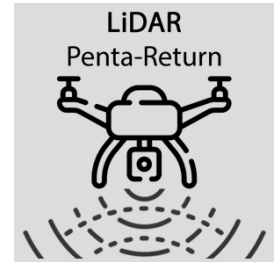


Oct 16, 2025

DroneScape: Collection of Penta-Return LiDAR for Ecosystem Plot Monitoring

DOI

<https://dx.doi.org/10.17504/protocols.io.n92ldn4w7v5b/v1>



Juan Carlos Montes-Herrera^{1,2,3}, Alice Robbins², Carla Franson^{1,3}, Troy Bektas^{1,3}, Ben Sparrow^{1,3}, Arko Lucieer²

¹Terrestrial Ecosystem Research Network (TERN);

²School of Geography and Spatial Sciences, University of Tasmania;

³School of Biological Sciences, The University of Adelaide

MontesHerrera

TerraLuma



Juan Carlos Montes-Herrera

University of Tasmania

Create & collaborate more with a free account

Edit and publish protocols, collaborate in communities, share insights through comments, and track progress with run records.

Create free account

OPEN  ACCESS



DOI: <https://dx.doi.org/10.17504/protocols.io.n92ldn4w7v5b/v1>

Protocol Citation: Juan Carlos Montes-Herrera, Alice Robbins, Carla Franson, Troy Bektas, Ben Sparrow, Arko Lucieer 2025. DroneScope: Collection of Penta-Return LiDAR for Ecosystem Plot Monitoring. **protocols.io**
<https://dx.doi.org/10.17504/protocols.io.n92ldn4w7v5b/v1>

License: This is an open access protocol distributed under the terms of the **[Creative Commons Attribution License](#)**, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited

Protocol status: Working

We use this protocol and it's working

Created: June 15, 2025

Last Modified: October 16, 2025

Protocol Integer ID: 220283

Keywords: uav, drone, monitoring, mapping, landscape, ecology, lidar, point-cloud, return lidar for ecosystem plot monitoring, aerial lidar data collection, drone protocol, creation of drone protocol, georeferenced color point cloud, dronescape, drone, ecosystem plot monitoring, return lidar, color point clouds with centimeter, georeferencing, dji zenmuse l2 sensor, hectare ecosystem plot, dji matrice, dji rtk base station, ready data products for tern

Disclaimer

In the context of this protocol, we use the term 'drone' to refer to a remotely piloted aircraft system (RPAS) also referred to as uncrewed/unoccupied aerial vehicle (UAV) or uncrewed/unoccupied aircraft system (UAS). This protocol assumes that the operator is already familiar with the assembly of the DJI Matrice 350 drone as outlined in the DJI Official User Manual. It is not a substitute for the comprehensive assembly instructions in the manual.

Approvals and procedures for land-access, permits, drone operations, and compliance as per national regulations (e.g., **[Australian Government Civil Aviation Safety Authority \(CASA\) regulations](#)**) are outside the scope of this document. The protocol is best used with two staff: a pilot and a spotter.

Abstract

This protocol describes the procedures for deploying an DJI Matrice 350 equipped with a DJI Zenmuse L2 sensor for aerial LiDAR data collection of **1-hectare ecosystem plots**.

The protocol includes flight planning and data collection procedures to cover a 100 × 100 m (1 ha) area, with a varying margin of 0 to 100 m (up to 300 × 300 m). Georeferencing is achieved using a DJI RTK base station. The expected result is the generation of georeferenced color point clouds with centimeter-level accuracy. The steps outlined here support the creation of drone protocols and analysis-ready data products for **TERN**'s programs.

Image Attribution

Flaticon.com & Juan C. Montes-Herrera



Guidelines

- Approvals and procedures for drone operations and compliance as per flying regulations are outside the scope of this document.
- Coordinate with local authorities and landowners to ensure all permissions and road access, are obtained before conducting flights.
- Ensure all drone operations comply with official aviation safety regulations. For Australia, check Civil Aviation Safety Authority (CASA) regulations and the organization's ReOC processes.
- Pilot must be certified to operate the DJI Matrice 300/350 RTK and be properly trained.

Materials

- Google Earth Pro for mission preparation.
- Single Gimbal DJI M300 or M350
- Remote controller and charger.
- DJI D-RTK2 Mobile Station antenna, tripod and extension rod.
- Tablet or phone
- Spare propellers
- Matrice battery charging station
- M300 or M350 batteries (x8)
- USB-C cables (x2)
- D-RTK2 batteries (x4)

Tools:

- Laptop for data backup, formatting cards, etc.
- SD and microSD card reader
- Sturdy rubber mat to launch/land drone
- DGPS unit
- Star pickets, filing tool, battery-powered engraver, and flagging tape to mark the location of D-RTK2 base if site revisit is likely
- Case to secure and store memory cards
- Tool kit with spare parts: gimbal grommets, spare gimbal covers and lens caps, spare screws of types used; screwdrivers, and cable ties.
- First aid kit
- Radios and air band radio
- Generator (if required to charge batteries in the field).

Memory Card Specifications and Storage Capacity

Below are the specifications and requirements for memory cards used with each sensor, including recommendations for sufficient storage capacity per field day, which typically involves capturing data from 3 to 5 plots (16 ha each).

Zenmuse L2

- *Recommended Memory Card:* microSD UHS-I Speed Grade 3 rating or above, sequential writing speed 50 MB/s or above, Max capacity: 256 GB.

Backup Storage

- Two Portable 4 TB SSDs for efficient data backup.
 - Recommended Product: Samsung T7 Shield 4TB USB-C Portable SSD.



Troubleshooting

Problem

Unable to lock sensor to Gimbal

Solution

Press release button and manually rotate the gimbal to the unlocked position.

Safety warnings

- ❗ - Store batteries in a dry, ventilated area at room temperature and avoid leaving them unattended in vehicles.
- Ensure battery cases are labeled for transport (e.g., Class 9 - Miscellaneous dangerous goods)
- Do not operate the drone in rain, precipitation, or wind speeds exceeding 18 m/s.
- Ensure flight operations are paused if obstacles or hazards are detected in the surroundings.
- Comply with official aviation safety regulations.

Ethics statement

- Avoid disturbing wildlife.
- Annotate any birdlife interaction and evasion maneuver if needed.
- If needed, use non-invasive reference points for marking D-RTK2 base stations in protected or sensitive areas, such as close to roads and national parks.
- Adhere to ethical data collection practices that prioritize safety, accuracy, and minimal environmental impact.



Before start

Before departure

- Inspect all drone equipment for visible damage or wear, including airframe, propellers, sensors, landing gear, and batteries.
- Verify latest firmware is installed on all devices, including the drone, sensors, remote controller, and base station. **Note:** *Some labs may have specific protocols for firmware updates or may prefer that a designated person carries out this task. Always check with lab-specific procedures before proceeding.*
- Charge all batteries to full capacity one day before the mission, and store in LiPO safe storage. Do not use damaged or swollen batteries.
- Verify that memory cards are properly formatted and sufficient storage is available for fieldwork.
- If unsure of internet access in the field, pre-cache study area imagery in the DJI Pilot app before departing for fieldwork.

Flight Operational Safety

- Manually check and calibrate the compass at each site after significant travel distance.
- Ensure mapping mission is safe and spatially accurate.
- Ensure sensor is secured and working correctly.
- Use manual takeoff and landing to maintain control, particularly in areas with uneven terrain or obstructions.
- Maintain constant communication between the pilot and spotter, especially near roads or other potential hazards.
- Always monitor the drone speed, altitude, and battery levels during the mission to ensure safe operations.
- Monitor correct sensor exposure, gimbal position and angle during mission flight time, use the multiple view options (e.g., L2 camera view or FPV).

