab. If using the battery stated in the above section “Drone components”, check if the settings match those shown below. If using a different battery, ensure this power settings are updated accordingly before flight.

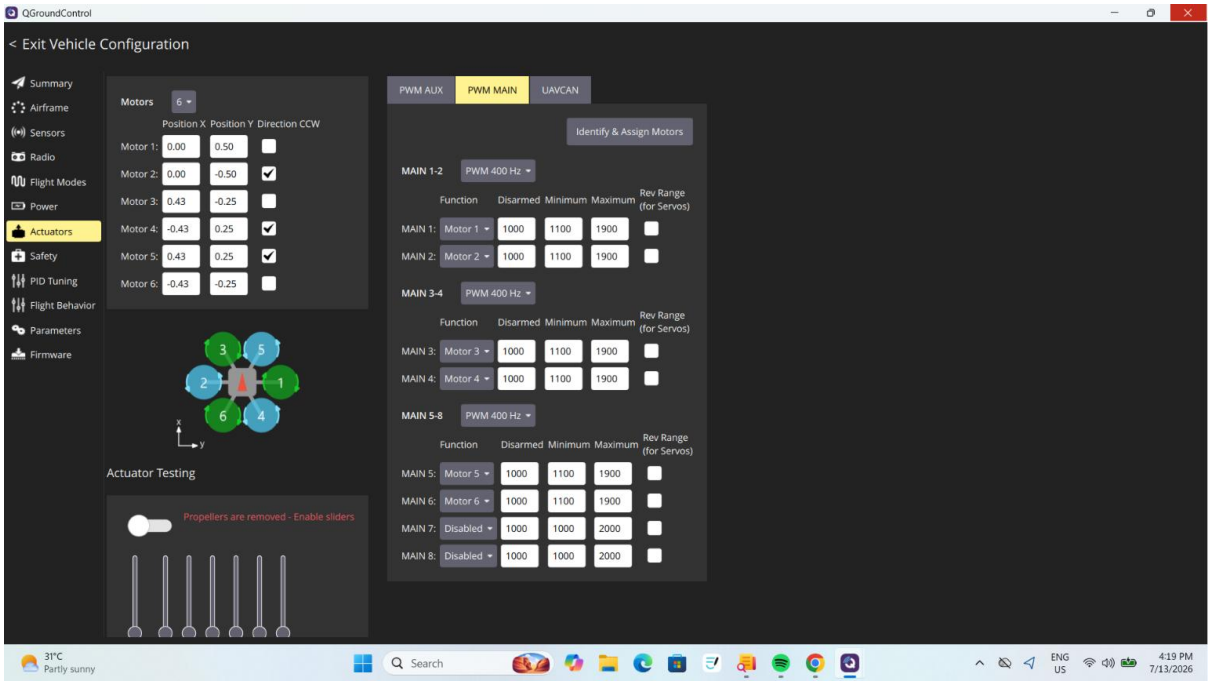


Batter Configuration

The ESC can also be calibrated under this tab. Follow the instructions on screen to do so. ESC calibration can be performed as a troubleshooting step if motor speeds appear abnormal.

Actuator Setup

As mentioned earlier, motor spin direction and output range can be configured in the "Actuators" tab. Below shows the settings used for this project.



Actuators setup

Quick testing of motor spin direction can be done using the "Identify & Assign Motors" button. Motor speeds can also be checked by clicking the tab highlighted in red above and increasing the motor speed bar. Ensure blades are removed from motors prior to testing to avoid flight.

Parameters

Various flight parameters can be controlled under the “parameters” tab. Below are some important ones to check before flights.

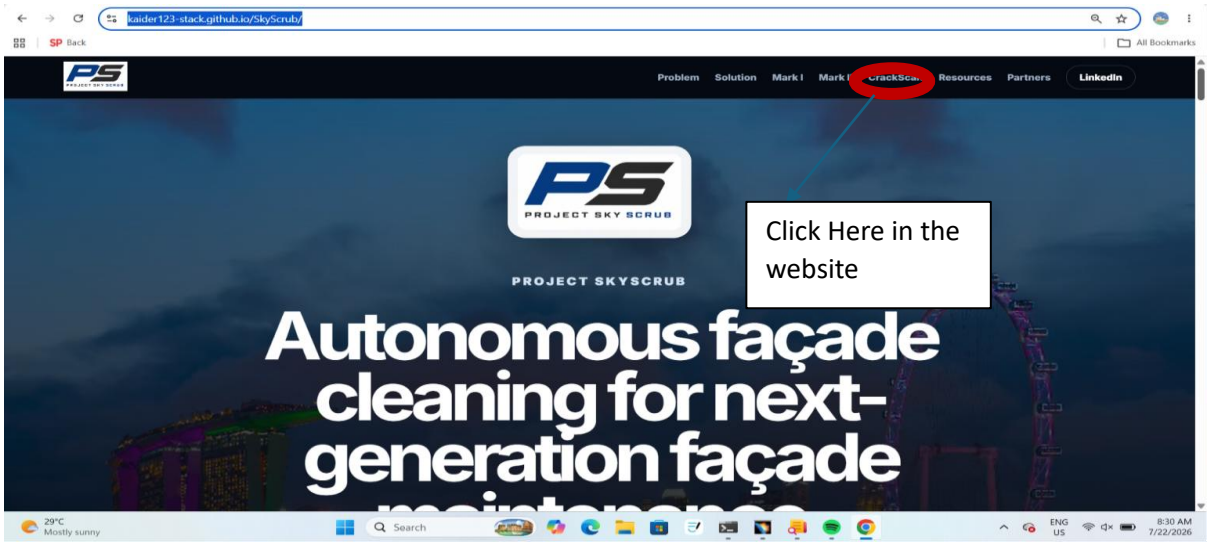
Parameters	Purpose of Parameters
Com_disarm_land	Idle duration before motors stop after landing [Current value: 5.0s]
com_disarm_prflt	Idle duration before motors stop after arming [Current value: 5.0s]
SENS_EN_LL40LS	Indicates the type of physical connection used by the sensor. The Lidarlite v3 is connected using I2C on the flight controller [Selected option: I2C]
SENS_TFMINI_CFG	Indicates the type of physical connection used by the sensor. The TF mini is connected using I2C on the flight controller [Selected option: I2C]
EKF2_HGT_REF	Indicates the type of sensor prioritised by the flight controller, Range Sensor was chosen to prioritise lidar over GPS. [Selected option: Range Sensor]
EKF2_RNG_CTRL = 1	Precaution for indoor testing, only allows Range Sensor control up to a certain height. (Max: 5.0m) [Current value: 1.0m to 5.0m]

Summary of Parameters

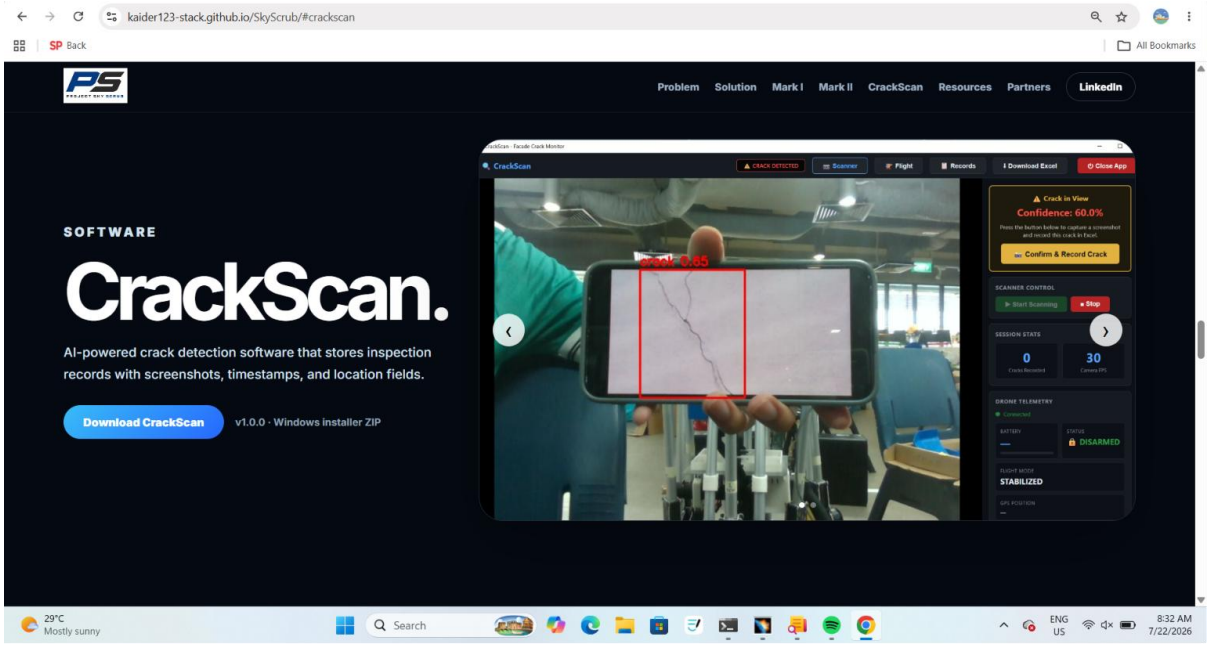
3.0 Installing CrackScan

Step 1: SkyScrub Website

To find the installer for the CrackScan software, first navigate to the official [Project SkyScrub Website] using your web browser. On the website, under the navigation bar, click on the header for CrackScan

