DJI ENTERPRISE

DJI Zenmuse L2
Operation Guide V1.0

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01 | Applicable Versions

Before you proceed, please confirm that your device's firmware version is not earlier than the following. The Operation Guide will be updated to reflect any changes in content caused by firmware updates.

| Product/Software Application	Version	Update Method
Zenmuse L2	v01.00.0002	Using microSD card/App Update All/Offline Update
Matrice 350 RTK	v08.00.0004	DJI Assistant 2 Update/App Update
Matrice 300 RTK [1]	v58.00.0010	
DJI RC Plus	v02.02.0507	DJI Assistant 2 Update/App Update
DJI Pilot 2	v8.0.0.38	Built-in remote controller firmware
DJI Terra	v4.0.1	Download from the DJI official website
DJI Assistant 2	v2.1.12	Download from the DJI official website
D-RTK 2 Mobile Station	v03.01.00.00	Download from the DJI official website

[1] Matrice 300 RTK must work with DJI RC Plus.

Note: The parameters mentioned in the Operation Guide are for reference only and do not apply to all scenarios. Please adjust them as appropriate to adapt to the practical conditions.

02 | Introduction to Zenmuse L2

2.1. Overview

Zenmuse L2 integrates a LiDAR module, a high-accuracy IMU, and an RGB mapping camera on a 3-axis stabilized gimbal, which can be used with Matrice 350 RTK and Matrice 300 RTK. With Point Cloud LiveView, users can take a quick view of the 3D point cloud effect in the DJI Pilot 2 app. When used with DJI Terra, L2 offers a turnkey solution that generates point cloud output and extracts ground points to generate DEM results, which efficiently completes highly accurate reconstructed models of complex structures.
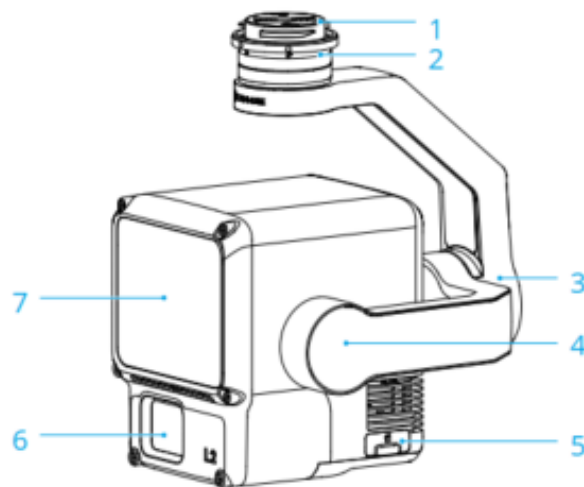
1. Gimbal Connector   2. Pan Motor   3. Roll Motor

4. Tilt Motor   5. microSD Card Slot   6. RGB Mapping

7. LiDAR

Figure: L2 components

2.2. Specifications

Table: L2 specifications

General	
Dimensions	155×128×176 mm (L×W×H)
Weight	905 ± 5 g
Power	28 W (typical), 58 W (max.)
IP Rating	IP54
Operating Temperature	-20° to 50° C (-4° to 122° F)
Storage Temperature	-20° to 60° C (-4° to 140° F)
Supported Aircraft	Matrice 350 RTK Matrice 300 RTK (requires DJI RC Plus)
System Performance	
Detection Range [1]	450 m @50% reflectivity, 0 klx 250 m @10% reflectivity, 100 klx
Point Cloud Rate	Single return: max. 240,000 pts/s Multiple returns: max. 1,200,000 pts/s
System Accuracy [2]	Horizontal: 5 cm @ 150 m Vertical: 4 cm @ 150 m
Real-Time Point Cloud Coloring Coding	Reflectivity, Height, Distance, RGB

LiDAR	
Ranging Accuracy (RMS 1σ) [3]	2 cm @ 150 m
Maximum Returns Supported	5
Scanning Mode	Non-repetitive scanning pattern, Repetitive scanning pattern
FOV	Repetitive scanning pattern: 70°×3° Non-repetitive scanning pattern: 70°×75°
Minimum Detection Range	3 m
Laser Beam Divergence	0.6 mrad× 0.2 mrad
Laser Wavelength	905 nm
Laser Spot Size	Horizontal 4 cm, vertical 12 cm @ 100 m (FWHM)
Laser Pulse Emission Frequency	240 kHz
Laser Safety	Class 1 (IEC 60825-1:2014)
Inertial Navigation System	
IMU Update Frequency	200 Hz
Accelerometer Range	± 6 g
Angular Velocity Meter Range	± 300 dps
Yaw Accuracy (RMS 1σ) [4]	Real-time: 0.2°, Post-processing: 0.05°
Pitch/Roll Accuracy (RMS 1σ) [4]	Real-time: 0.05°, Post-processing: 0.025°
Positioning Accuracy (RTK FIX)	Horizontal: 1 cm + 1 ppm Vertical: 1.5 cm + 1 ppm

RGB Mapping Camera	
Sensor	4/3 CMOS, Effective Pixels: 20 MP
Lens	FOV: 84° Equivalent Focal Length: 24 mm Aperture: f/2.8-f/11 Focus Points: 1 m to ∞
Shutter Speed	Mechanical Shutter: 2-1/2000 s Electronic Shutter: 2-1/8000 s
Shutter Count	200,000
Photo Size	5280×3956 (4:3)
Still Photography Modes	Single Shot: 20 MP Timed: 20 MP JPEG Timed Interval: 0.7/1/2/3/5/7/10/15/20/30/60 s RAW/JPEG + RAW Timed Interval: 2/3/5/7/10/15/20/30/60 s
ISO	Photo: 100-6400 Video: 100-6400
Video Codec and Resolution	H.264 4K: 3840×2160 @30fps FHD: 1920×1080 @30fps
Video Bitrate	4K: 85Mbps FHD: 30Mbps
Supported File System	exFAT
Photo Format	JPEG/DNG (RAW)
Video Format	MP4 (MPEG-4 AVC/H.264)

Gimbal	
Stabilization System	3-axis (tilt, roll, pan)
Angular Vibration Range	0.01°
Mounting	Detachable DJI SKYPORT
Mechanical Range	Tilt: -143° to +43° Pan: ±105°
Controllable Range	Tilt: -120° to +30° Pan: ±90°
Operation Mode	Follow/Free/Recenter
Data Storage [5]	
Raw Data Storage	Photo/IMU/Point cloud/GNSS/Calibration files
Point Cloud Data Storage	Real-time modeling data storage
Supported microSD Cards	microSD: Sequential writing speed 50 MB/s or above and UHS-I Speed Grade 3 rating or above; Max capacity: 256 GB
Recommended microSD Cards	Lexar 1066x 64GB U3 A2 V30 microSDXC Lexar 1066x 128GB U3 A2 V30 microSDXC Kingston Canvas Go! Plus 128GB U3 A2 V30 microSDXC Lexar 1066x 256GB U3 A2 V30 microSDXC
Post-Processing Software	
Supported Software	DJI Terra
Data Format	DJI Terra supports exporting point cloud models and trajectory files in the following formats: Point cloud format: PNTS/LAS/PLY/PCD/S3MB Trajectory file format: sbet.out/sbet.txt

[1] Measured using a flat subject with a size larger than the laser beam diameter, a perpendicular angle of incidence, and an atmospheric visibility of 23 km. In low-light environments, the laser beams can achieve the optimal detection range. If a laser beam hits more than one subject, the total laser transmitter power is split, and the achievable range is reduced. The maximum detection range is 500 m.