Field cheat sheet - LiDAR mapping mission settings

1 **dronescape: Penta-Return LiDAR field cheat sheet**

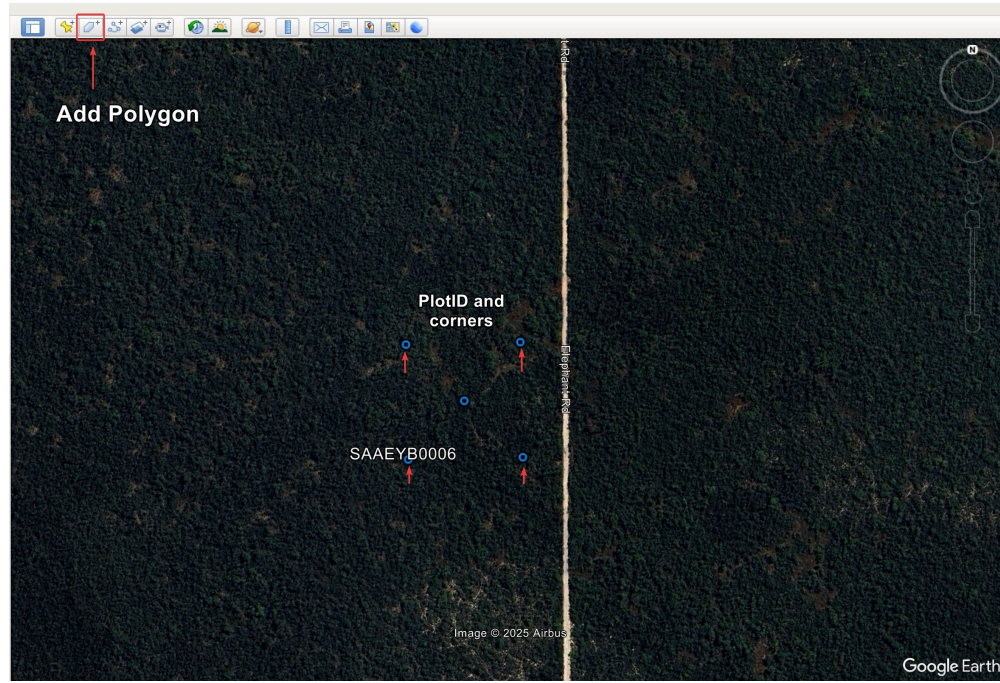
	Parameter	Value	Note
	General Settings		
	Area Route	YYYYMMDD-PlotID-L2	E.g. (20250120-NTAFIN0011-L2)
	Aircraft	M300/M350 RTK	
	Camera Model	L2	
	Lens	LiDAR Mapping	
	Payload Settings		
	Return Mode	Penta-Return	
	Sampling Rate	240 KHz	
	Scanning Mode	Repetitive	Consider Non-Repetitive for structurally complex vegetation. Based on findings from Gassilloud et al. 2025.
	RGB Coloring	Enabled	
	Route Altitude	50 m	
	Elev Optimization	Enabled	
	Safe Takeoff Alt	20 m	Pilot to assess.
	Speed	5 m/s	
	Course Angle	0	
	Upon Completion	Return to Home	Pilot to assess.
	Advanced Settings		
	Target to Surface (TS)	0	Pilot to assess (see Table in Mission Planning section)
	Side Overlap (LiDAR)	52%	Pilot to adjust based on TS
	Forward Overlap (Visible)	70%	Increase to 80% if TS > 25 m
	Margin	100 m	Pilot to assess if needs to be reduced; roads, land property, safety, etc.

Parameter	Value	Note
Photo Mode	Timed Interval Shot	
Custom Camera Angle	Disabled	
Route Start Point	-	Set to the farthest point from takeoff.
Takeoff Speed	Default	Manual takeoff recommended.
L2 Sensor Settings		
Capture Mode	S - Shutter Priority	
ISO	Auto	
Shutter Speed	1/1000 sec	
Aperture	Auto	

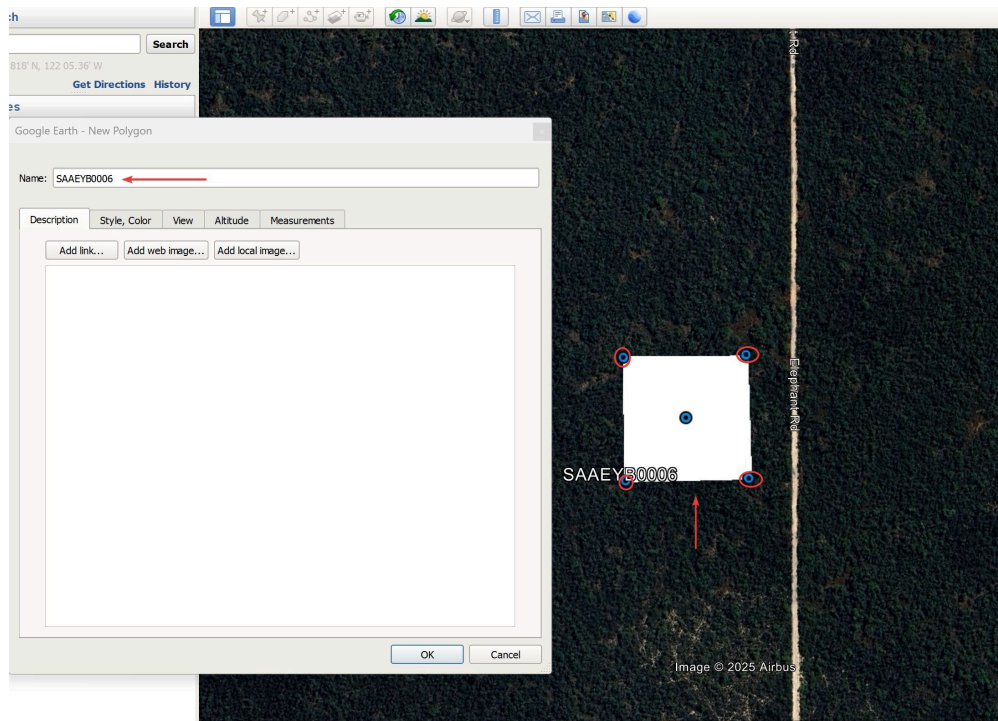
LiDAR flight mission planning settings in DJI Pilot 2 app for quick use in the field.

Mission Planning - Google Earth Polygon (or preferred GIS)