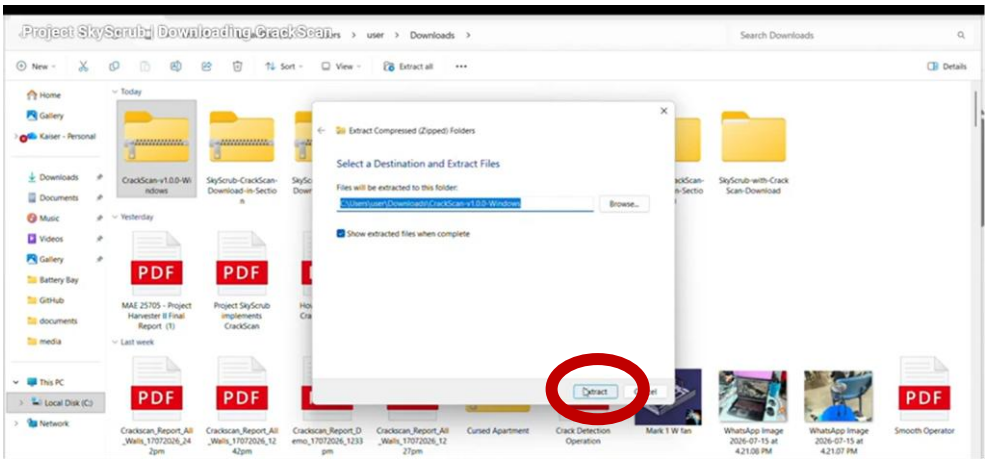


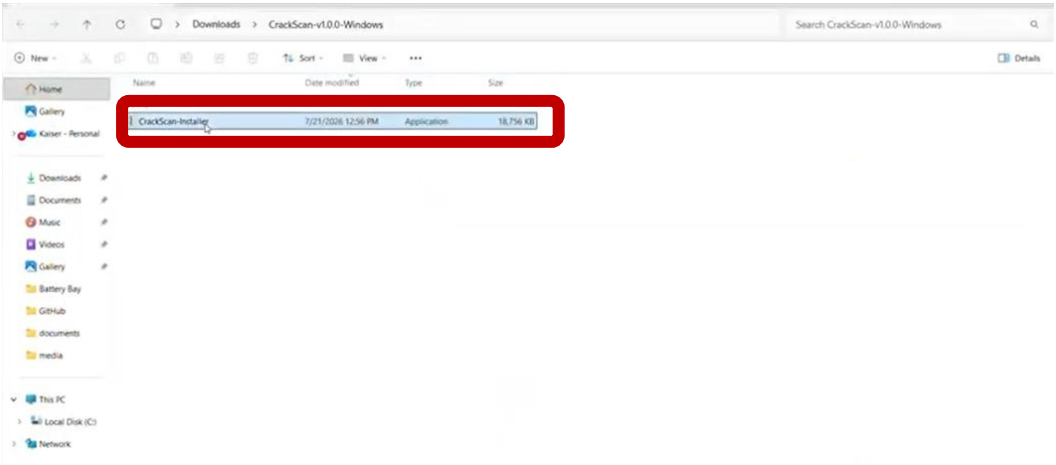
Click on the installer button to download the official CrackScan installer to begin the installation process



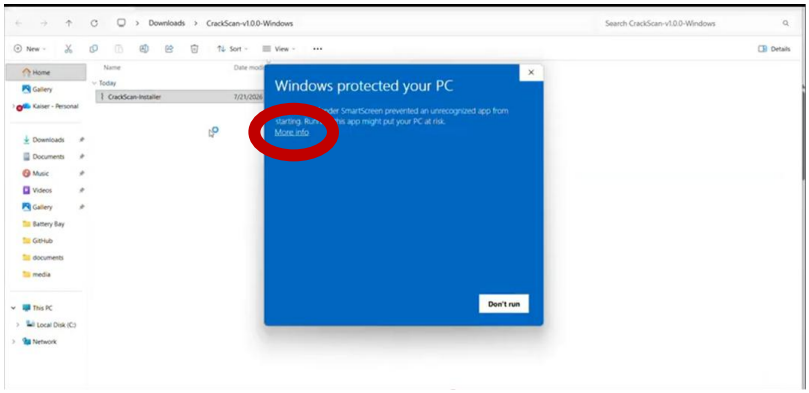
Step 2: Installing CrackScan

Extract the downloaded zip file and click on the installer once it is extracted.





Windows will provide a prompt as a safety feature. To run the software, click on the **More Information** button and then click **run**. Follow the steps on screen provided by the installer wizard.



Once the installation process is complete, the CrackScan software will appear on the home page of your device and can be used if both the Jetson Nano and the Ground Control System are connected to the internet

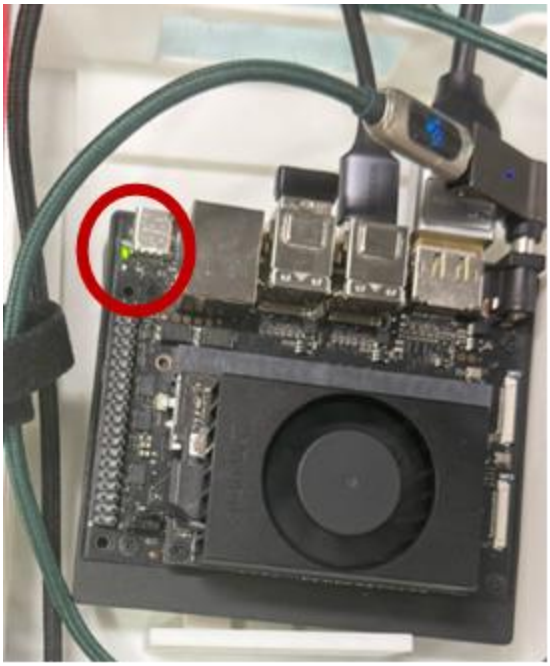


3.0 Crack Detection Operation

This section outlines how to setup and use the CrackScan software It covers the software startup process, wall configuration, crack detection, report generation, and system shutdown.

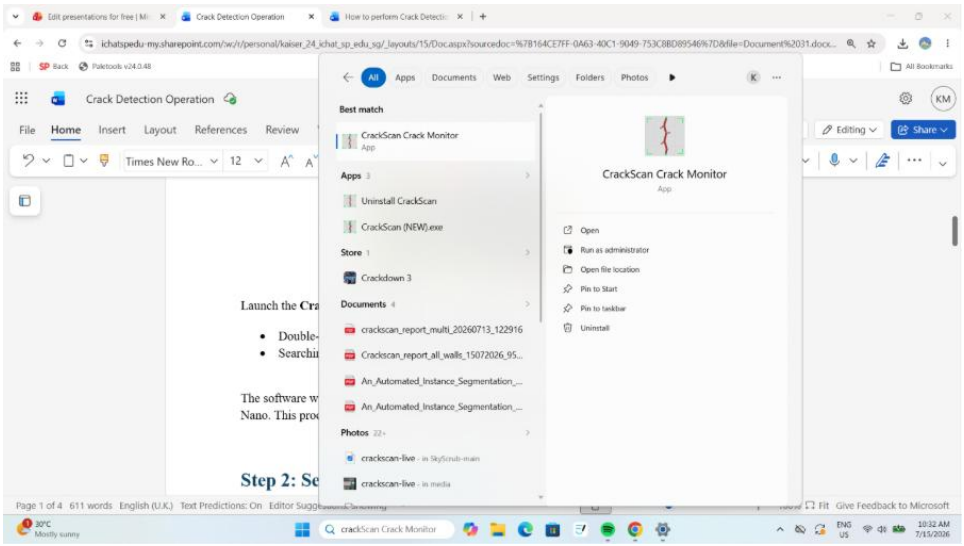
Step 1: Launch System

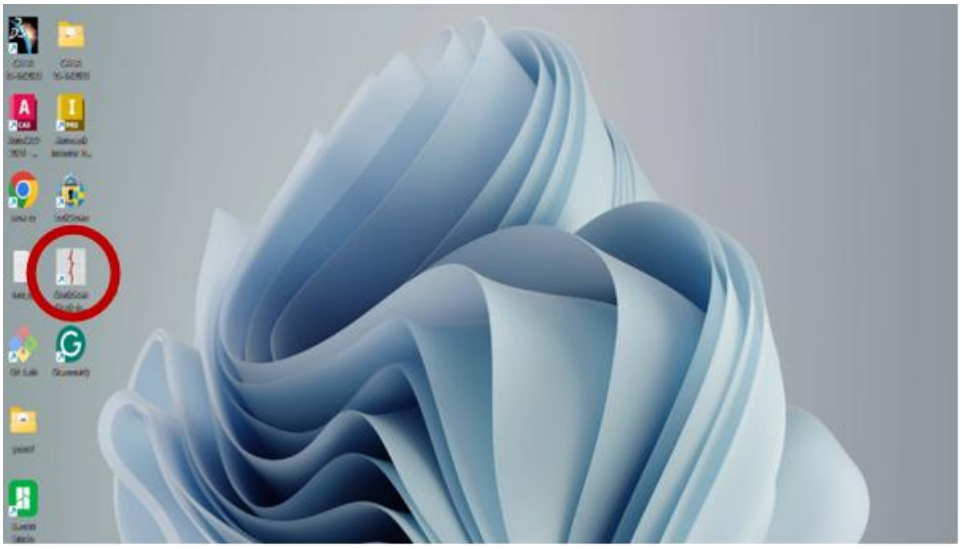
Ensure that the drone, Jetson Orin Nano, camera, and flight controller are powered on and properly connected. Verify that the Jetson Orin Nano is powered by checking that the green power LED located at the corner of the board is illuminated, as shown in the image below circled in red.