[2] Measured under the following conditions in a DJI laboratory environment: Zenmuse L2 was mounted on Matrice 350 RTK and powered on. In DJI Pilot 2, the Area Route mode was used to plan the route (with IMU Calibration enabled), repetitive scanning was used, and the RTK status was set to FIX. The relative altitude was set to 150 m, flight speed to 15 m/s, and gimbal tilt to -90°, and each straight segment of the route was no more than 1500 m. The field contained objects with obvious angular features, and exposed hard-ground checkpoints that conformed to the diffuse reflection model were used. DJI Terra was used for post-processing with Optimize Point Cloud Accuracy enabled. Under the same conditions with Optimize Point Cloud Accuracy disabled, the vertical accuracy is 4 cm and the horizontal accuracy is 8 cm.

[3] Measured in an environment of 25° C (77° F) with a subject of 80% reflectivity at a distance of 150 m. The actual environment may differ from the testing environment. The result listed is for reference only.

[4] Measured under the following conditions in a DJI laboratory environment: Zenmuse L2 was mounted on Matrice 350 RTK and powered on. In DJI Pilot 2, the Area Route mode was used to plan the route (with IMU Calibration enabled) and the RTK status was set to FIX. The mission height was set to 150 m, flight speed to 15 m/s, and gimbal tilt to -90°, and each straight segment of the route was no more than 1500 m.

[5] Zenmuse L2 supports the Security Code function. Users can go to Data and Privacy in DJI Pilot 2 and set a security code to encrypt microSD cards inserted into payloads. DJI Decrypt Tool can be downloaded from the DJI official website to decrypt the microSD cards on a Windows computer and access the microSD card content.

2.3. Key Terms

2.3.1. Detection Range

The farthest measurable distance of the LiDAR module. This parameter is greatly affected by the actual environmental conditions. The main influencing factors include the target object's surface reflectivity and shape and ambient light interference. In most cases, measurable distances under different lighting and reflectivity conditions are provided on LiDAR by manufacturers.

In the case of DJI Zenmuse L2, its LiDAR supports a detection range of 450 m under 0 klx when the target object's reflectivity is 50%, and 250 m under 100 klx when the target object's reflectivity is 10%.

"450 m @50% reflectivity, 0 klx" means that when the solar illuminance is 0 klx and the target object's reflectivity is greater than 50% (the reflectivity of a concrete floor or a road surface is 15% to 30% and the reflectivity of a white plaster wall is 90% to 99%), the maximum measurable distance is 450 m.

"250m @10% reflectivity, 100 klx" means that when the solar illuminance is 100 klx and the target object's reflectivity is greater than 10% (the reflectivity of a concrete floor or a road surface is 15% to 30% and the reflectivity of a white plaster wall is 90% to 99%), the maximum measurable distance is 250 m.

Most LiDAR sensors in the market use diffuse reflective objects (with reflectivity at 90%) as the testing benchmark. However, this parameter has limited practical significance. The measurable distance at a reflectivity of 10% has practical significance instead.

2.3.2. Multiple Returns

LiDAR can receive multiple returns. This characteristic can be used to detect the edges of

objects. DJI Zenmuse L2 provides the multiple-return mode, with five returns supported at most. Among the multiple returns, the first return acquires information about the height of the measured object, the intermediate returns usually correspond to the structure of the object, and the last return corresponds to the bare ground. In densely vegetated areas, the multiple return mode can obtain information such as the number of trees, crown width, and height of trees. For example, in sparsely vegetated areas for which lightweight data is required, the triple return mode can be enabled. In densely vegetated areas, the penta return mode is more appropriate for stronger penetrability.
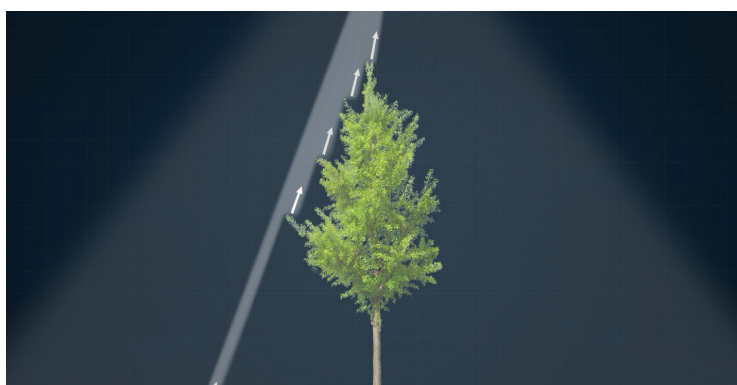
Figure: Penta returns

2.3.3. Point Cloud Rate

Point cloud rate is also called sampling rate or pulse frequency, and refers to the maximum number of laser beams emitted by the laser within unit time. Given the same conditions, the higher the frequency, the more the number of measured points and the higher the operating efficiency.

Zenmuse L2 supports five return modes: single return, dual return, triple return, quad return, and penta return. The sampling rate is 240 kHz (meaning that 240,000 laser beams are emitted per second) in all these modes.

2.3.4. Scanning Mode and FOV

L2 can produce different scan shapes in different scanning modes. Note that the shape formed by the LiDAR on the ground depends on not only the laser scanning mode, but also the flight direction, flight speed, and terrain.

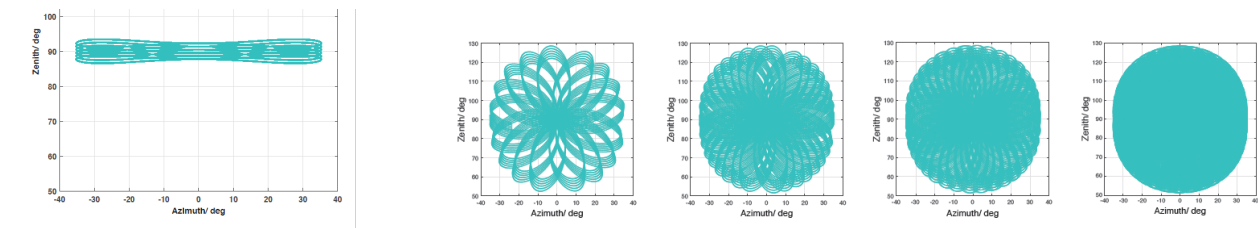L2 supports non-repetitive scanning and repetitive scanning.