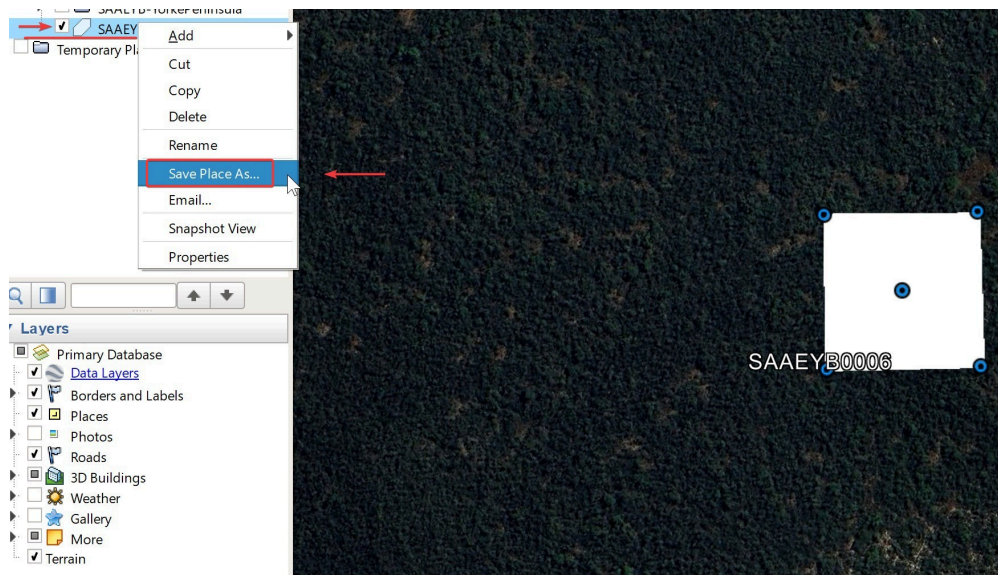
- 2 **Note:** If a historical polygon in a compatible format (e.g., .KML or .SHP) is available, can skip to section 3.
Open Google Earth Pro to create KML files for each 1 ha plot to be surveyed during field trip.
- 2.1 Load KMZ file of plot corners or polygon area to be mapped. If not available, navigate to the area of interest to create polygon.
- For existing plots refer to previous documentation to download exact coordinates for each plot corner.
- 2.2 Within Google Earth click 'Add Polygon'



- 2.3 Notice cursor icon change (white cross box on map screen), click **once on each plot corner** (red circles).
 Name polygon, best to use standardised Plot ID.
 Click OK



- 2.4 - Right click Polygon layer on sidebar, then 'Save Place As...'
- Save as KMZ file.



- 3 - Store in the **DJI controller memory** via **USB cable** or **microSD card**.

4 **Advanced: Assessing topographic complexity of study area.**

For monitoring plots established with steep slopes or elevation changes, enabling Terrain Follow in the flight mission settings during data collection is recommended to ensure consistent image overlap.

Selecting the appropriate **Terrain Follow** parameter and Digital Elevation Model (**DEM**) is dependent on the drone platform and the study area.

Options for Terrain Follow:

1. Import Local File (recommended): review the spatial data available for the study area using (e.g., for Australia; **Elvis – Elevation and Depth – Foundation Spatial Data**).

Availability of elevation data can be limited in remote areas.

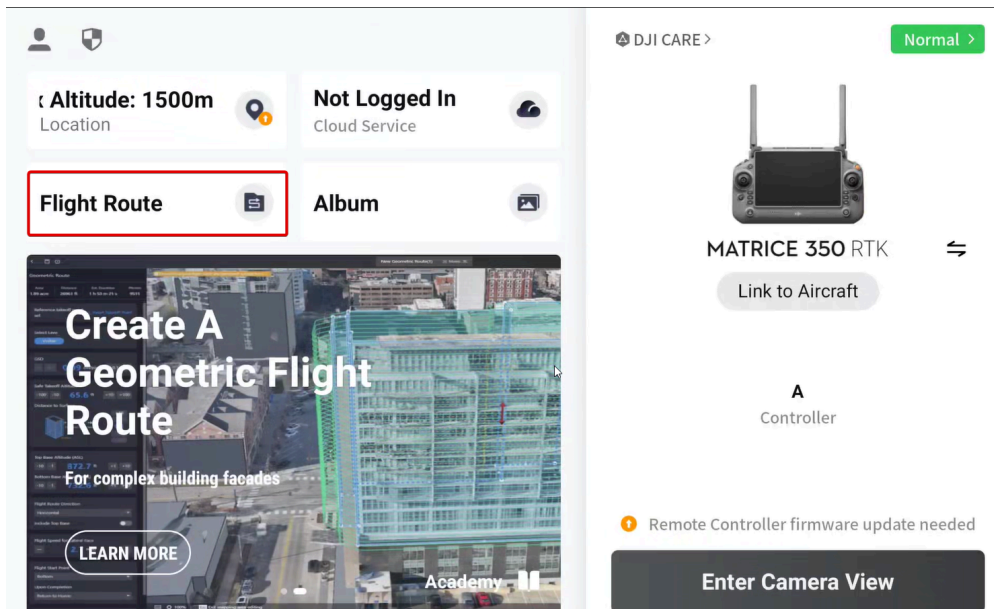
- If there is a suitable elevation model available for the study area, select the data required and complete the relevant fields to order data from online provider.
- It is critical to select **WGS84 Lat/Longs (EPSG:4326)** to ensure the local DEM is compatible with DJI Pilot 2.
- The local DEM can be imported directly onto the drone controller or onto a microSD card and selected during mission planning

2. Download directly from **DJI Pilot** during mission planning (below): if this option is selected in DJI Pilot 2 during mission planning (Altitude Mode → AGL → DSM Files → Download from Internet) the **ASTER Global Digital Elevation Map (GDEM)** will be used for Terrain Follow.

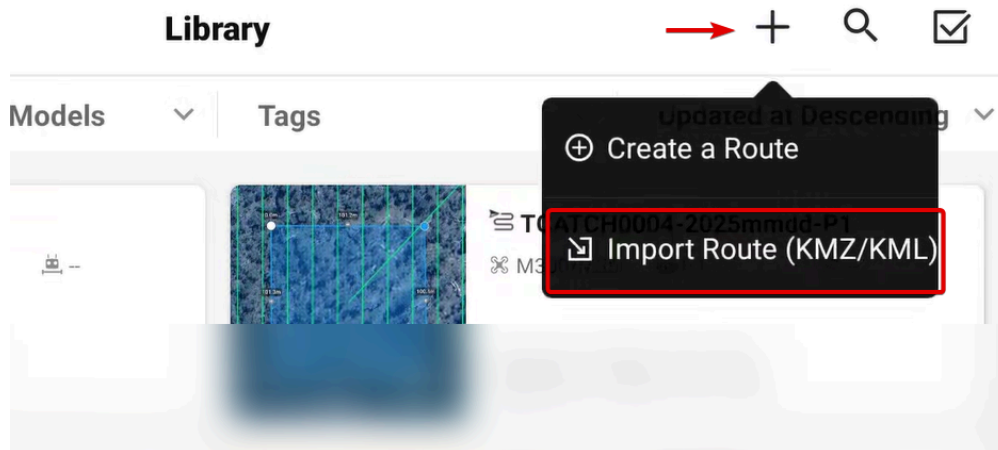
- The resolution of this DEM is approximately 30 metres and caution should be taken with using this elevation model in complex terrain or to map complex/tall vegetation.

Mission Planning - DJI Pilot App

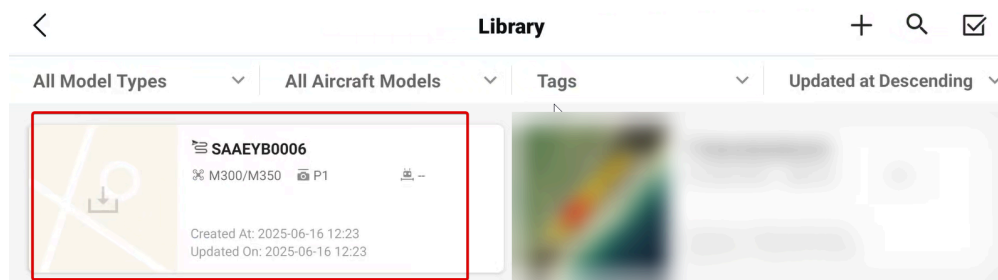
- 5 Prepare **2D mapping mission** settings with **DJI Controller**
- Select Flight Route