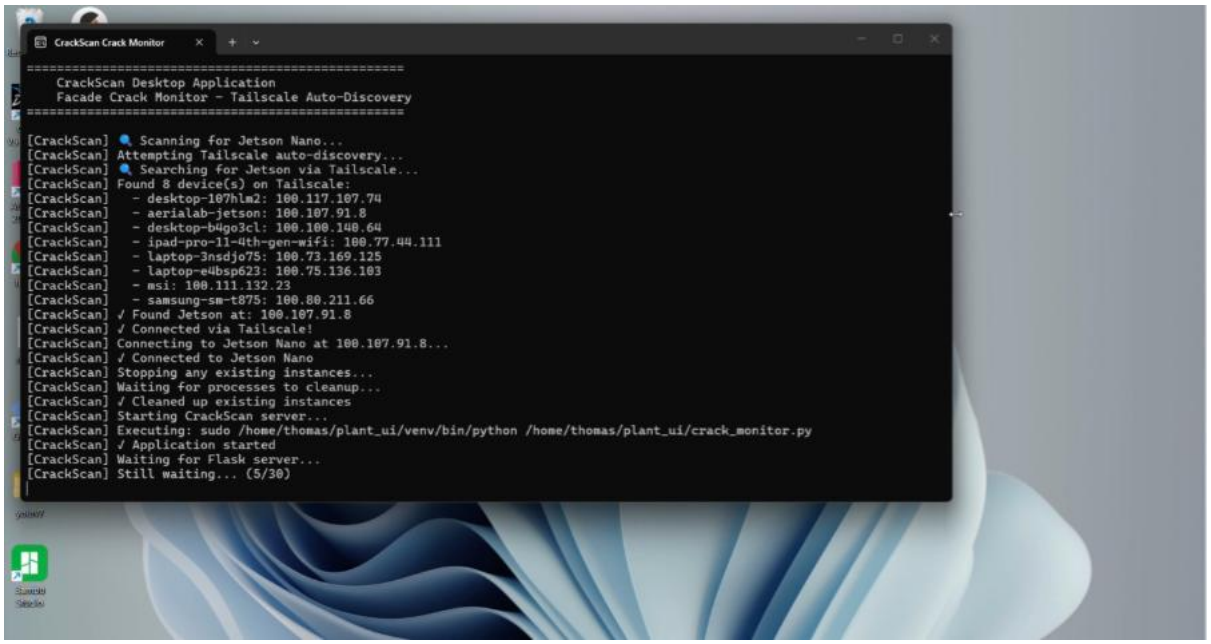
Launch the **CrackScan** application on the Ground Control Station (GCS) by either:

- Double-clicking the CrackScan desktop shortcut; or
- Searching for **CrackScan Crack Monitoring** using the Windows search bar.





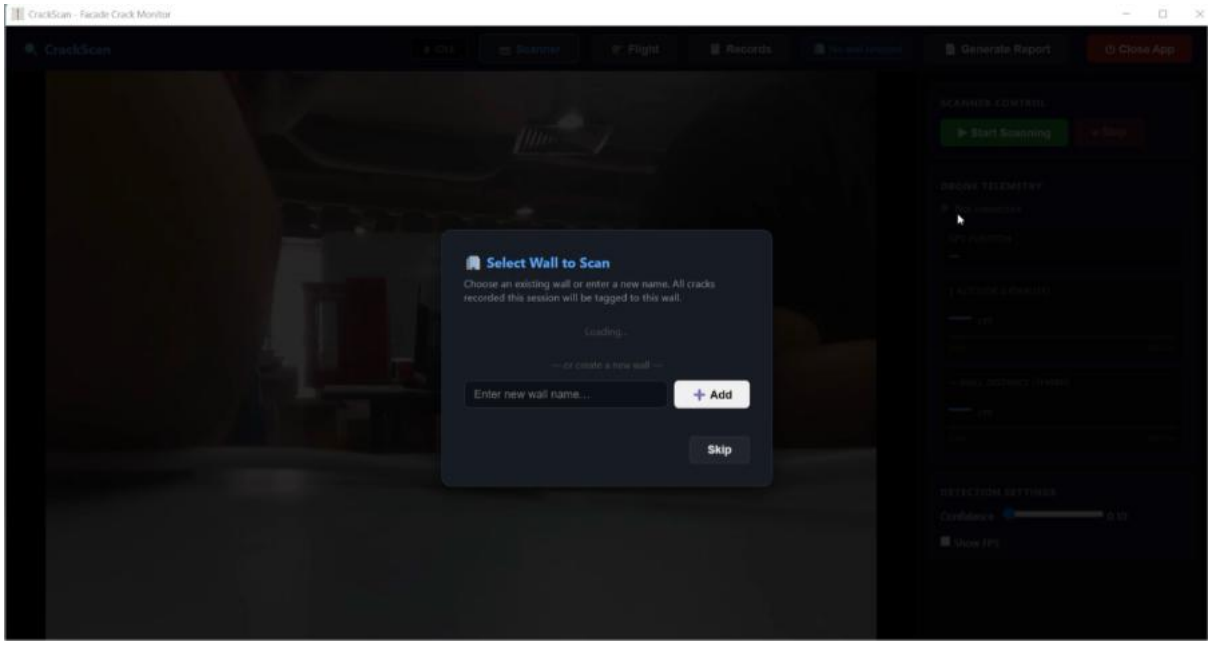
The software will automatically establish a Remote Desktop connection to the Jetson Orin Nano. This process typically takes approximately **30 seconds**.



Step 2: Select or Create a Wall

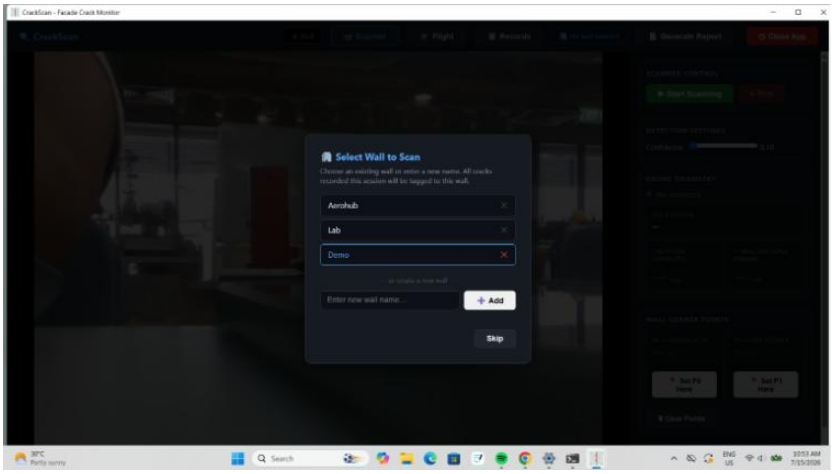
Once CrackScan has launched successfully, the user will be prompted to either:

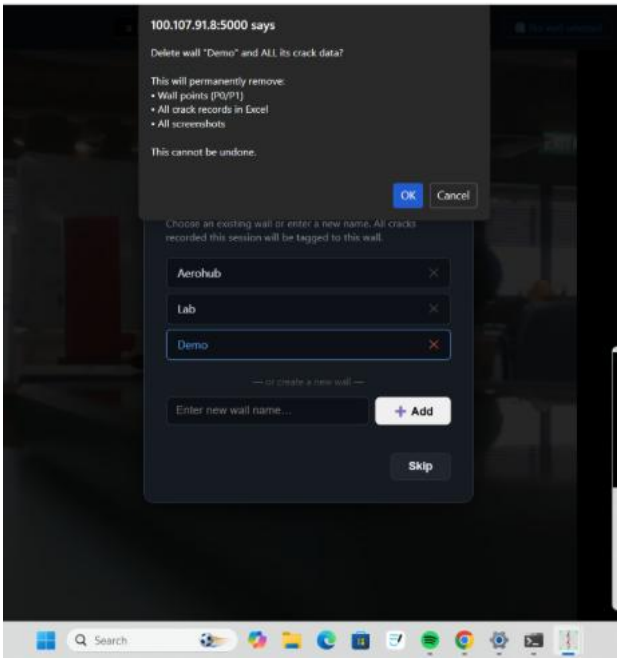
- **Select an Existing Wall** to continue a previous inspection; or
- **Scan a New Wall** to create a new inspection project; or
- **Skip** to bypass the selection phase.



Choose the appropriate option based on the inspection being performed.

If the user wants to delete the walls created in the previous session for a cleaner workflow, simply click the **X** next to the labels and then click ok on the popup to purge the wall.

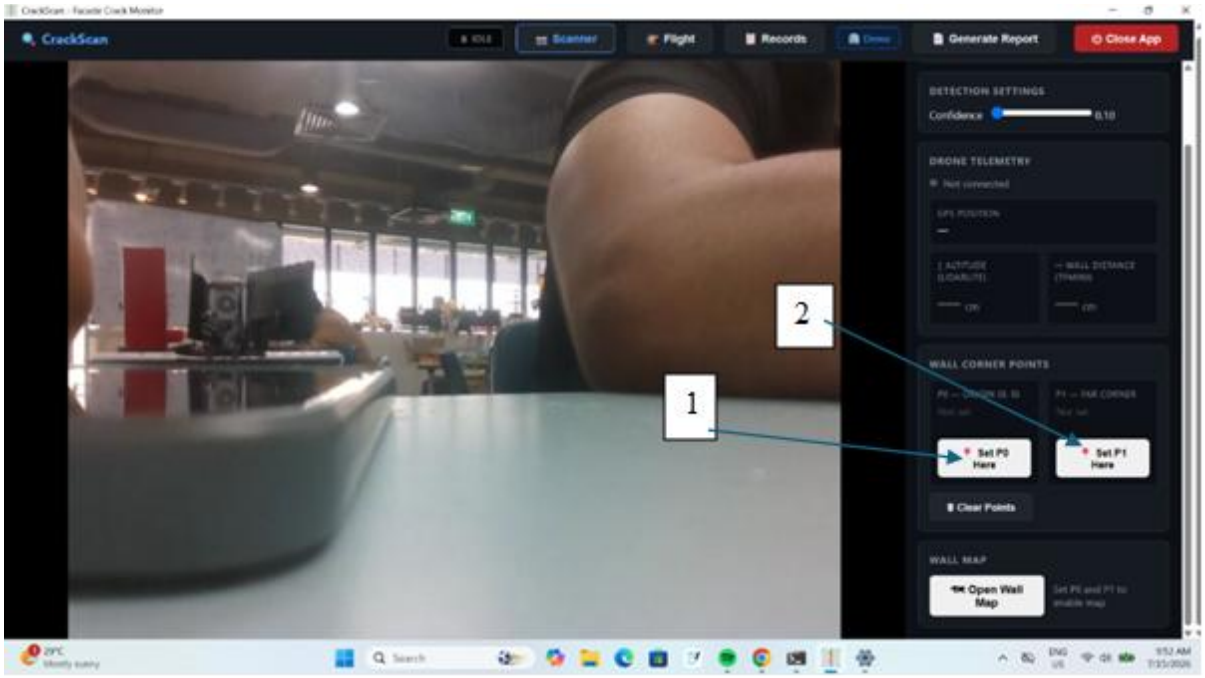



100.107.91.8:5000 says
Delete wall "Demo" and ALL its crack data?
This will permanently remove:
• Wall points (P0/P1)
• All crack records in Excel
• All screenshots
This cannot be undone.
OK
Cancel
Choose an existing wall or enter a new name. All cracks recorded this session will be tagged to this wall.
Aerohub
Lab
Demo
— or create a new wall —
Enter new wall name...
Add
Skip
Search

Step 3: Calibrating the Wall Boundary

Before crack detection can begin, the wall boundary must be calibrated by defining two reference points at the extreme ends of the facade under inspection.