Figure: Scan shapes formed in different scanning modes of Zenmuse L2 in the static state
The first shape from the left is produced by a repetitive scan, and the rest shapes from the left are produced by a non-repetitive scan for different lengths of time.

Field of view (FOV), also known as scan angle, represents the angle of laser beams during scanning. It refers to the maximum angle range of the laser beams from the scanner. The FOV of L2 varies in different scanning modes.

Repetitive scanning pattern: The FOV is 70°×3°. This scanning mode features a narrow scan range but high accuracy. This mode is recommended for high-accuracy mapping.

Figure: Scan angle in repetitive scanning mode

Non-repetitive scanning pattern: The FOV is 70°×75°. This scanning mode features a wide scan range, which can obtain more facade information. This mode is recommended for taking photos of complex structures, such as the facades of a building.

Figure: Scan angle in non-repetitive scanning mode

Note:

The effective detection range of Zenmuse L2 varies based on where the object is within the FOV. The closer to the edge of the FOV, the shorter the effective detection range. The closer to the center of the FOV, the longer the effective detection range.

2.3.5. Beam Divergence

A divergence angle, if any, of the beams from the LiDAR can produce light spots which increase in size as the distance increases.

2.3.6. Ranging Accuracy

Ranging accuracy refers to the gap between the LiDAR measured distance and the actual distance. Ranging accuracy is different from system accuracy in that the former does not represent the accuracy of the final result.

2.3.7. IMU Calibration

The accuracy of the Inertial Navigation System is gradually degraded when the aircraft is flying at a consistent speed. In the case of Zenmuse L2, after the aircraft flies at a consistent speed for 200 seconds, the accuracy of the Inertial Navigation System drops below the nominal accuracy. With IMU Calibration, as long as there is a rapid speed change within a short period of time, the accuracy can be restored to a high level.

2.3.8. Point Cloud Coloring

Point cloud coloring provides LiDAR with real-time RGB rendering to generate RGB 3D point cloud models.

03 | Application Scenarios of Zenmuse L2

3.1. Mapping Scenarios

Zenmuse L2 can apply to scenarios where topographic maps, contour lines, engineering cross-section profile analysis, earthwork measurements, and many others like forestry survey projects such as single-tree segmentation.

3.1.1. Preparation

3.1.1.1. RTK/PPK Solution Confirmation

For the purpose of point cloud data processing, Zenmuse L2 needs to have **accurate-to-centimeters positioning data** in place for calculations. Before an operation, Zenmuse L2 must be connected to an RTK and ensure RTK status is fix through the whole flight mission. If an RTK connection cannot be guaranteed, please consider setting up a base station and performing post-processing. The method to obtain accurate-to-centimeters positioning data is as follows.

3.1.1.1.1. Network RTK (NTRIP) Solution

You can connect to a custom network RTK by entering an NTRIP account. If the aircraft is connected to the RTK and the RTK outputs a fixed solution throughout the flight, the base station file will be automatically saved in Zenmuse L2's result file.
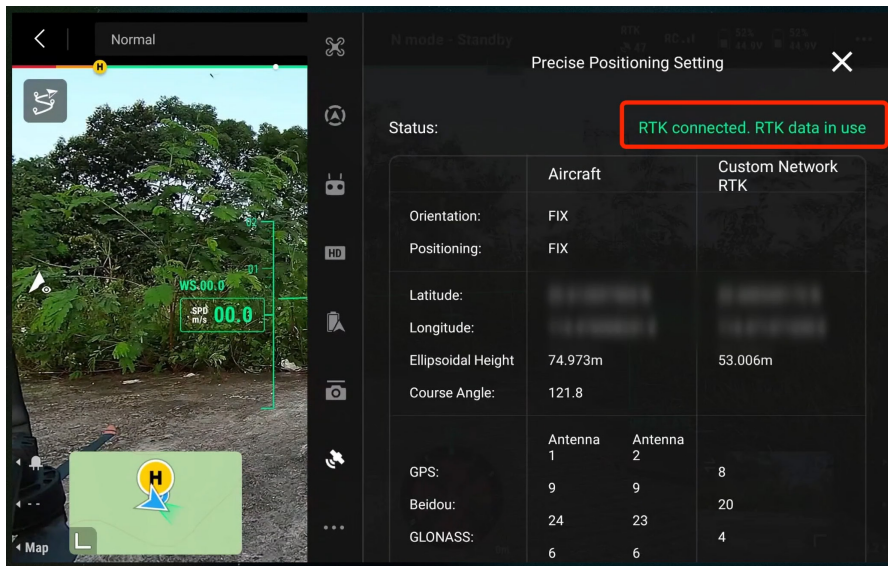
Figure: Network RTK connection

3.1.1.1.2. Physical Base Station Solution (D-RTK 2)

Set up D-RTK 2 at a point with known coordinates and keep the measuring rod touching the ground. This solution requires that the base station is set up stably and protected properly. If tilt or displacement exists, calculations cannot be performed properly.

On the settings screen of Matrice 300 RTK or Matrice 350 RTK, select D-RTK 2 and change its status to Mode 5. Then, link the aircraft to D-RTK 2 by entering the password, which is 123456 by default. Go to the Advanced Settings screen in the app and change D-RTK 2's coordinates to those of the known point. (In elevation scenarios, add the device height of 1.8 meters to the elevation of the known point on the ground.)
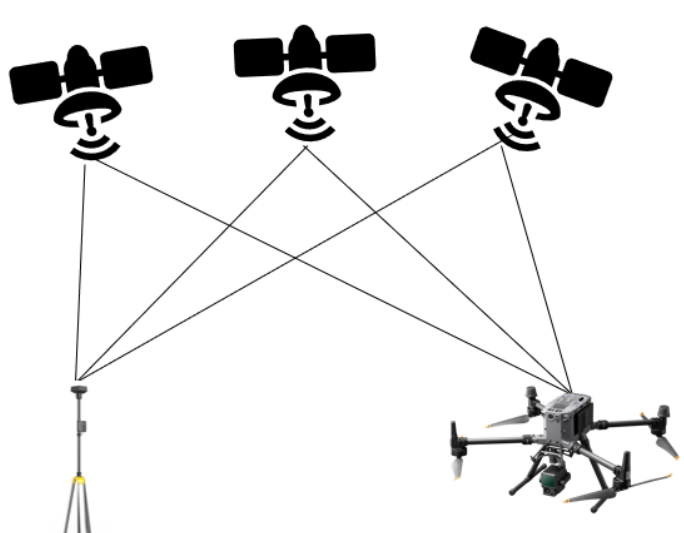
Figure: D-RTK 2 setup

After setting up the D-RTK 2 base station, you can connect to D-RTK to fly the aircraft. Alternatively, you can set RTK to None in the RTK settings of the remote controller to switch to the GNSS flight mode. After the data collection for the task is done, use a Type-C cable to connect the aircraft to D-RTK 2. Copy the base station file with a suffix of .DAT for the corresponding time slot, and paste the file into the same folder as the raw point cloud data. DJI Terra can then calculate the difference automatically during data post-processing.