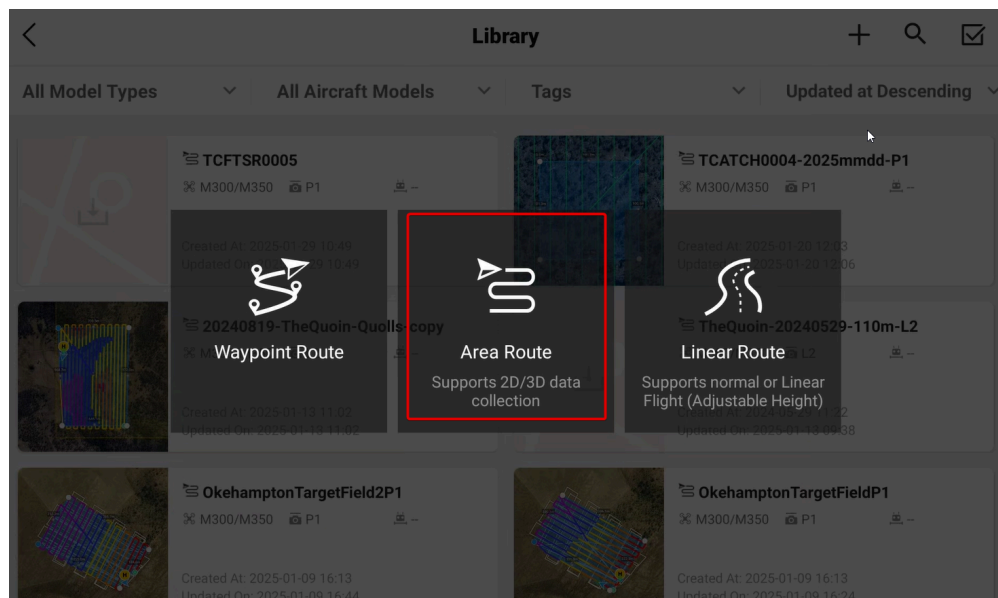
- Within the Library, press '+' icon on top right → Import Route (KMZ/KML)



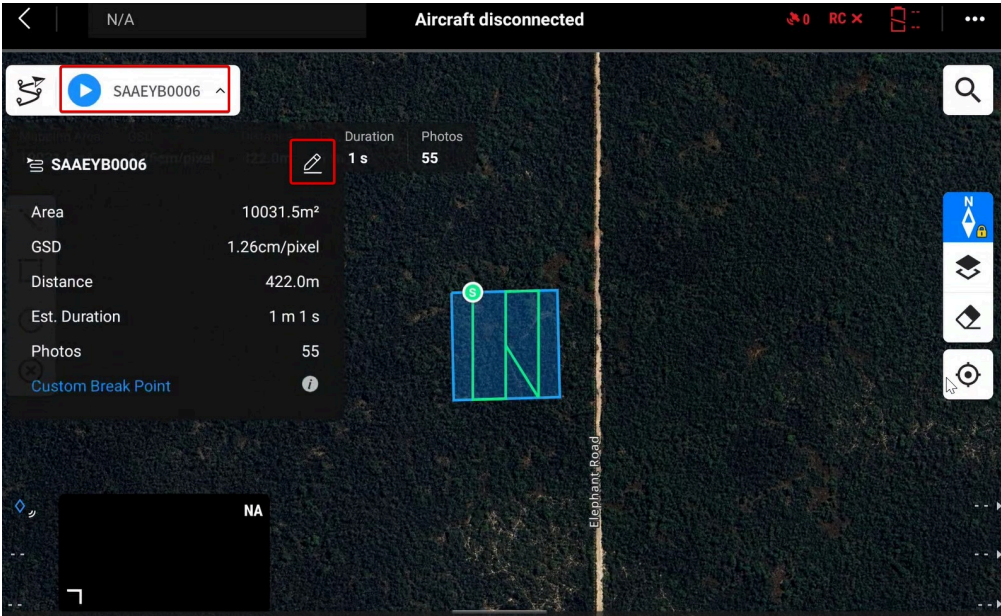
- Load mission by navigating the memory to the KMZ file stored in previous step.



- Select Area Route



- On the top left, toggle the mission menu, and click the 'Edit' icon (Pencil)



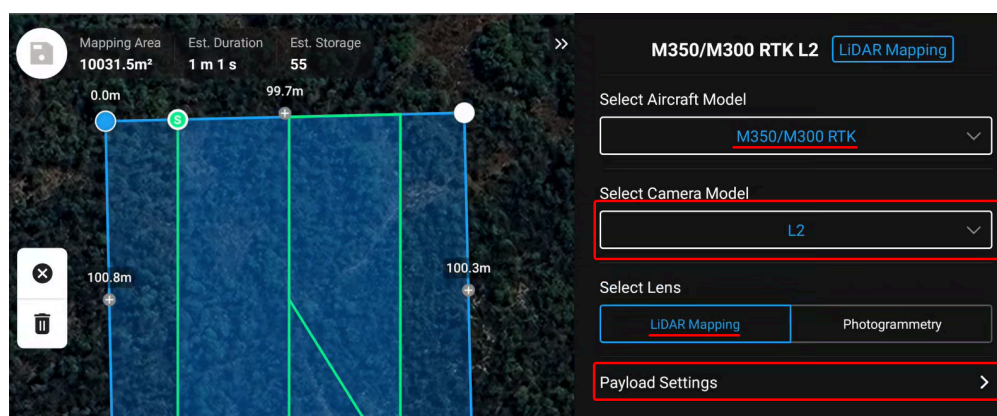
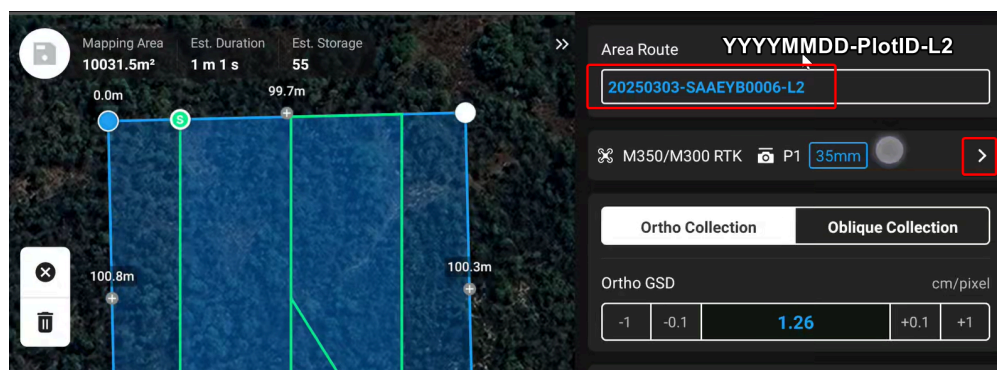
6 Table I. LiDAR mapping settings for Zenmuse L2