- **P0 (Origin)** – Bottom-left corner of the wall.
- **P1 (Far Corner)** – Opposite corner of the wall, typically the top-right corner.



These reference points establish the wall dimensions and enable CrackScan to accurately map detected cracks onto the wall layout in a cartesian coordinate system

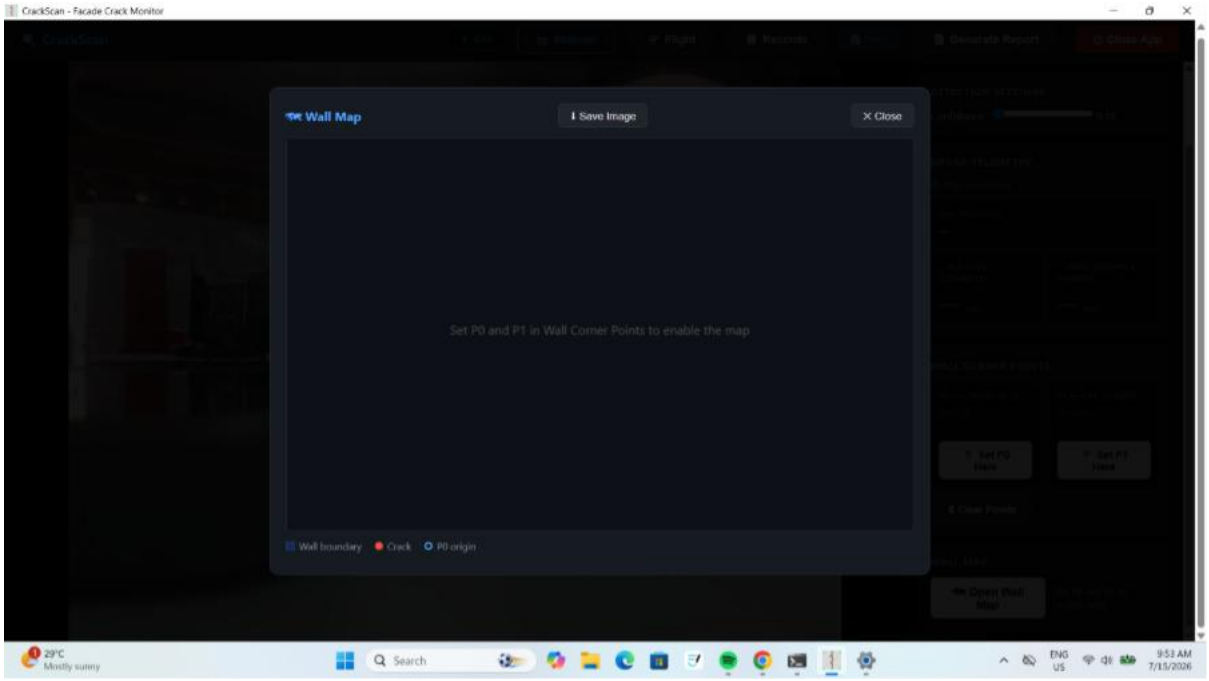
Setting P0

1. Fly the drone to the **bottom-left corner** of the wall.
2. Hover until the drone is completely stationary.
3. Click **Set P0 Here** to record the wall origin (0, 0).

Setting P1

1. Fly the drone to the opposite (**top-right)** corner of the wall.
2. Hover steadily.
3. Click **Set P1 Here** to record the far corner.

Verify that both coordinates have been successfully recorded in the **Wall Corner Points** panel.

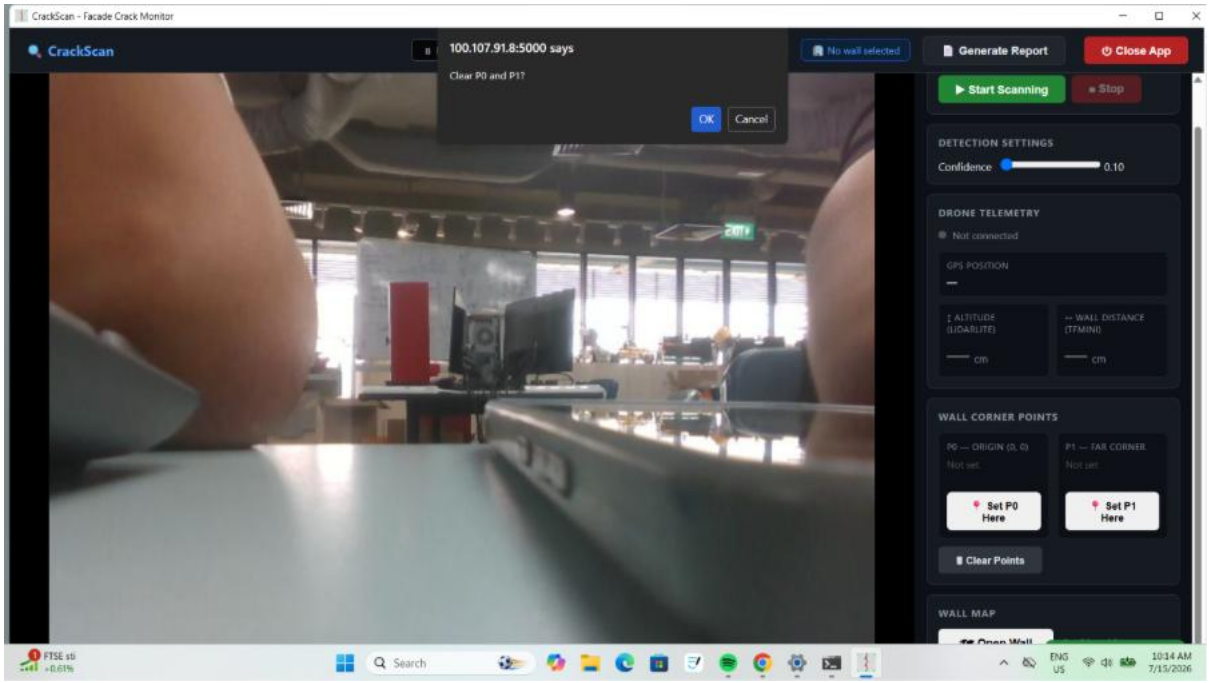


Click **Open Wall Map** to confirm that the wall boundary has been generated correctly.

Note: Always ensure the drone is stationary before recording either reference point. Incorrect positioning of P0 or P1 will reduce the accuracy of crack localisation and provide skewed data.

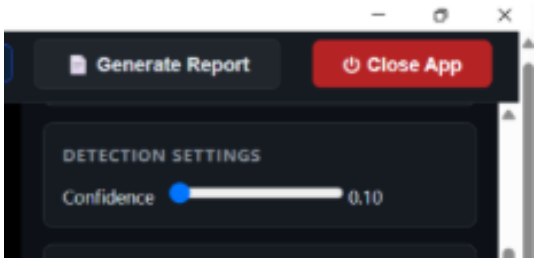
Tip: If an incorrect point is recorded, click **Clear Points** and repeat the calibration before commencing the inspection.




CrackScan - Facade Crack Monitor
CrackScan
100.107.91.8:5000 says
Clear P0 and P1?
OK
Cancel
No wall selected
Generate Report
Close App
Start Scanning
Stop
DETECTION SETTINGS
Confidence
0.10
DRONE TELEMETRY
Not connected
GPS POSITION
ALTITUDE (LIDARLITE)
WALL DISTANCE (TFMINI)
cm
cm
WALL CORNER POINTS
P0 — ORIGIN (0, 0)
Not set
P1 — FAR CORNER
Not set
Set P0 Here
Set P1 Here
Clear Points
WALL MAP
Search
ENG
US
10:14 AM
7/15/2026

Step 4: Set the Detection Confidence

After the wall boundary has been calibrated, adjust the **Confidence Threshold** by dragging the slider.