Note: If you need higher absolute accuracy or need to change the setup point of the D-RTK 2 base station, set up D-RTK 2 at a known point instead of directly using its self-convergent GNSS coordinates. This is because the statically convergent coordinates of D-RTK 2 have meter-level errors and the error direction is unknown. If the data is used directly, the absolute accuracy of the result cannot be guaranteed and the data of multiple flights cannot be spliced together.

3.1.1.1.3. Physical Base Station Solution (Third-Party RTK Device)

When no network RTK is available and D-RTK 2 Mobile Station is unavailable, a third-party RTK base station device can be set up at a known point in the mapping area. In this case, no connections are required between the aircraft and the RTK base station. After the flight is complete, search for the base station file for the corresponding time slot and rename the file to the RTB file name in the lidar file folder following the suffix rules below. Then copy the base station file to the same directory as the lidar file.

Zenmuse L2 supports the following base station protocols and versions. (Note: The renamed file DJI_YYYYMMDDHHMM_XXX must share the same name as the .RTB file in the point cloud data directory.)

Protocol Type	Protocol Version	Message Type	Renamed File
Rinex	V2.1.x	/	DJI_YYYYMMDDHHMM_XXX.obs
	V3.0.x	/	
RTCM	V3.0	1004 and 1012	DJI_YYYYMMDDHHMM_XXX.rtcm
	V3.2	MSM4, MSM5, MSM6, and MSM7	
OEM	OEM4	RANGE	DJI_YYYYMMDDHHMM_XXX.oem
	OEM6	RANGE	
UBX	/	RAWX	DJI_YYYYMMDDHHMM_XXX.ubx

Table: RTK protocol types supported by Zenmuse L2

Note: Base station files are necessary for Zenmuse L2's data processing. If no network RTK is connected and no base station file exists, Zenmuse L2's data cannot be processed. If the RTK gets disconnected during the flight, the aircraft will automatically pause the task to ensure data validity.

3.1.1.2. Checkpoint Layout

In topographic mapping operations, total-station instruments and RTK devices are generally used to measure several checkpoints to verify the accuracy. Zenmuse L2 outputs point cloud in LAS format. Unlike the 3D model obtained by using visible light, Zenmuse L2's point cloud contains no structural information, so its checkpoint layout is different from that for mapping in visible-light display mode. Several recommended checkpoint layouts are listed below.

3.1.1.2.1. Plane Elevation Checkpoints

Combination of black and white paint: Zenmuse L2's point cloud result contains the reflectivity data of ground objects, which helps to lcoate the checkpoint centers based on reflectivity differences. The combination of white paint (reflectorized road paint, highly reflective heat-insulating paint) with a high reflectivity and black paint with a low reflectivity is recommended, and the checkpoint diameter should be greater than 1 m × 1 m. During point cloud-based coordinate measurement, you are advised to use the visible-light display mode to roughly locate the checkpoints and then switch to the reflectivity display mode to accurately measure the coordinates of the checkpoint centers.

Figure: Field checkpoint layout
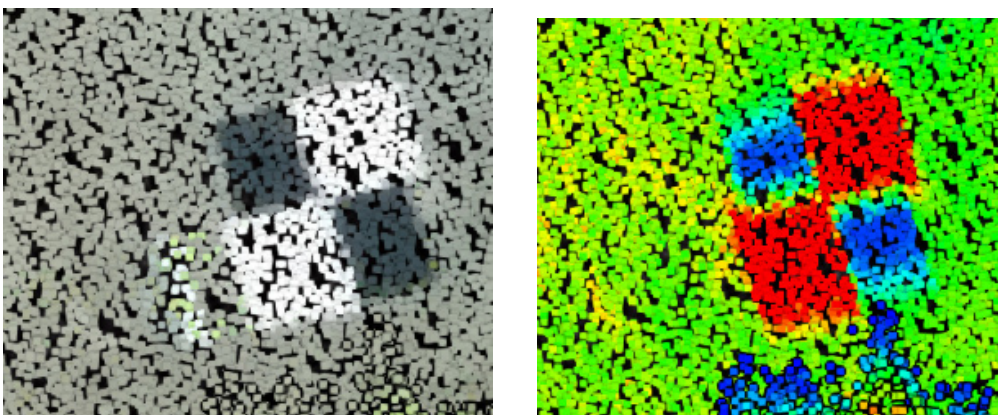
Figure: Checkpoint icons in the point cloud result (left: visible light; right: reflectivity)

In addition, if a zebra crossing or another object with sharp reflectivity differences exists in the mapping area, the object's corners can be set as checkpoints.
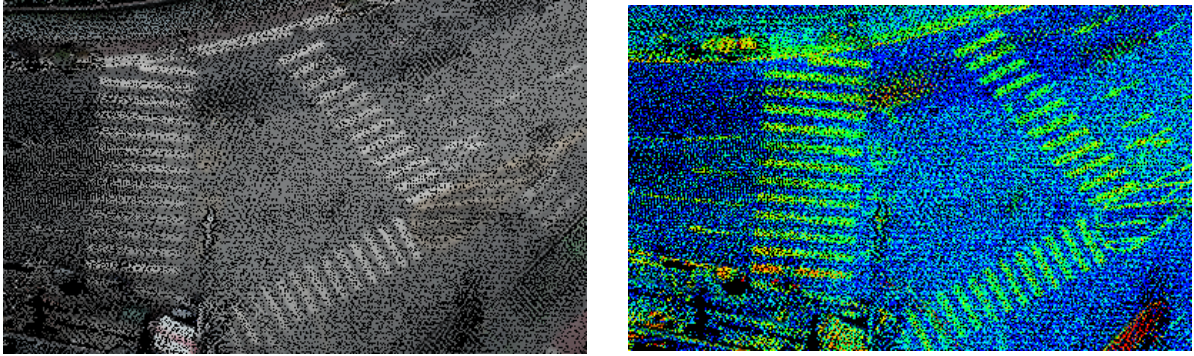
Figure: Zebra crossing icons in the point cloud result (left: visible light; right: reflectivity)

3.1.1.2.2. Elevation Checkpoints

With DJI Terra used for accuracy check, the aircraft can output an elevation accuracy report, with a focus on the Root Mean Square Error (RMSE) indicator. Note that this type of software only checks the elevation accuracy but does not generate any plane check reports. The basic principle of elevation check is explained as follows: Take the 3D position of the checkpoint as the center, calculate the weighted mean elevation of the 3D points around it in a certain range, and then calculate the difference between the weighted mean coordinates and the measured coordinates. This test method assumes that the LiDAR's plane error can be ignored, and that the points near the checkpoint are all on roughly the same elevation plane.