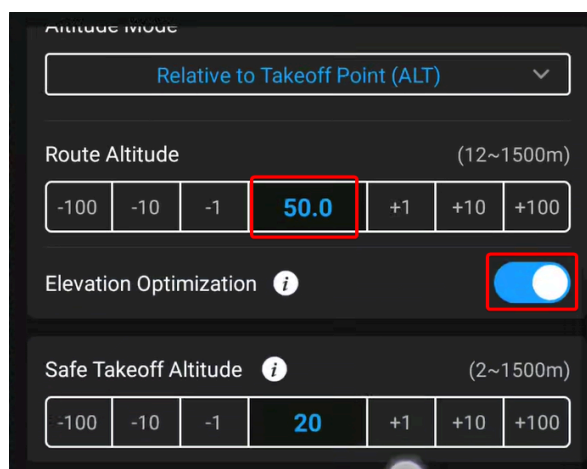
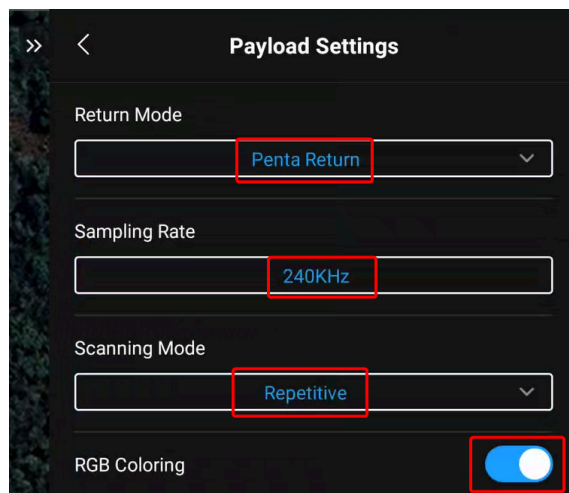
	A	B	C
	Parameter	Value	Note
	Area Route	YYYYMMDD-PlotID-L2	E.g. (20250120-SAAEYB0006-L2)
	Aircraft	M300/M350 RTK	
	Camera Model	L2	
	Lens	LiDAR Mapping	
	Payload Settings		
	Return Mode	Penta Return	
	Sampling Rate	240 KHz	
	Scanning Mode	Repetitive	Consider Non-Repetitive for structurally complex vegetation.
	RGB Coloring	Enabled	
	Route Altitude	50 m	
	Elev Optimization	Enabled	

	A	B	C
	Safe Takeoff Alt	20 m	Pilot to assess.
	Speed	5 m/s	
	Course Angle	0	
	Upon Completion	Return to Home	Pilot to assess.

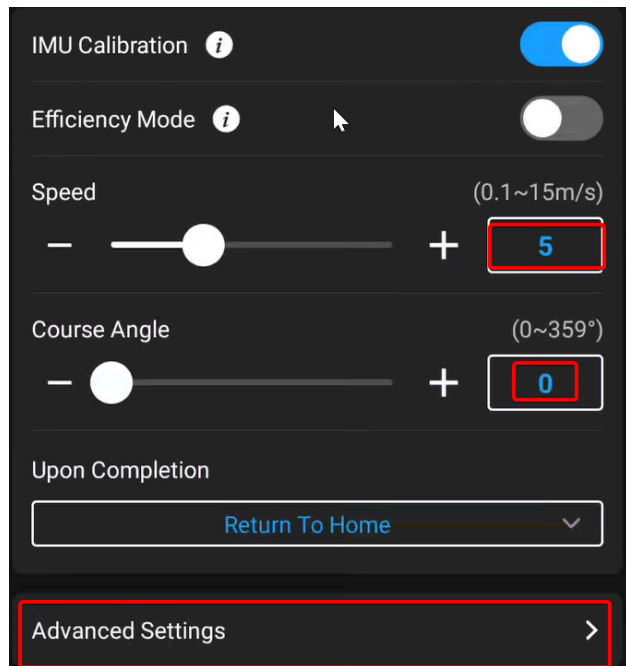
7 Mapping Mission - General Settings

A panel to edit the mapping mission settings should appear on the right. Follow the table below to adjust the general mapping settings.





8



9 Mapping Mission - Advanced Settings

Target Surface to Takeoff Point

- Target Surface to Takeoff Point parameter depends on canopy height (CH) and terrain complexity.
- Similarly the difference in terrain between plot and the drone takeoff area must be considered when setting a suitable target surface.
- This is essential to ensure that the overlap calculations are applied appropriately. When the terrain to map and the takeoff point differ in elevation, set this to the distance from the takeoff point to the target surface.
- For tall canopies >30 m, flight altitude might be automatically changed by the DJI Pilot App, assess for flight regulations and safety.

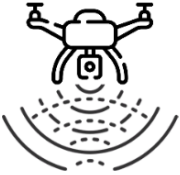
LiDAR Advanced Mission Settings for Different Canopy Height			
   			
Canopy Height (CH):	0 to 25 m	25 to 40 m	40 to 80 m
Flight Altitude:	50 m	70 m	100 m
Speed:	5 m/s	5 m/s	5 m/s
Target Surface to Takeoff Point:	CH < 10 = 0 m CH 10 to 15 m = 5 m CH 15 to 25 m = 10 m	Representative CH	Representative CH
Side Overlap (LiDAR):	52 %	65 %	75 %

Table II. Advanced settings for LiDAR mapping with Zenmuse L2

A	B	C
Parameter	Value	Note
Target Surface (TS)	0	Pilot to assess.
Side Overlap (LiDAR)	52%	Pilot to adjust protocol based on TS
Forward Overlap (Visible)	70%	Increase to 80% in TS above 25 m
Margin	100 m	Pilot to assess if needs to be reduced; roads, land property, safety, etc.
Photo Mode	Timed Interval Shot	
Custom Camera Angle	Disabled	
Route Start Point	-	Set to the farthest point from takeoff.
Takeoff speed	Default	Manual takeoff recommended.



 **Advanced Settings**

Target Surface to Takeoff Point

(-200~1500m)

-100

-10

-1

0.0

+1

+10

+100

Side Overlap (LiDAR)

(10~90%)

-100

-10

-1

52

+1

+10

+100

Side Overlap (Visible)

62%

Forward Overlap (Visible)

(10~90%)

-100

-10

-1

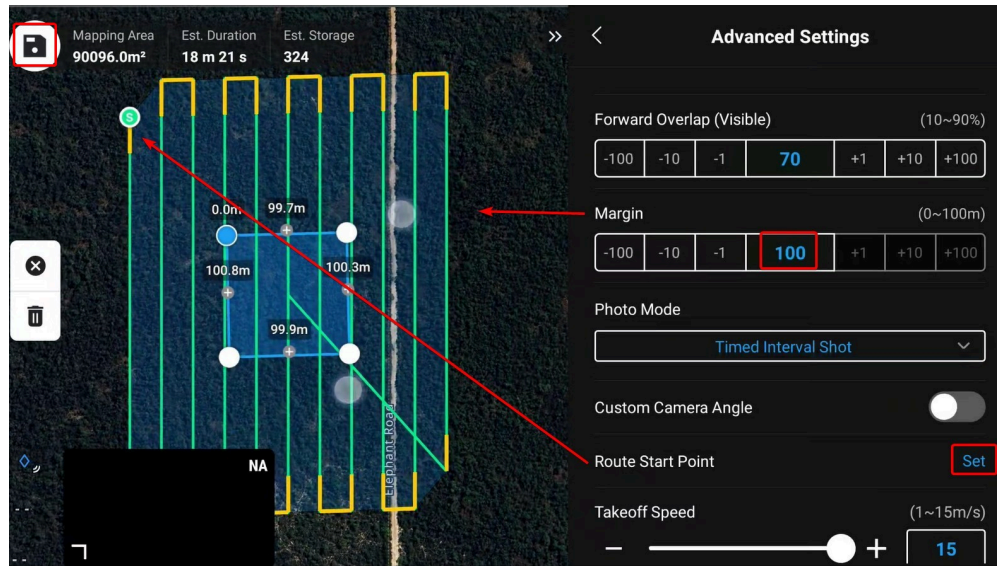
70

+1

+10

+100

- **Important:** For safety, the final flight **margin** should be determined in the field. However, previous mission planning helps to anticipate any constraints, such as roads or private land, that may cause a reduced margin.



Save Mission

- 10  **Double-check flight estimated duration, altitude, route, and any modified settings.**



In the Field: D-RTK2 Base Station Setup

- 11 The dual frequency RTK GNSS in the M300/M350 enables direct georeferencing of images using DJI D-RTK2 base station.