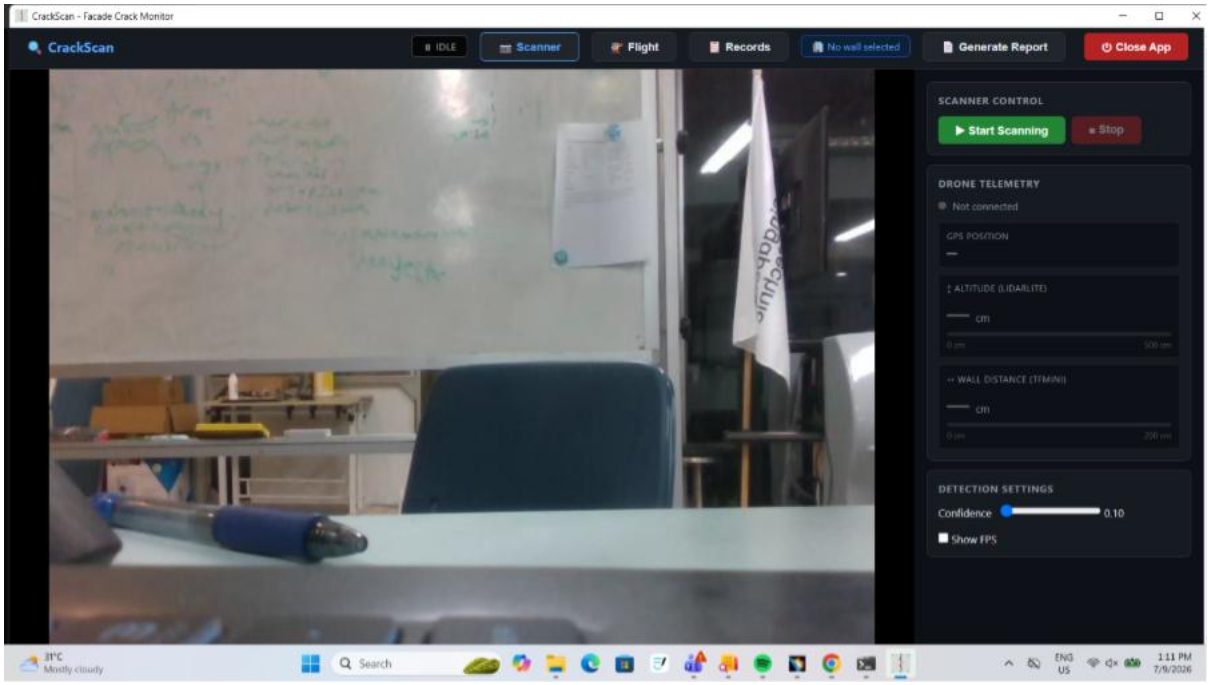


The confidence threshold defines the minimum confidence score required for the YOLOv8 model to classify the object as a crack.

Increasing the threshold reduces false detections and actuations, while lowering it allows smaller cracks to be detected as the model is more sensitive to the features captured by the camera.

Step 5: Start Crack Detection

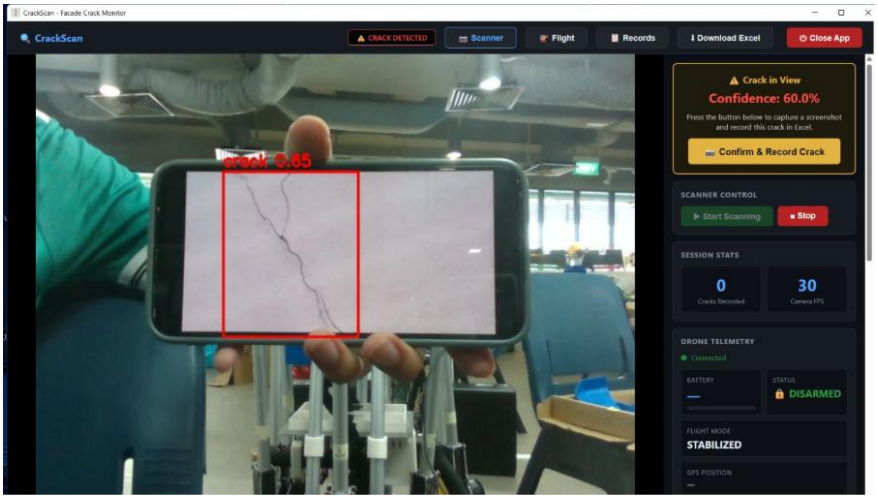
Click **Start Scanning** to begin the crack detection process. The detection process can be done in 2 different modes: Greyscale and Colour mode (RGB)



During inspection:

- The live camera feed will be analysed continuously by the YOLOv8 model.
- Detected cracks will be highlighted with a **red bounding box**.
- The confidence score for each detection will be displayed above the bounding box.

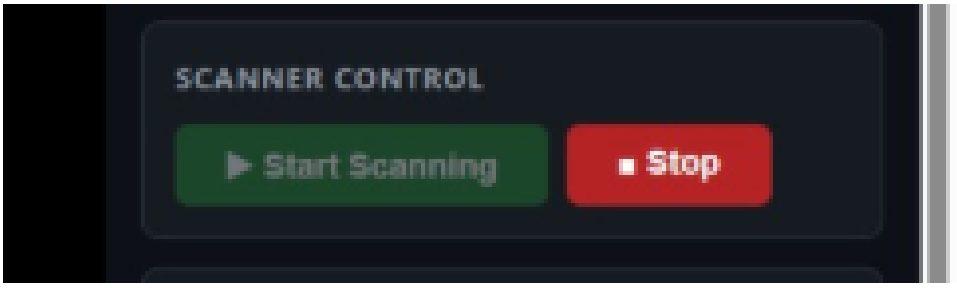
After verifying that the detected feature is a genuine crack, click **Confirm & Record Crack** to save the detection.



The captured image, crack location, and associated inspection data will be stored automatically.

Step 6: End the Inspection

Once the façade inspection has been completed, click **Stop Scanning** to terminate the crack detection process.



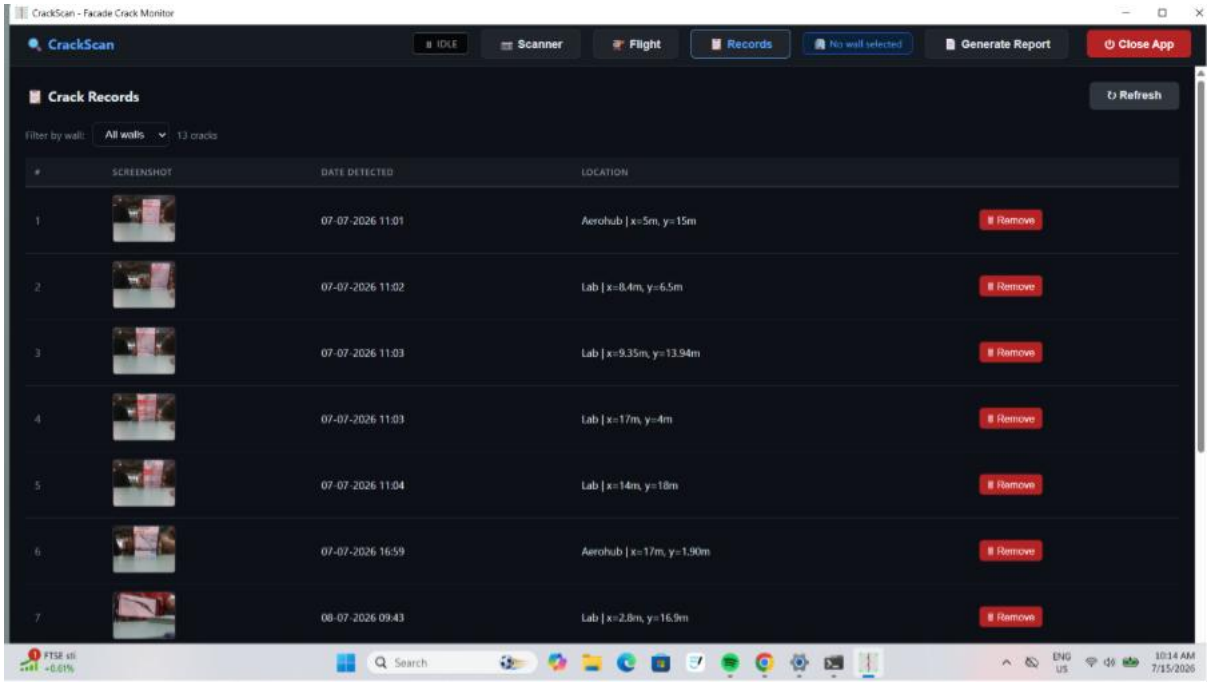
Step 7: View Inspection Records

Select **Records** from the navigation bar to access all saved crack detections.

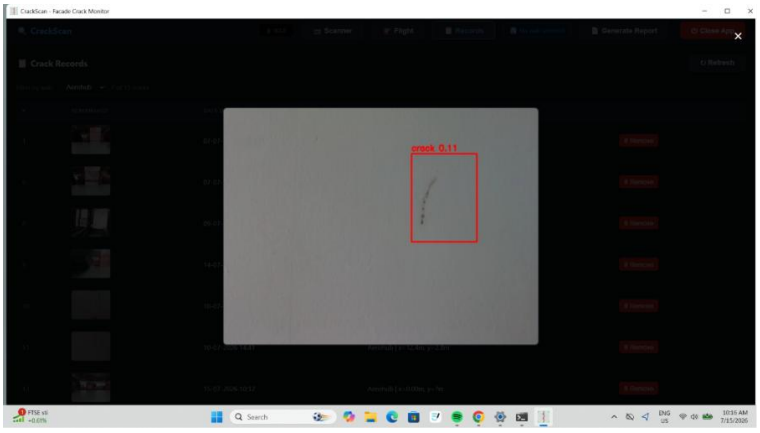


For each recorded crack, the following information is available:

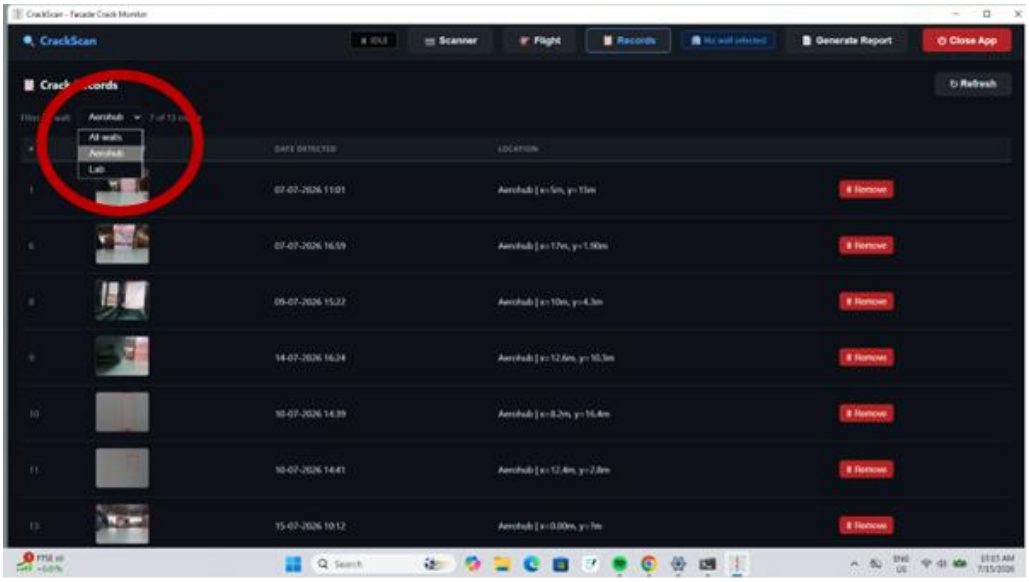
- Captured crack image
- Detection details
- Recorded inspection information



To enlarge an image, simply click on the image of the corresponding record in the screenshot column.