Therefore, when laying out elevation checkpoints in the field, you can choose a flat ground area of 1 m × 1 m. The checkpoints should be evenly distributed around and in the middle of the mapping area and have elevation differences, instead of being located on the same plane. To test the penetrability of LiDAR, you are recommended to set a certain number of checkpoints beneath vegetation. (Different from regular elevation checkpoints, checkpoints beneath vegetation are verified based on ground point classification.)

3.1.2. Field Data Collection

3.1.2.1. Power-On and Deployment

Mount Zenmuse L2 on the location of single downward gimbal No. 1, which faces the front of the aircraft and has a Type-C port on the right, of Matrice 350 RTK and insert a microSD card.

Figure: microSD card insertion

Power on the remote controller and the aircraft. Open the DJI Pilot 2 app for an auto-check.

Figure: Device power-on

Enter the camera view and go to General Settings > Precise Positioning Setting. Select RTK or PPK to obtain accurate-to-centimeters positioning data.
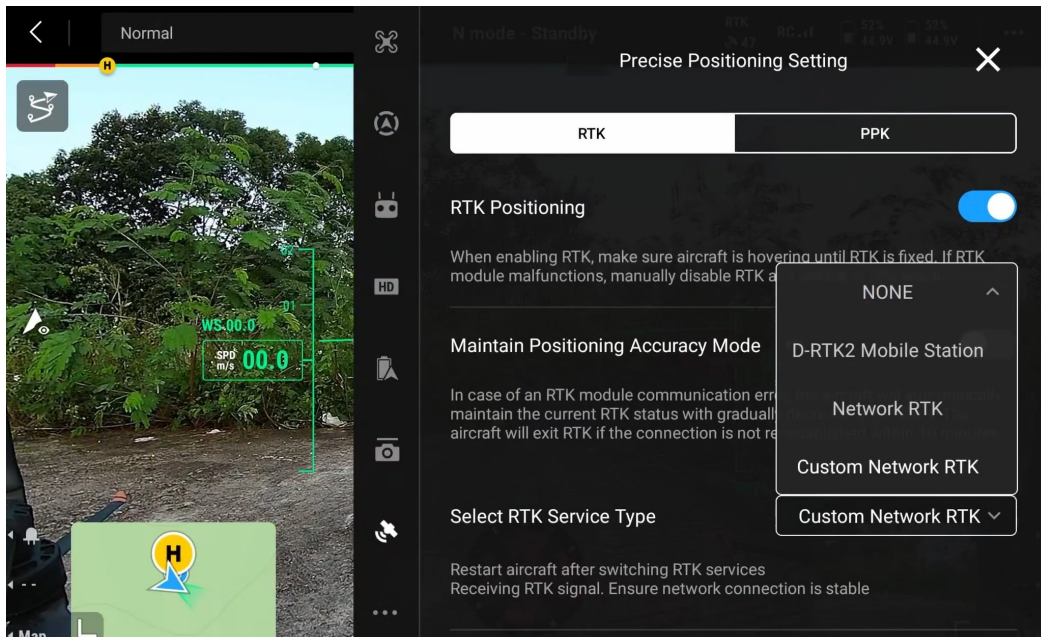
Figure: RTK settings

If a network RTK signal is available in the mapping area or the D-RTK 2 Mobile Station has been set up at a known point, you can enable RTK Positioning to obtain differential data. In this case, you are recommended to disable the Maintain Positioning Accuracy Mode.

RTK service types include D-RTK 2 Mobile Station and Custom Network RTK. In this example, when the status bar shows "RTK connected. RTK data in use" and the aircraft positioning is shown as FIX, the RTK is ready to use.
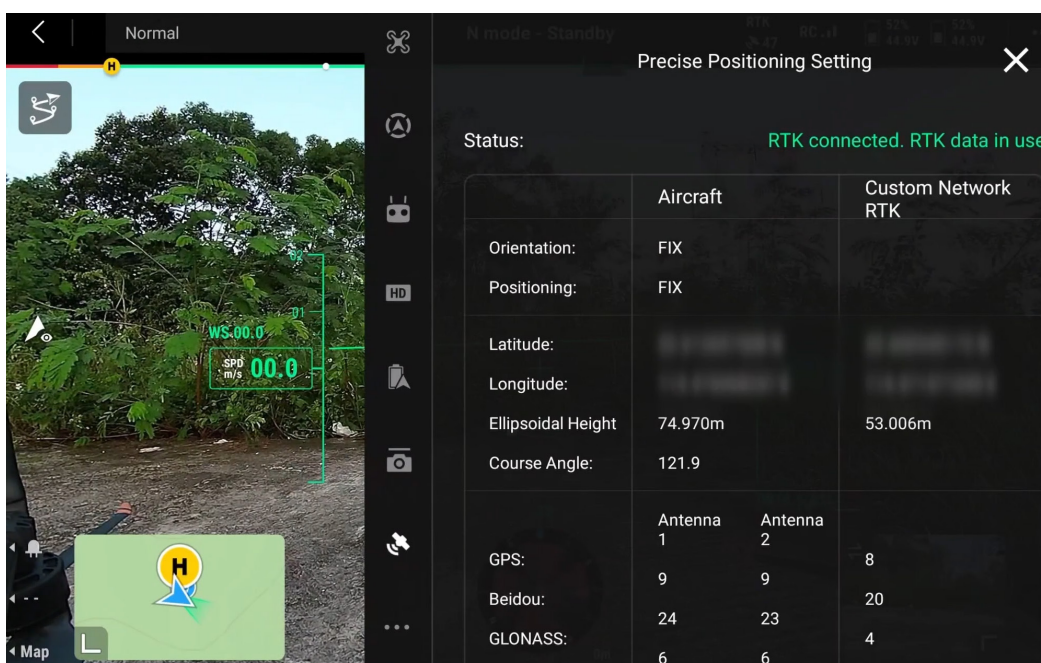
Figure: RTK connection success