Navigate with the DGPS pole, tablet for DGPS app, and the DJI D-RTK2 base station (ensure full battery), towards a plot corner easily accessible from the drone launch area.

Note that the preference is to use the plot corner closest to drone launch area. The base station must be in an open area to prevent GNSS signals from being blocked. In woodlands or dense canopies look for flat open ground within 15m of the corner, if not viable locate a suitable area close to the plot corner (within 200m).



D-RTK2 base station established on top of a permanent marker stake in proximity to a plot corner. Below the hammer used for grounding stake, and DGPS blue pole used for coordinate retrieval.

12 **Permanent Marker Establishment**

As necessary, the plot corners can also be used as a permanent marker for future surveys, without need of a ground stake.

Stake ground exactly where DGPS point is intended to be collected.



- If using short stake (45cm) – hammer flush with surface and cap.
- If using taller stake (150cm) – hammer 1/3rd into substrate and cap.

In some cases, harder or rocky substrates may prove difficult to drive in a stake resulting in partially exposed stakes. In this situation the height of the stake after being capped must be measured and subtracted from the 1.8m pole so that the height of the pole remains 1.8m from the ground when placed on top of the capped stake.



Capped ground stake used as central position for D-RTK2.

13

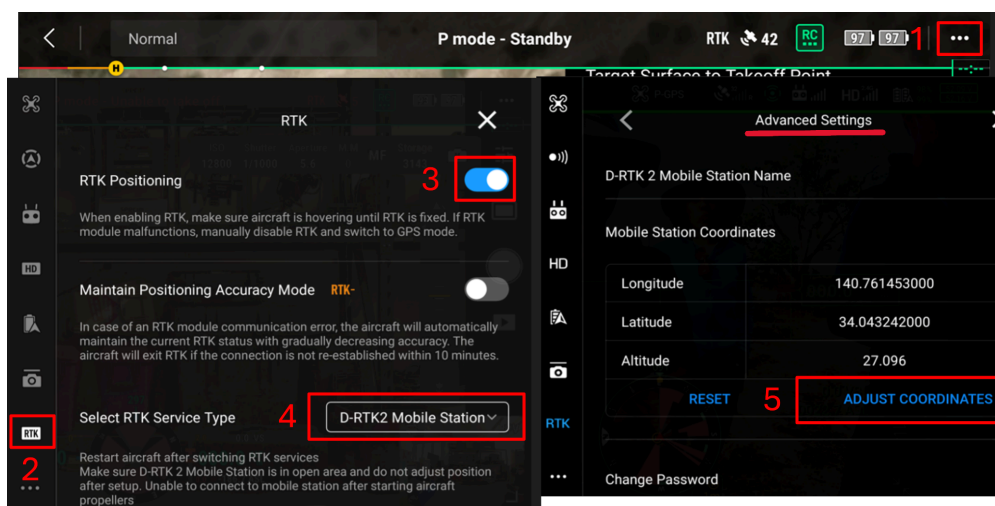
- Check that the battery in D-RTK2 antenna is fully charged.
- Power up the antenna by clicking Power button twice and hold.
- Ensure the third LED (left to right) has a blinking pattern of 5 times. This indicate DRTK is operating in Mode 5. If necessary, long press the Mode button for 2 seconds to change Mode.



- Take a photo of the entire base station and include this in the metadata folder with the raw data.

14 Adjust D-RTK2 base station coordinates.

1. Open the Mission screen on the DJI Pilot App
2. Press '...' on the right side of the main menu
3. Go to RTK and **toggle RTK Positioning ON**
4. Set RTK Service Type to D-RTK2 Mobile Station
5. Open Advanced Settings (password: 123456)
6. Select ADJUST COORDINATES and enter the known DGPS coordinates for the plot corner.



14.1 Adjusted coordinates:

- If DGPS provides Latitude, Longitude, and Altitude (from a DGPS list or direct reading): Enter Lat/Lon (8 decimal places) and add 1.8 m to the DGPS Altitude.
- If only Latitude and Longitude are available: Enter them and leave altitude as is.

Press Save and restart the aircraft.

If a persistent RTK base station error appears, restart the base station, **verify the coordinates**, and restart the aircraft.

14.2 Check RTK settings:

- D-RTK2 Mobile Station Status is connected.
- Base station coordinates have been updated.
- Aircraft Orientation and Positioning **FIX** status.
- RTK icon on top displaying number of satellites.



	aircraft	Station
Orientation:	FIX	
Positioning:	FIX	
Latitude:	34.044785499	34.043242000
Longitude:	140.761593271	140.761453000
Ellipsoidal Height	105.559	27.096
Course Angle:	89.4	

Prepare Aircraft and Sensors

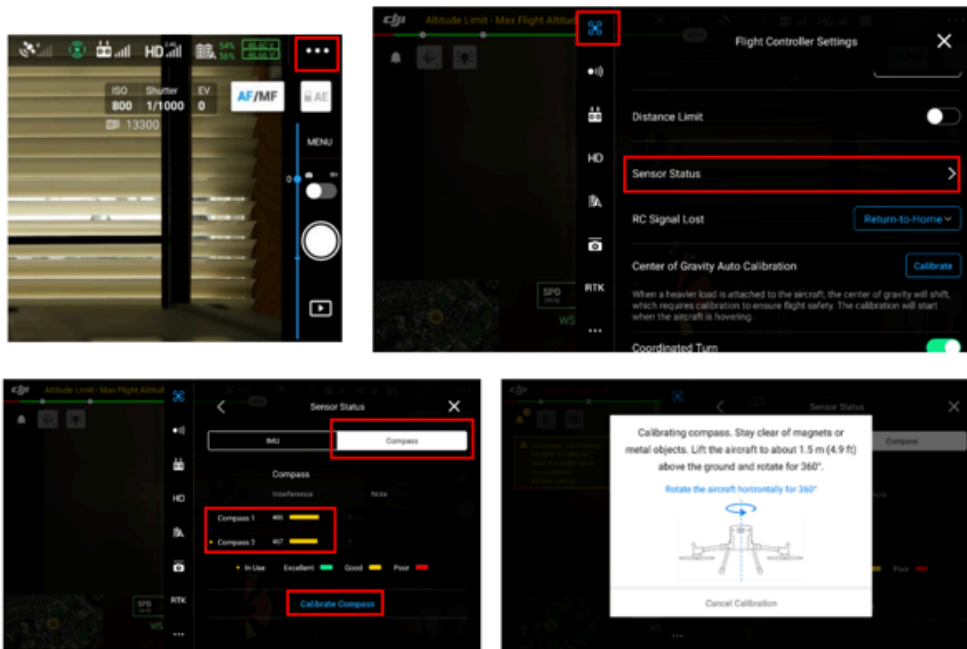
- 15 This protocol assumes that the operator is already familiar with the assembly of the DJI Matrice 350 RTK aircraft as outlined in the DJI Official User Manual. It is not a substitute for the comprehensive assembly instructions in the manual.

- **Check Components:** Confirm all parts, including aircraft, propellers, batteries, controller, dual-gimbal, and downwelling light sensor (DLS) are present, and in good

conditions.

- **Install Batteries:** Insert **fully charged** batteries until they click into place, ensure to **use labeled pairs**.
- Turn **ON** Aircraft.

- 16 **Compass calibration** must be performed at all sites following significant travel. It is recommended to do this step before the sensors are installed to avoid damaging the sensors or gimbal dampeners. To calibrate the compass, follow the steps below:
- Click on the '...' on the right-hand side on the main screen
 - Click on the drone image in the following screen to access 'Flight Controller Settings'. Scroll down and select 'Sensor Status'.
 - Click on the Compass tab. Click on 'Calibrate Compass' and follow on-screen instructions to calibrate the compass. The process involves rotating the aircraft around the vertical and horizontal axes.