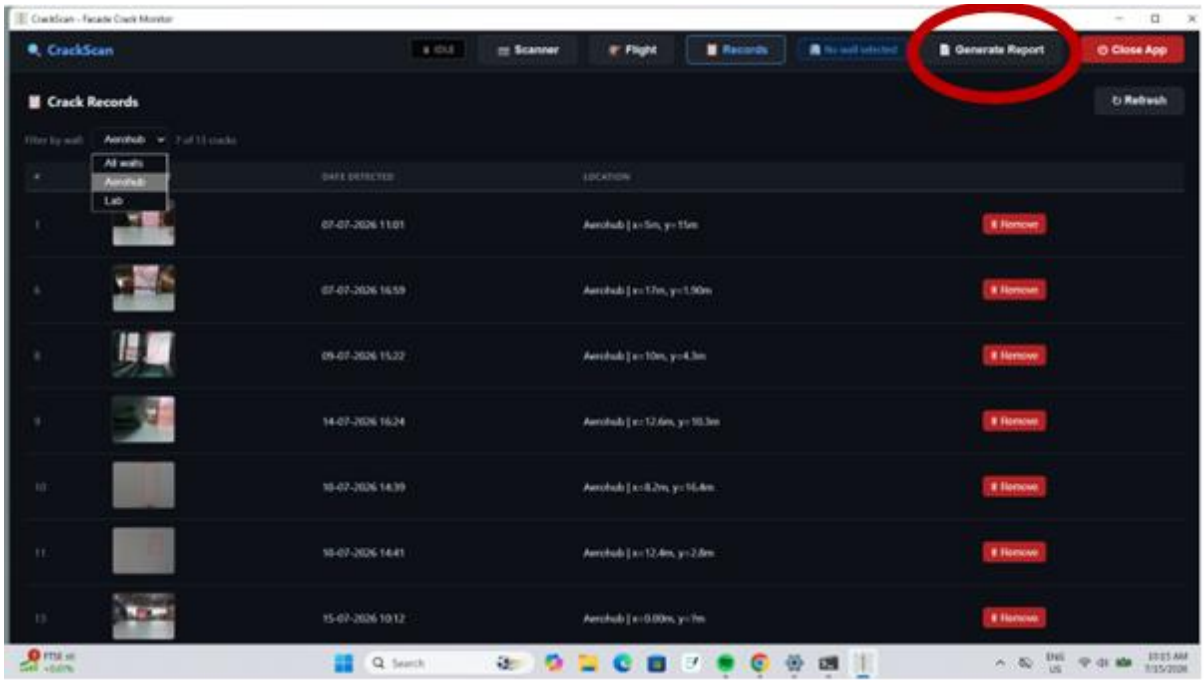


If multiple walls have been inspected, use the **Wall Selection** drop-down menu to filter records by the desired inspection surface for easier navigation and a cleaner workflow.

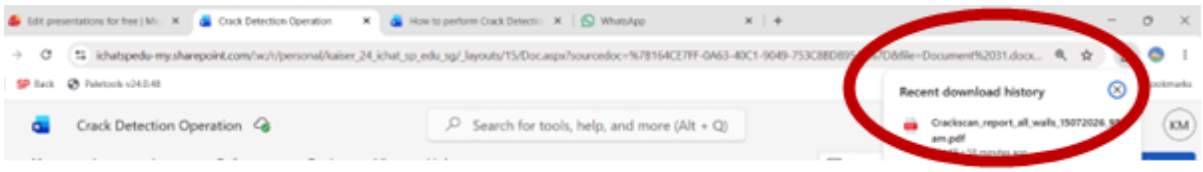

CrackScan
Scanner
Flight
Records
Generate Report
Close App
Refresh
All walls
Aerohub
Lab
DATE DETECTED
LOCATION
Remove

Step 8: Generate a PDF Report

To generate a summary of the inspection, click the **Generate PDF Report** button circled in Red



The default web browser will open, allowing for previewing and the downloading of the inspection report in PDF format for documentation or client submission.



By clicking on the download, the user will be able to access the generated report in a PDF format. A link to a sample report can be found here

4.0 Setting Up SkyScrub

This section outlines the basic steps taken for a flight test and drone operations in manual mode

4.1. Preparation and Conditions

Before commencing any flight, ensure that the operating environment, equipment, and personnel are suitable for flight. The operator and other relevant personnel should be fit, alert, and free from fatigue or any condition that may impair judgement or reaction time. All personnel involved in the operation should be familiar with their assigned roles and responsibilities.

Flight operations should be conducted in an open area that is clear of people, buildings, overhead obstacles, and other potential hazards to not jeopardise safety. Weather conditions should be favourable, with no rain, thunderstorms, or strong winds that may compromise flight stability or visibility, which may potentially damage the drone and the equipment.

Once these conditions have been verified, complete the following pre-flight equipment and inspection checklists before powering on the system.

Category	Items Required
Overall System	☐ Drone with all required components installed (camera pod optional for manual flight and flights with no inspection operations.) ☐ LiPo Battery Charger ☐ USB-C Charger ☐ Flight Batteries ☐ Flight Controller Batteries ☐ Battery Checker
Ground Control System	☐ Laptop with QGroundControl and CrackScan (if applicable) ☐ Futaba Controller ☐ Laptop Telemetry ☐ Router (if applicable)
Pressure Washing System	☐ Karcher Pump ☐ Cleaning Lance ☐ Extension Hoses ☐ Tap Adapters ☐ Nozzle Set
Tools and Fasteners	☐ Cable Ties ☐ Allan Keys (Manual) ☐ Allan Key (Electric) ☐ Torque Wrench ☐ Spare M3 Screws

Category	Items to be completed
General Inspection	☐ Ensure No loose components and connections on the drone ☐ Inspect for frayed cables or any physical damages
Battery	☐ Check Battery level using the battery checker (black lead to GND, red lead to positive with battery level above 95%)
Fasteners	☐ Tighten all general fasteners in a criss-cross manner with a force of 1 Nm using the electric Allen key ☐ Tighten the main fastener holding the arms in the folding arm tube joint with a force of 5 Nm with either a torque wrench or electric Allen key

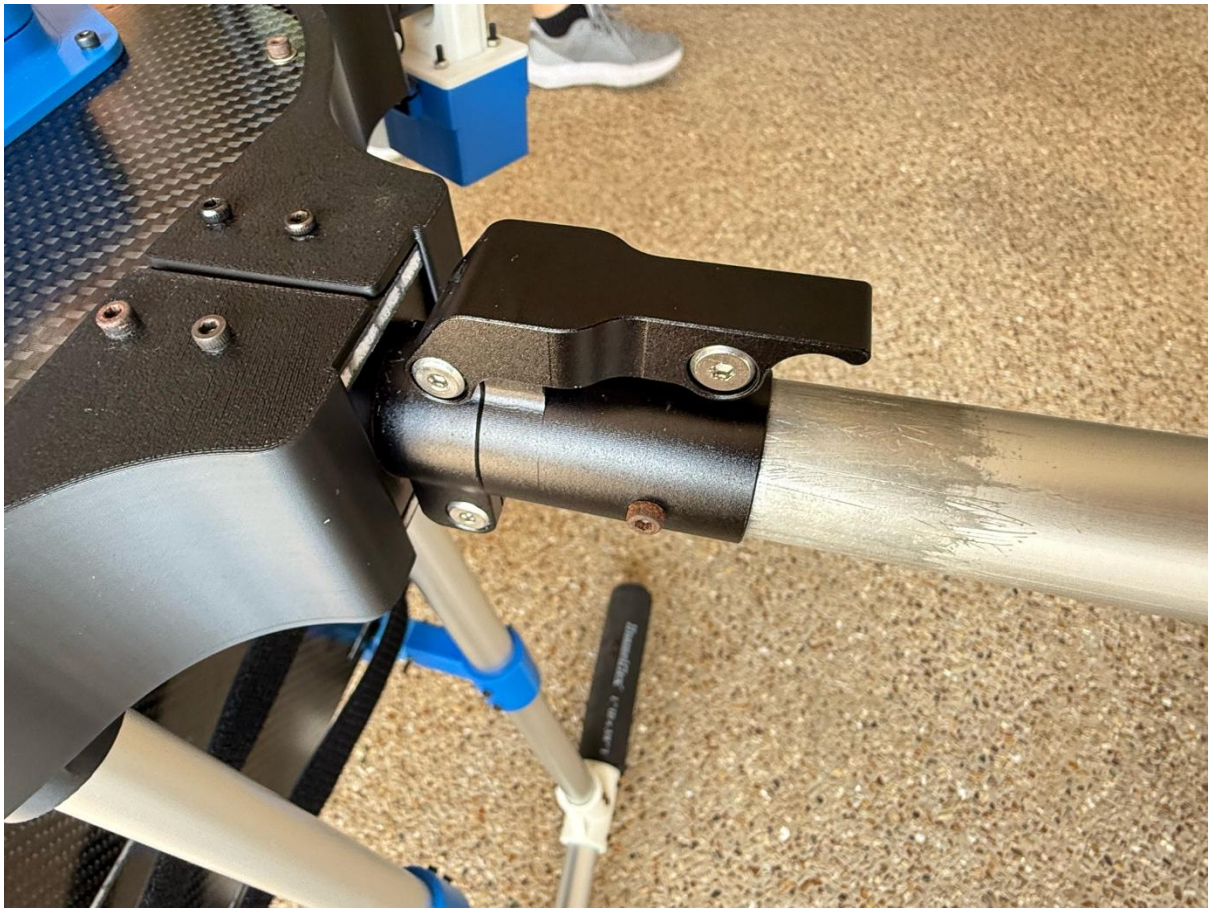
Step 1: Position the Drone

Ensure the area is level and free from loose objects or obstacles to ensure safe take-off and landing, prevent the drone from becoming unstable, and reduce the risk of rotor strikes, foreign object damage (FOD), and injury to personnel.