3.1.2.2. Area Route Planning

3.1.2.2.1. Area Route Creation

After the auto-check is complete, tap the route icon. On the Library screen, tap Create a Route or tap Import Route (KMZ/KML) to import operation area data. Alternatively, enter the camera view, tap the route icon, and then tap the plus icon (+) to create a route.
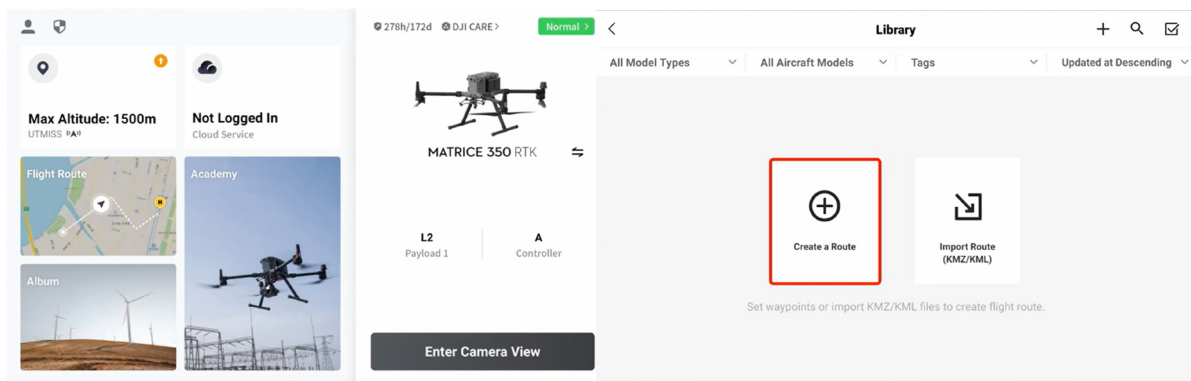
Figure: Route creation

Tap Area Route to enter the editing screen. Tap on the map view, and drag boundary points to adjust the range of the mapping area. You can also tap + between two boundary points to add a boundary point, tap the delete icon to delete a selected boundary point, and tap the clear icon to delete all boundary points. After editing, tap the check mark to confirm the mapping area.
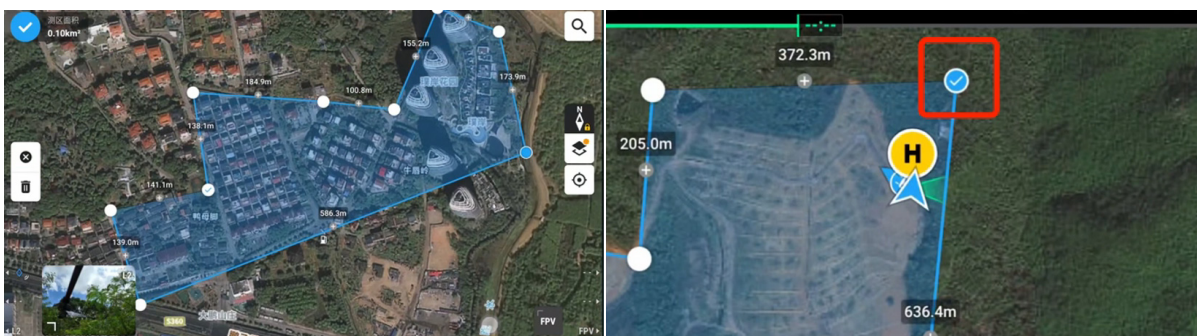
Figure: Mapping area editing

Select the aircraft model, select L2 for the camera model, and select LiDAR Mapping to use the LiDAR to collect the point cloud data of the measured object. Then, tap Payload Settings.
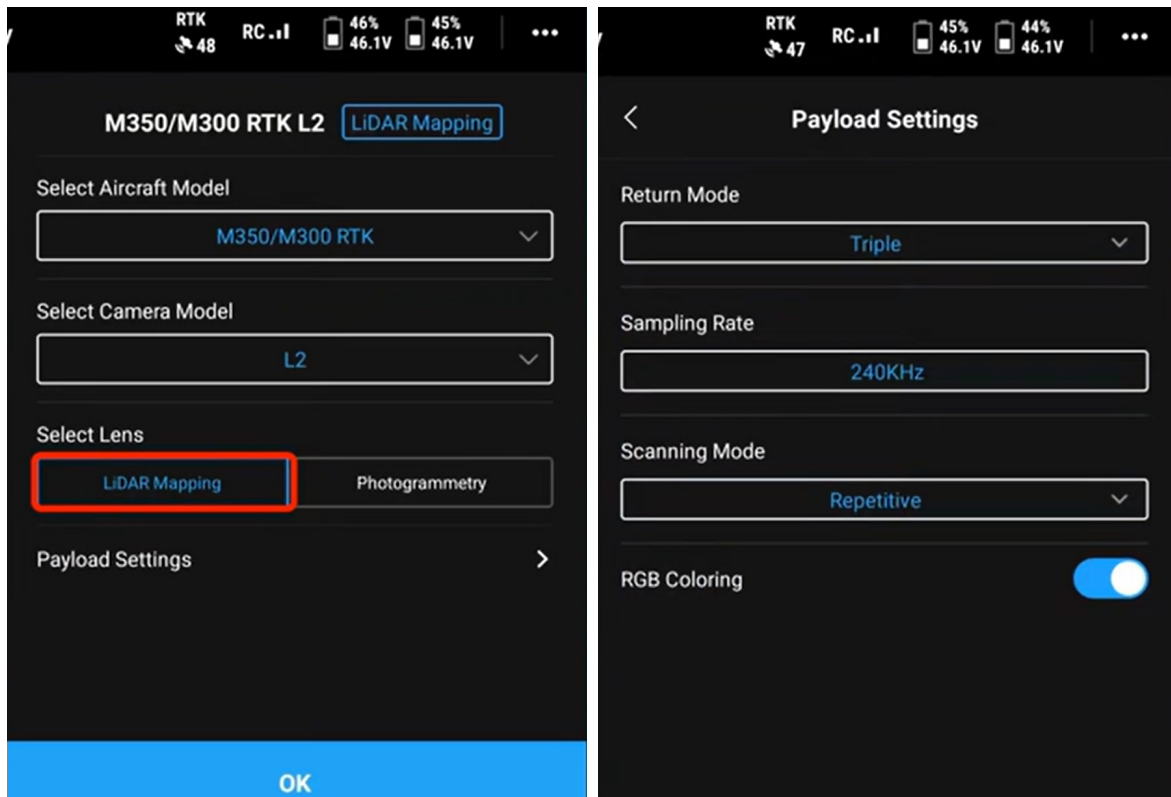

Figure: Payload settings

3.1.2.2.2. Design of Payload Parameters

❶ Return Mode: Penta return is recommended. In penta return mode, up to five returns can be received for each laser beam emitted. The penta return suits scenarios with a relatively high point cloud density. In areas with sparse and low vegetation (less than 5 m high), you can select a mode with fewer returns, such as triple return.

❷ Sampling Rate: It is 240 kHz in any return mode, meaning that Zenmuse L2 emits 240,000 laser beams per second.