17 **Install DJI Zenmuse L2 (LiDAR sensor)**

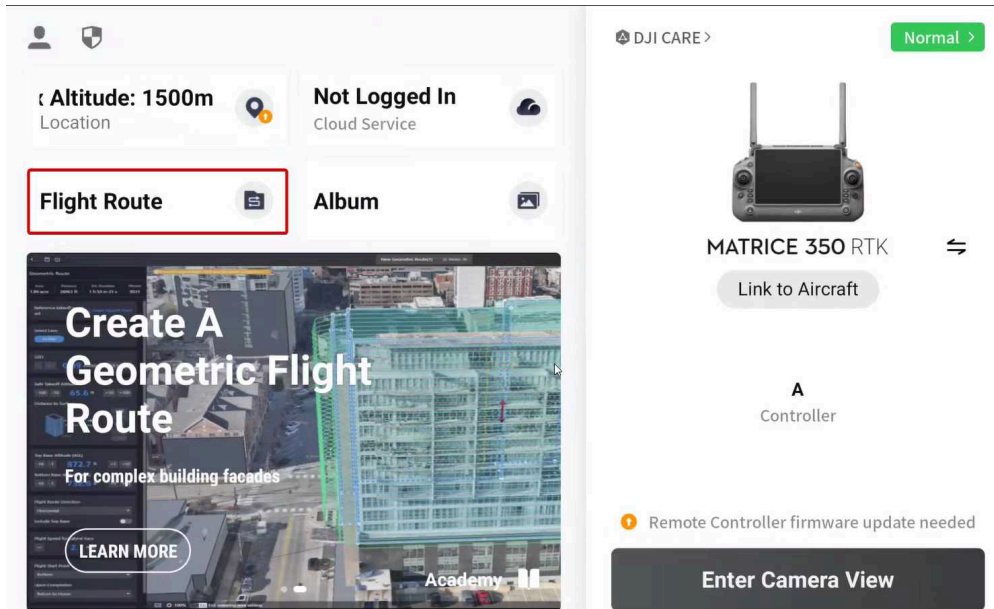
- Check that Zenmuse L2 sensor has an empty microSD card.
- Press the gimbal detachment button to release the cover.
- Align the white dot on the Zenmuse L2 with the red dot on gimbal to connect the sensor. Rotate the gimbal lock to the locked position (red dots aligned).
- If unable to rotate gimbal lock, it is possibly stuck. While pressing the gimbal button, manually rotate the lock to its unlocked position (white dot).



Zenmuse L2 Settings

18 Preparing to fly

- Load the previously saved Mission File from the Flight Route Library.



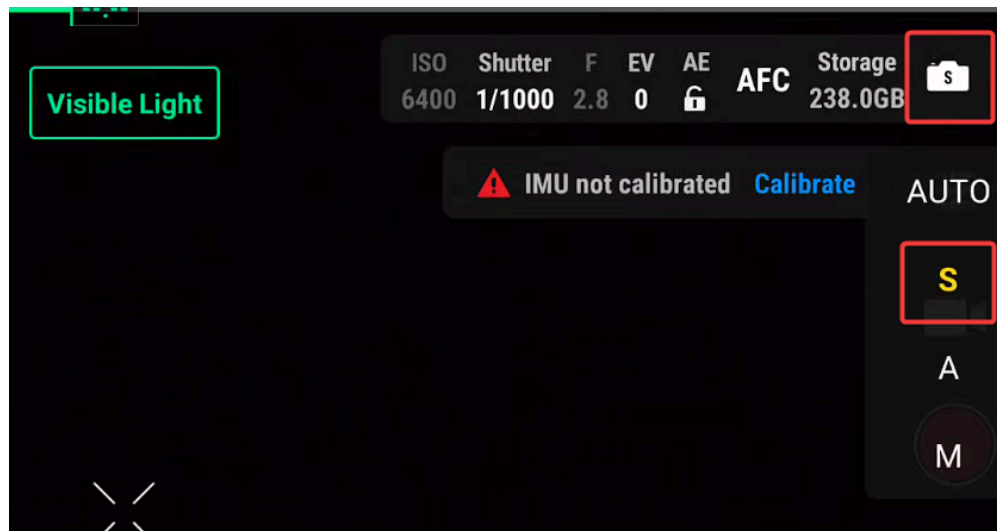
- Once mission has been loaded, click on bottom left square (or press L3 in the controller) to enter L2 camera view and adjust settings.



Access L2 camera view

18.1 Within the L2 camera view, click top right icon to select capture mode:

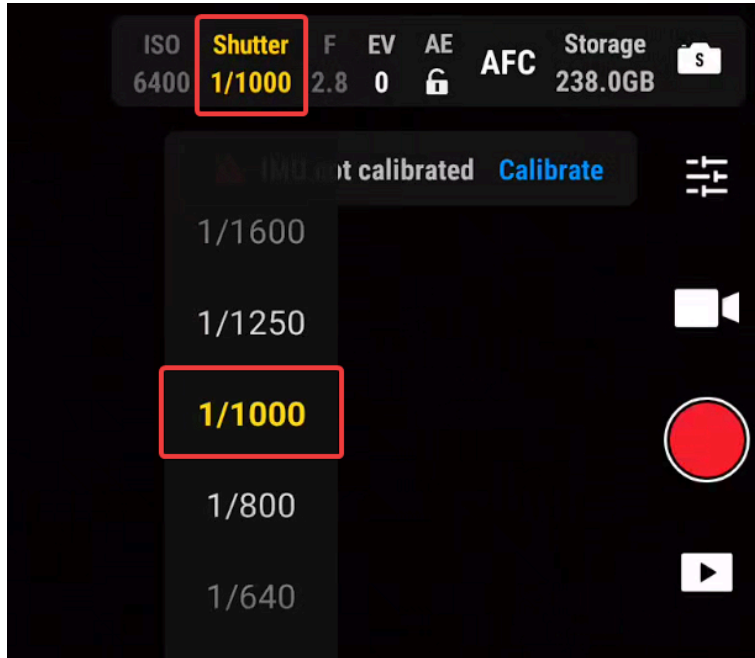
- Ensure **Shutter Priority** mode is selected 'S'.



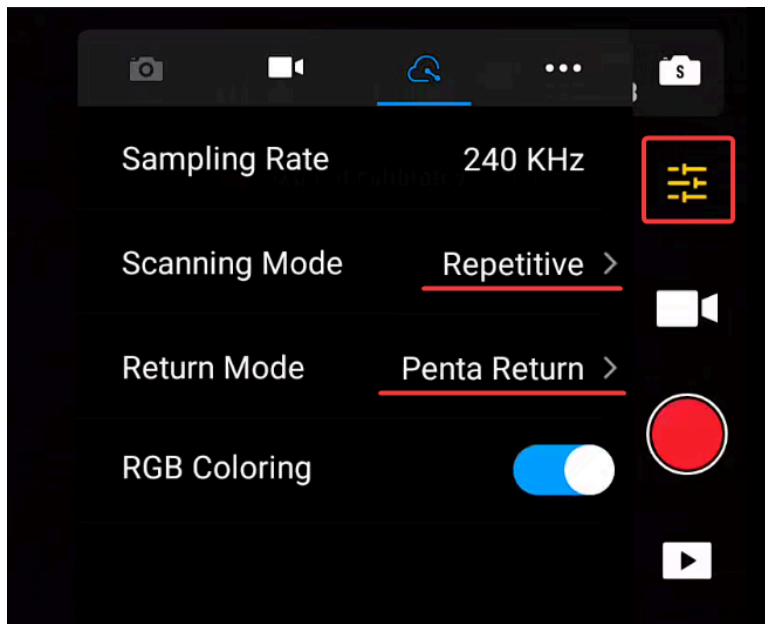
Select Shutter Priority 'S'

- Ensure the capture settings are as follows.