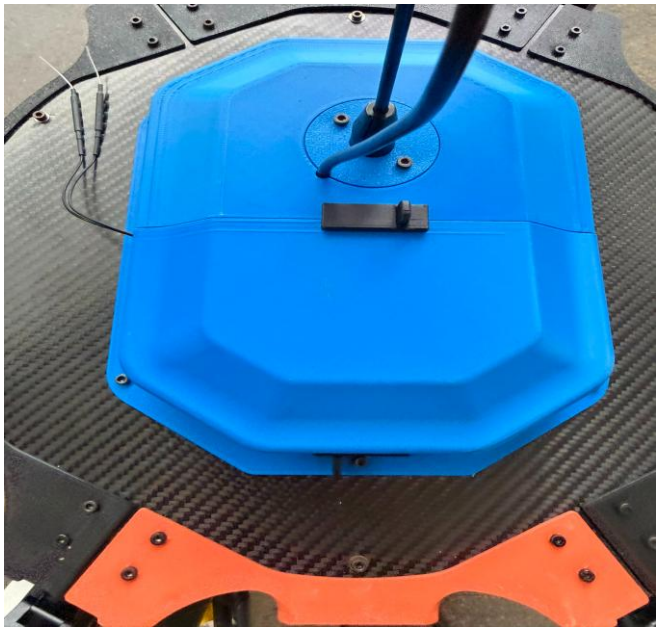
Step 2: Unfold and Secure the Arms

Fully extend each folding arm and confirm that every locking mechanism is properly engaged to allow easy access for the upcoming steps.



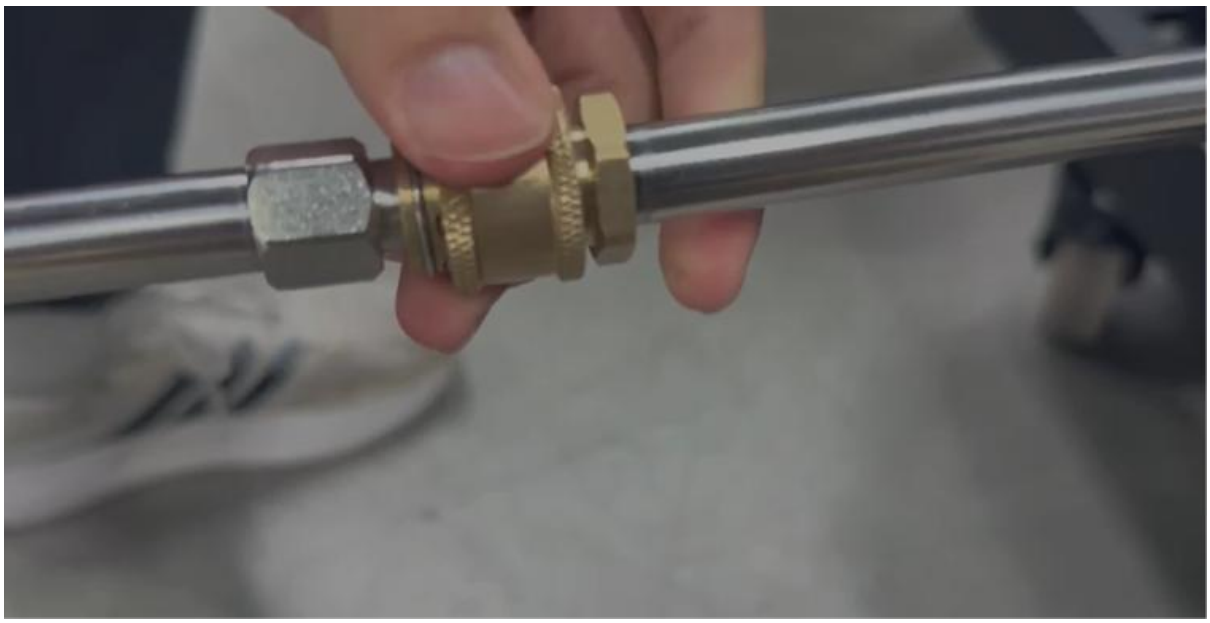
Step 3: Power the Flight Controller

Connect the XT60 battery to power the flight controller and close the enclosure with the 2 sliding latches facing opposite directions, as seen in the image below, circled in red and green.



Step **4: Attach the Pressure-Washing System**

Connect the hose and pressure-washer lance securely to the mounting point on the SkyScrub drone. Ensure proper connection to prevent leaks or disconnections



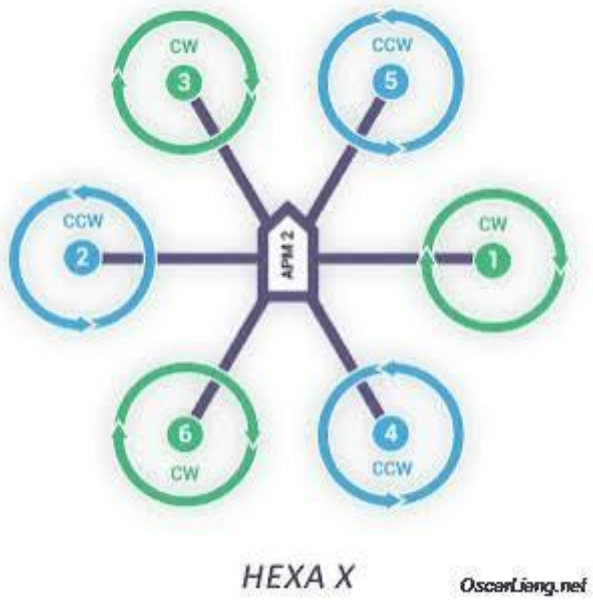
Step **5: Install the Propellers**

Install the propellers in the correct orientation. Tighten with hand tightening followed by a gentle final tightening using the manual Allen key to ensure a proper and secure engagement. (It must be done in this manner, or the props may get damaged).





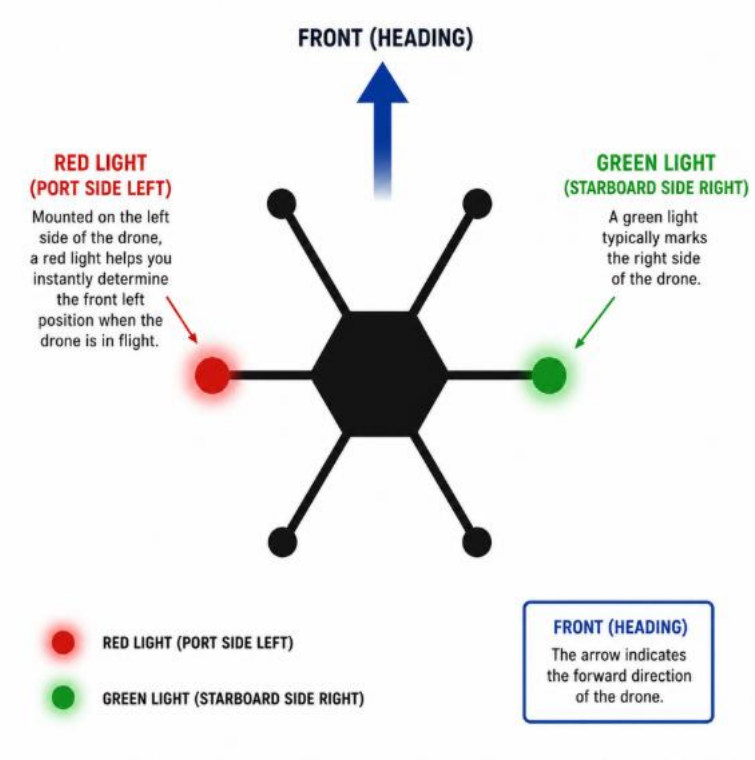
Ensure the propellers are installed in the correct orientation to generate thrust in the intended direction. Incorrect installation may result in loss of lift, unstable flight, or failure to take off. Install the propellers according to the motor rotation directions shown in the image below. Motors **1, 3, and 6** use **clockwise (CW)** propellers, while motors **2, 4, and 5** use **counterclockwise (CCW)** propellers.



HEXA X OscarLiang.net

Step 6: Turn on the Navigation Lights

The red light is on the port side, and the green light is on the starboard side to serve as heading indicators for the drone operator. Simply hold the button to power on and shuffle the colours if needed.