❸ Scanning Mode: Non-repetitive scanning and repetitive scanning mode are available. The repetitive scanning mode is recommended for high-accuracy scenarios. The higher the accuracy, the higher the point cloud density. If you need to obtain more facade information or achieve stronger penetrability, the non-repetitive scanning mode is recommended because its scan angle is wider.
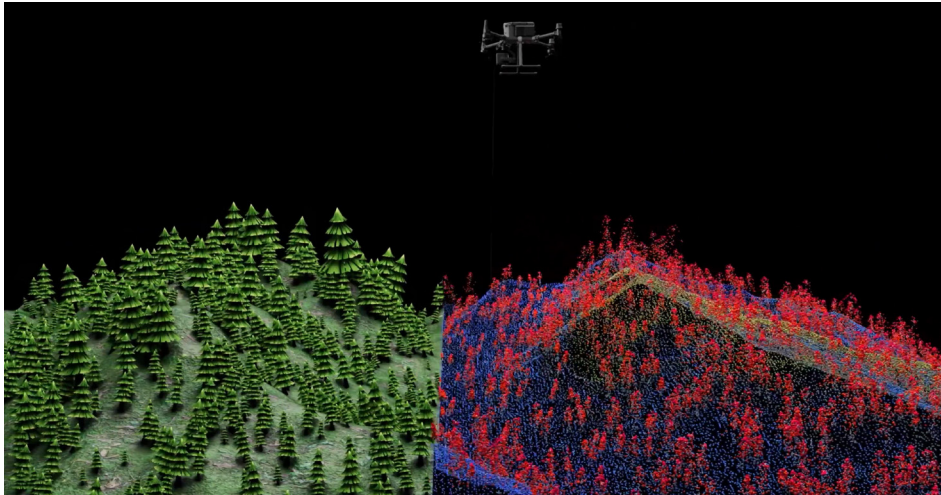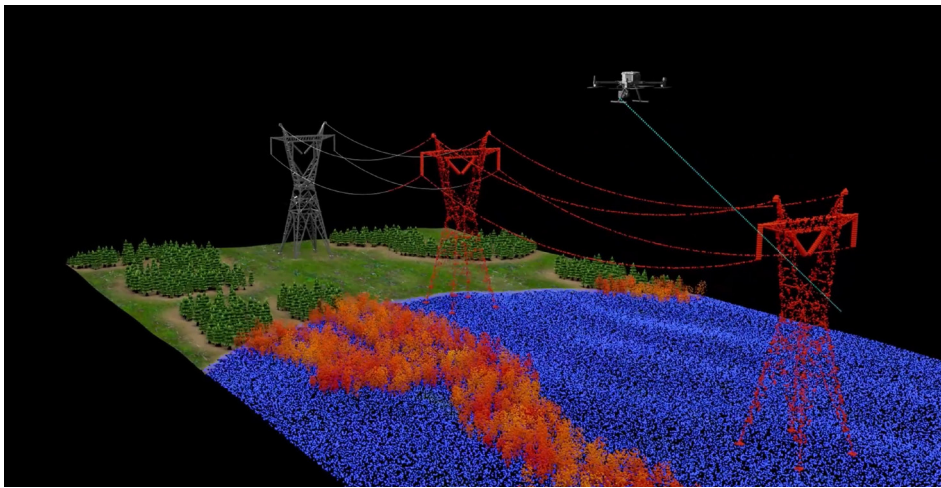
Figure: Repetitive scanning

Figure: Non-repetitive scanning

❹ RGB Coloring: This feature is enabled by default and can be disabled in nighttime operations. RGB coloring uses photos taken by the RGB camera for point cloud coloring. Such photos can also be used for 2D or 3D visible-light model reconstruction.

3.1.2.2.3. Design of Route Parameters

After completing payload settings, tap OK to enter the route parameters setting screen.

1) Enter an area route name and select a collection method for LiDAR Mapping. Ortho Collection is recommended.

2) Set Ortho GSD, which specifies the GSD used by the RGB camera to collect images.

3) Point Cloud Density specifies the average number of LiDAR points (non-ground points) per square meter in principle.
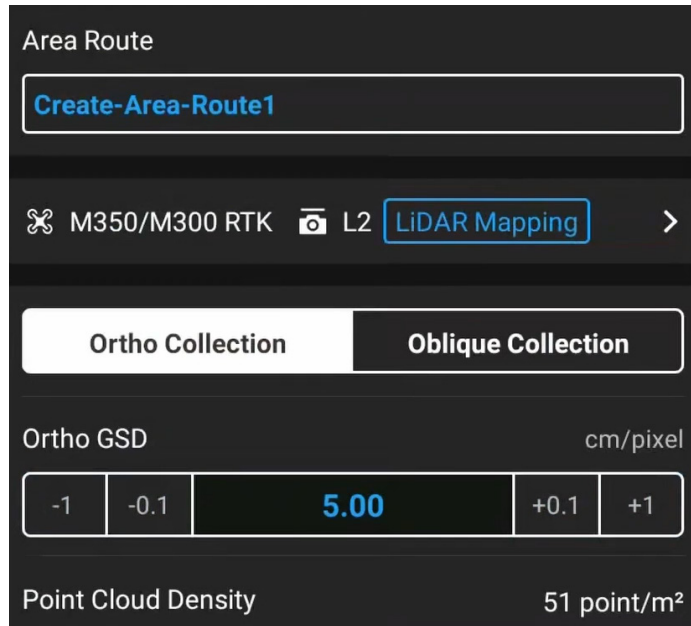
Figure: Route editing

4) Set ASL/ALT to Relative to Takeoff Point (ALT), ASL (EGM96), or AGL. We recommend that you select AGL to enable Terrain Follow.

Figure: ASL/ALT setting

5) Select DSM files. Matrice 350 RTK supports two methods of obtaining terrain data: Import Local File and Download from Internet. In this example, select Download from Internet. The app downloads terrain elevation data of the mapping area and generates a route with altitude changes to ensure accurate terrain follow with the aircraft flying at obtained heights with strict accuracy.
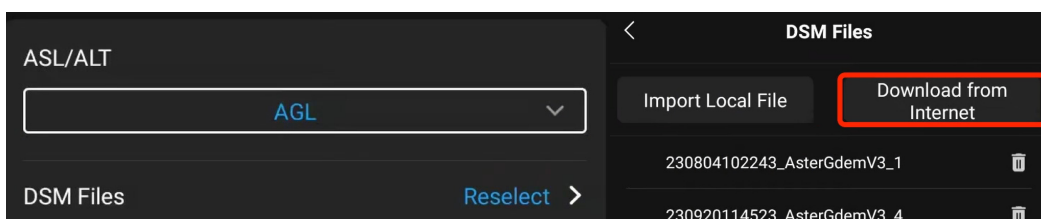

Figure: DSM file selection

6) We recommend that you set Terrain Follow Altitude to 150 m. You can also set a lower altitude, such as 100 m, if you need stronger laser penetrability to obtain more ground point information. If the mapping area is sparsely vegetated, you can set a higher altitude, such as 200 m, to improve operating efficiency.
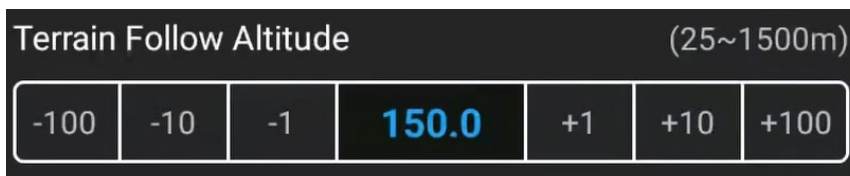

Figure: Flight altitude settings

7) If the mapping area is flat and has no undulations, you can select Relative to Takeoff Point (ALT) for ASL/ALT.