	A	B
Capture Mode		S - Shutter priority
ISO		Auto
Shutter Speed		1/1000 sec
Aperture		Auto
Sampling Rate		240 KHz
Scanning Mode		Repetitive
Return Mode		Penta-Return
RGB Coloring		Enabled



- Press the 3 adjustment lines, ensure the following settings are selected:



19 ⚠️ Ensure the L2 **microSD card** has been backed up or is empty.



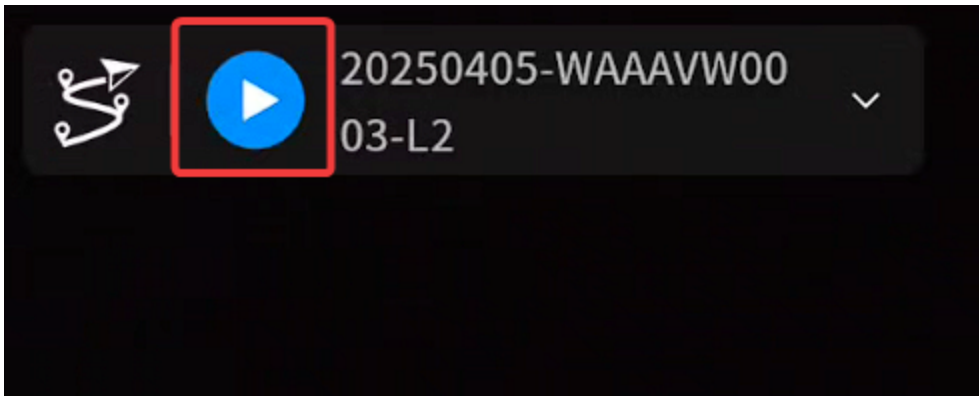
Flight: Take-off, Mapping Mission, and Landing

20 ⚠️ TakeOff

- Use manual takeoff to maintain control, particularly in areas with uneven terrain or obstructions.



- 21
- Once a safe altitude has been reached, and drone is stable in the air.
 - Press **Play to start mission**, double check all flight parameters.



● **Upload Mission** to Aircraft (bottom right corner button, press twice).

22 ⚠ **While flying ...**

- Monitor mission progress, switch between camera views, do not distract pilot, and follow airspace regulations.

23 ⚠ **Landing**

- Fly manually for landing to maintain control, particularly in areas with uneven terrain or obstructions.

Data Backup

- 24 Remove microSD card from L2 sensor, use appropriate card adaptors and a computer with enough internal storage and RAM capacity. We recommend using Solid State Drives (SSDs) for data backup, with original data cables and adequate data transfer speeds (above 500 mb/s).

We suggest backing up data daily with a directory structure as follows:

Expected result

```
PlotID/ (Unique Plot ID)
├── YYYYMMDD/ (Visit date in year-month-day format)
│   ├── lidar/
│   │   └── level0_raw/ (DJI Zenmuse L2 raw data)
│   ├── drtk/ (DJI D-RTK logs)
│   └── metadata/ (Flight mission files, logs, and site visit metadata)
```

- 25 It is important to back up the raw drone data, the D-RTK 2 GNSS log and all other relevant metadata as soon as possible, ideally at the end of day (or at the end of each day if collecting drone data as part of an extended trip). The following data backup workflow and flight metadata standards has been defined to enable the comparison of drone surveys through time.

The following data needs to be exported and backed up:

1. Raw imagery data for the mission off the RGB and multispectral sensors (as above)
2. Flight mission KMZ from the controller (export from controller)
3. .DAT GNSS log from the D-RTK 2 base station antenna

Flight environmental conditions and site metadata

A .CSV file should be completed for the site to capture flight environmental conditions and site metadata including sky code, wind speed, base station location (and

coordinates as required) and any additional comments (e.g. if drtk battery was changed, data collection issues, or any other relevant metrics depending on the study).

An example is shown below.

	A	K	L	M	N	O	P	Q
	Site	Cloudy Sky Code	Wind	Base_station_position	Base_station_latitude_WGS84	Base_station_longitude_WGS84	Ellipsoid al_height_WGS84	Comments
	SAAEY B0006	4	Calm	NE corner of Plot	Lat. Coordinates	Long. Coordinates	As available	Environmental conditions

Note: All the flight parameters (e.g., Altitude, overlap, and margin) and sensor (e.g., shutter speed, exposure) are saved within the flight mission KMZ and the image exif metadata. Hence the importance of backing up all the mission files.

26 **DJI D-RTK 2 base station logs**

1. Connect the D-RTK 2 base station antenna to the laptop and copy the raw GNSS data to the campaign drtk folder.
2. At a minimum, the relevant .DAT file from the rtcmlaw folder should be saved. This is the raw GNSS log that can be post-processed to refine the D-RTK 2 base station coordinates.
3. The .DAT file is in UTC time - if multiple flights have been completed in one day, it can be confusing determining which log belongs to which mission. To prevent confusion, it is recommended the time the D-RTK 2 base station is turned on and off is recorded for each site.

The .DAT file can be post-processed using **AUSPOS** to refine the positional accuracy of the data during subsequent processing, and to derive highly accurate base station coordinates for on-going monitoring. Refer to the **TERN Drone RGB and Multispectral Data Processing Protocol** for steps on how to handle and process the .DAT file.

27 **Metadata**

1. Export the completed mission KMZ file from the Mavic 3M controller and save in the metadata folder.
2. Complete the site CSV file to record environmental conditions, base station location, and sensor and mission settings for the flight.
3. Save a photo of the base station set up for the site (if applicable).

Citation



28 If this protocol was used or helpful, please cite as:

Montes-Herrera, J.C., Robbins, A., Franson, C., Bektas, T., Sparrow, B. & Lucieer, A. 2025. DroneScape: Collection of Penta-Return LiDAR for Ecosystem Plot Monitoring. **protocols.io** DOI: [dx.doi.org/10.17504/protocols.io.n92ldn4w7v5b/v1](https://doi.org/10.17504/protocols.io.n92ldn4w7v5b/v1)

Protocol references

- Sivanandam, P., Turner, D. & Lucieer, A. (2022) Drone Data Collection Protocol Using DJI Matrice 300 RTK: Imagery and Lidar. Univ. Tasman. Aust. Terr. Ecosyst. Res. Netw. (TERN). 1–58. Available online: https://www.tern.org.au/wp-content/uploads/20221103_M300_data_collection.pdf
- Gassilloud, M., Koch, B., & Göritz, A. (2025). Occlusion mapping reveals the impact of flight and sensing parameters on vertical forest structure exploration with cost-effective UAV based laser scanning. *International Journal of Applied Earth Observation and Geoinformation*, 139, 104493. <https://doi.org/10.1016/j.jag.2025.104493>
- Assmann, J. J., Kerby, J. T., Cunliffe, A. M., & Myers-Smith, I. H. (2018). Vegetation monitoring using multispectral sensors — best practices and lessons learned from high latitudes. *Journal of Unmanned Vehicle Systems*, 7(1), 54–75. <https://doi.org/10.1139/juvs-2018-0018>

Acknowledgements

This work was funded and supported by TERN. The authors thank Poornima Sivanandam for conducting initial tests and developing early versions of this collection protocol. The authors also acknowledge Sally O'Neill and the TERN Surveillance Team (Adelaide) for their logistical and fieldwork support in establishing this protocol.