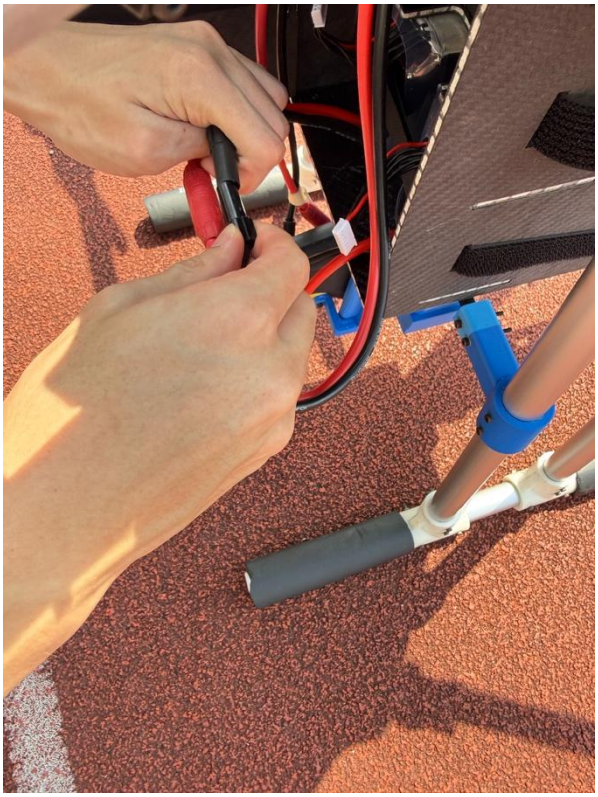
Step 7: Power on the Futaba T14SG Transmitter

Always power on the transmitter before connecting the main flight batteries. (MUST power on the transmitter before powering on the drone, as the receiver on the drone may latch onto a stray signal and spin motors unwantedly. This can cause a safety hazard as the user is not in control of the drone motors. Ensure all personnel remain a safe distance away.



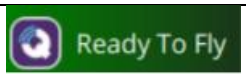
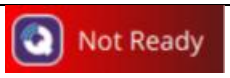
Step 8: Connect the Main Flight Batteries

Connect the batteries to the PDB, connecting the black connectors last, then secure the battery compartment. This order of connection must be followed as a safety rule to prevent short circuits and sparking. Do note that it is normal to hear a crackle when connecting the black connectors.



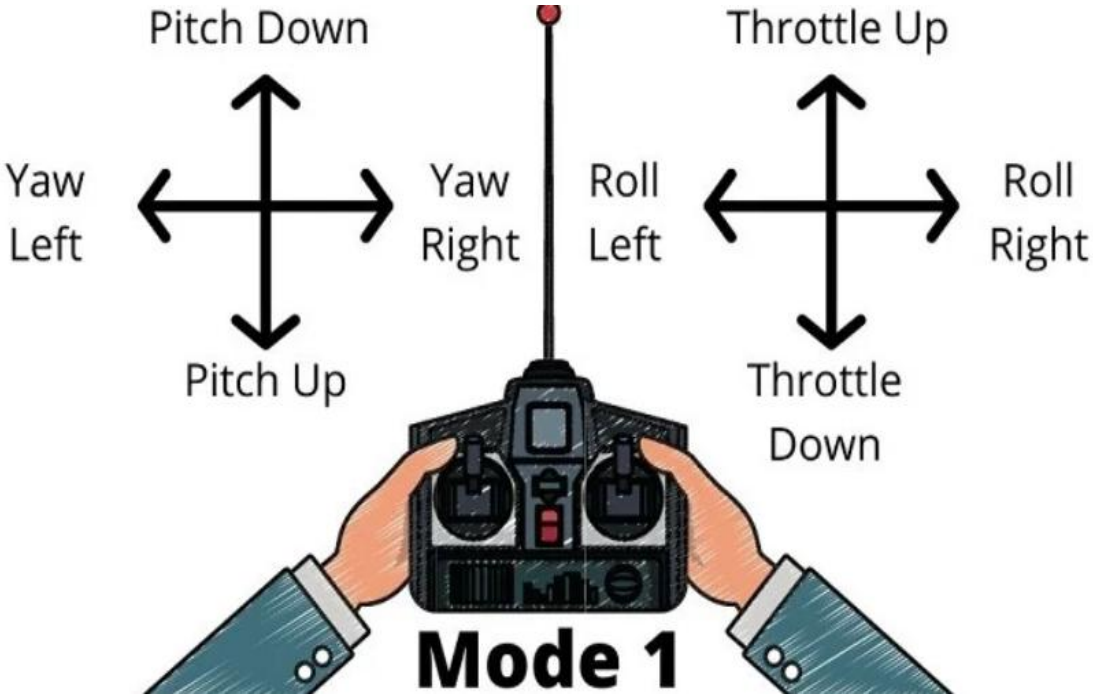
Step 9: **Verify 'Ready to Fly' Status**

Launch QGroundControl and wait for the connection status of the drone (top left corner) to show “Ready to Fly” with a green background. This confirms drone and GCS radios are connected and flight data can be monitored. Wait until the status indicator displays 'Ready to Fly' with a green background. A summary of the various statuses can be seen in the table below.

Status	Meaning
	Ready To Fly (green background) - Vehicle is ready to fly
	Ready To Fly (yellow background) - Vehicle is ready to fly in the current flight mode. But there are warnings which may cause problems.
	Vehicle is not ready to fly and will not takeoff.
	Vehicle is armed and ready to takeoff.
	Vehicle is in the air and flying.

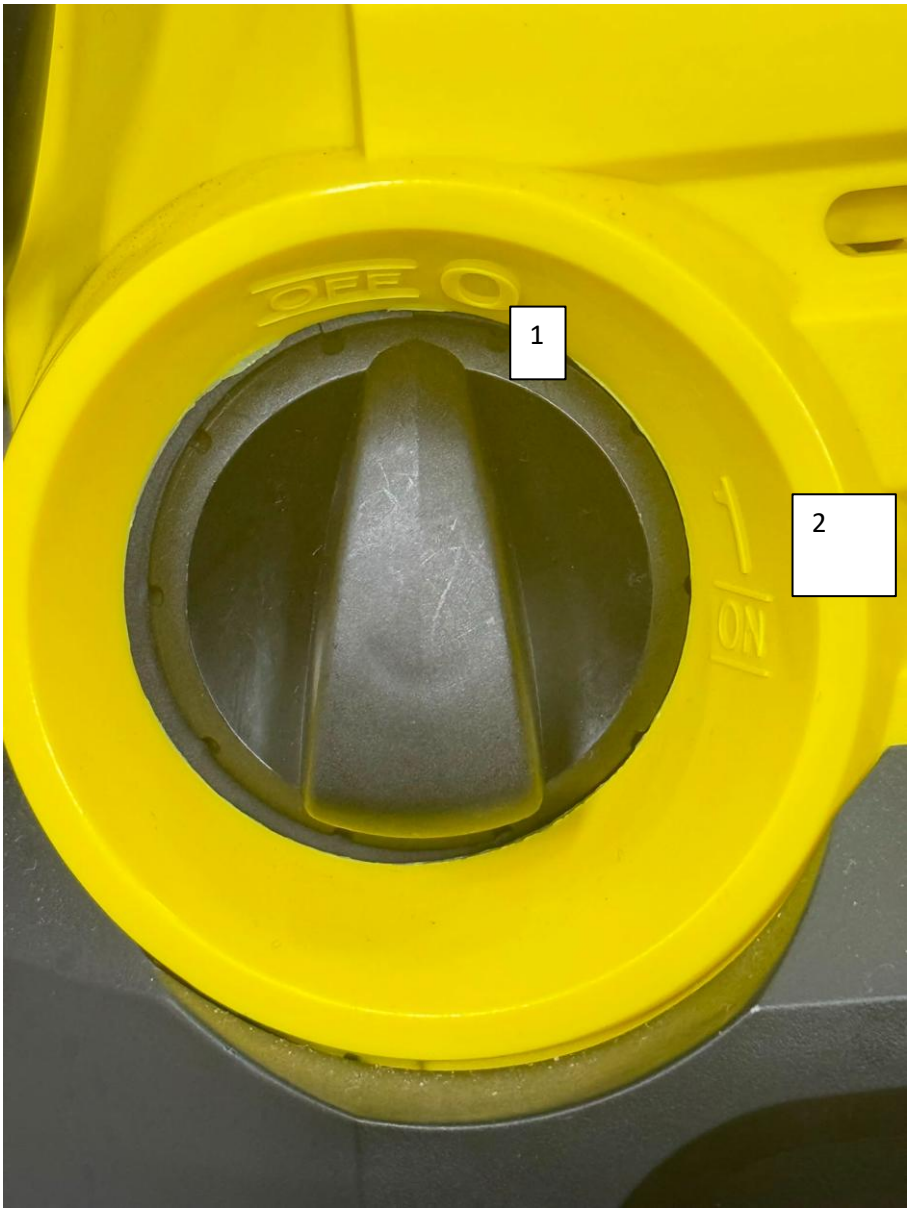
Step 10: Take-off

When ready to fly, ensure the throttle lever (lever on the right side of the transmitter) position is fully down. Flip the arming switch (the last switch on the top left of the Futaba) up. Slowly increase throttle to increase thrust until the drone lifts off. Below is a reference to flight controls for a radio transmitting in mode 1.



Step 11: Turn on the Pressure Washer Pump and Start Cleaning

Only activate the pump gradually after the drone has reached a stable hover. This allows the flight controller to stabilise the aircraft before compensating for the recoil force generated by the high-pressure water jet, ensuring safer and more controlled operation.



Step 12: Landing and Shutdown Procedure

When the cleaning operation is complete, turn off the pressure washer and slowly maneuver the drone to a clear landing area. Gently reduce the throttle while maintaining a stable descent until the landing gear makes full contact with the ground. Once the drone has landed, continue lowering the throttle until the motors stop completely. Disarm the drone. Finally, disconnect the flight battery (Black lead out first, followed by red lead) before powering down the remaining equipment for storage.