8) We recommend that you disable Elevation Optimization except when you need to produce digital orthophoto maps.

Figure: Elevation Optimization switch

9) If a high-rise obstacle exists between the takeoff point and the route starting point, Safe Takeoff Altitude must be set. The safe takeoff altitude must be higher than the obstacle's height. After takeoff, the aircraft ascends to the safe takeoff altitude (higher than the route starting point) and then flies to the starting point.
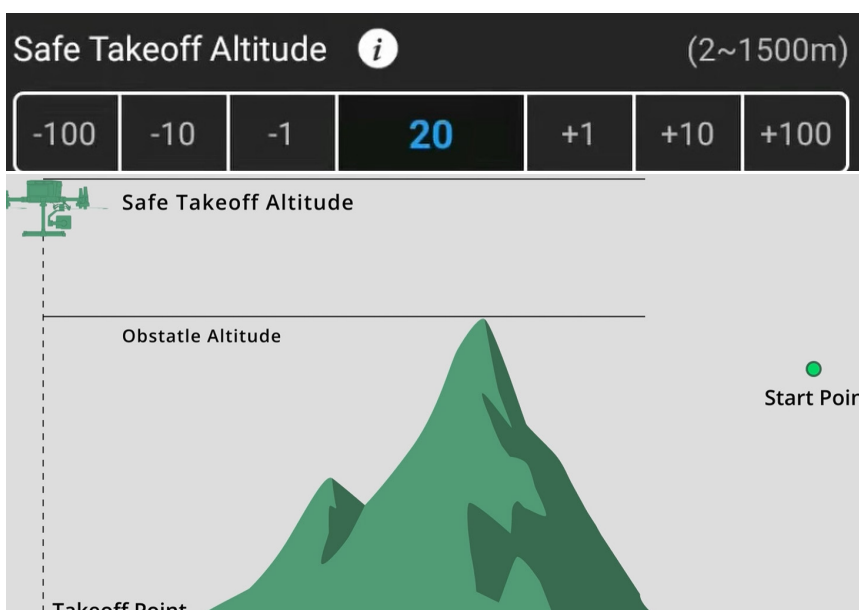

Figure: Safe Takeoff Altitude setting

10) We recommend that you enable IMU Calibration so that the aircraft can automatically speed up or down at each turning point (yellow segments of the route) and near the starting and end points of the route to ensure point cloud accuracy.
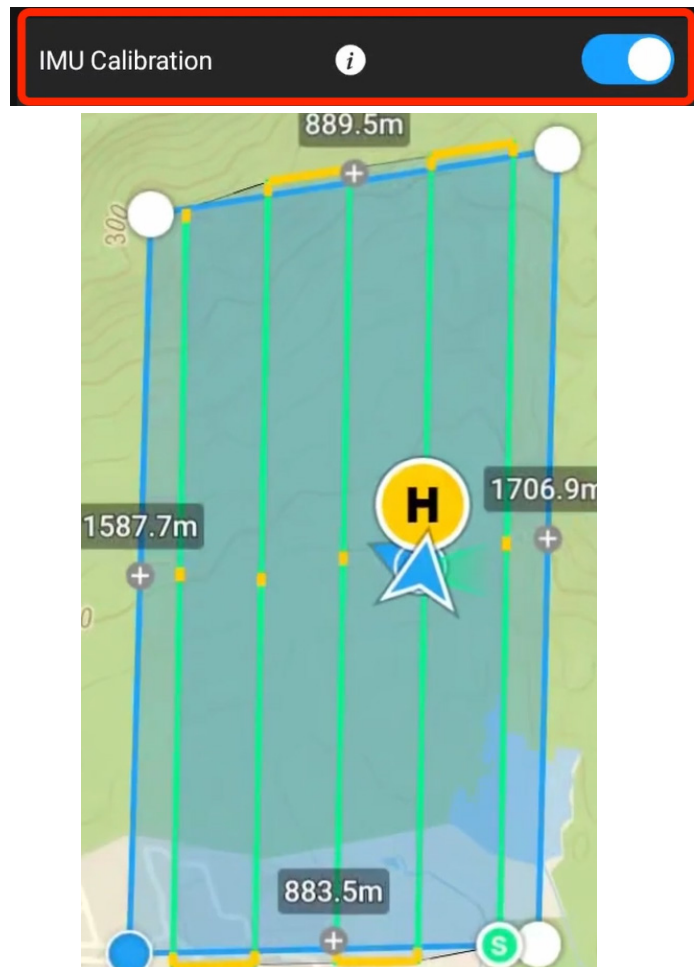

Figure: IMU Calibration enabled

11) We recommend that you set the flight speed to 15 m/s. (The lower the flight speed, the higher the point cloud density.)
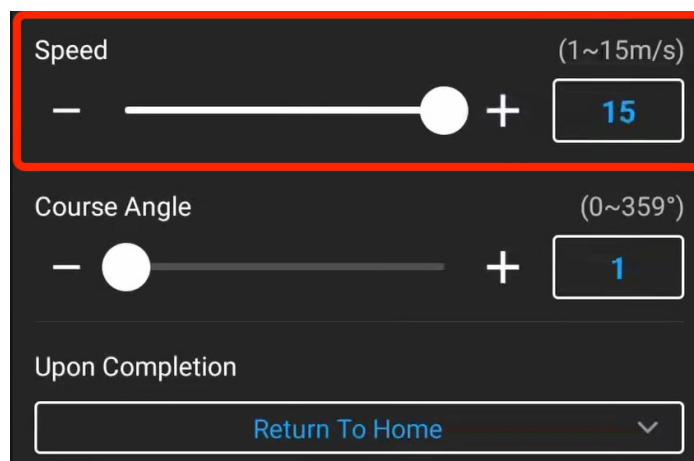

Figure: Flight speed at 15 m/s

12) You can set Course Angle to adjust the route direction. By default, the route is parallel to the long side of the mapping area.

13) We recommend that you set Upon Completion to Return To Home.

14) In Advanced Settings, set Side Overlap (LiDAR) and Forward Overlap (Visible).

15) The default value of Side Overlap (LiDAR) is 20%. If you need a higher point cloud density or the mapping area has large, steep terrain undulations, you can adjust the value to 50%.

16) If you need to obtain both LiDAR point cloud data and digital orthophoto map data, we recommend that you set Forward Overlap (Visible) to 70%. Note that adjusting the value of Forward Overlap (Visible) will affect the highest flight speed.
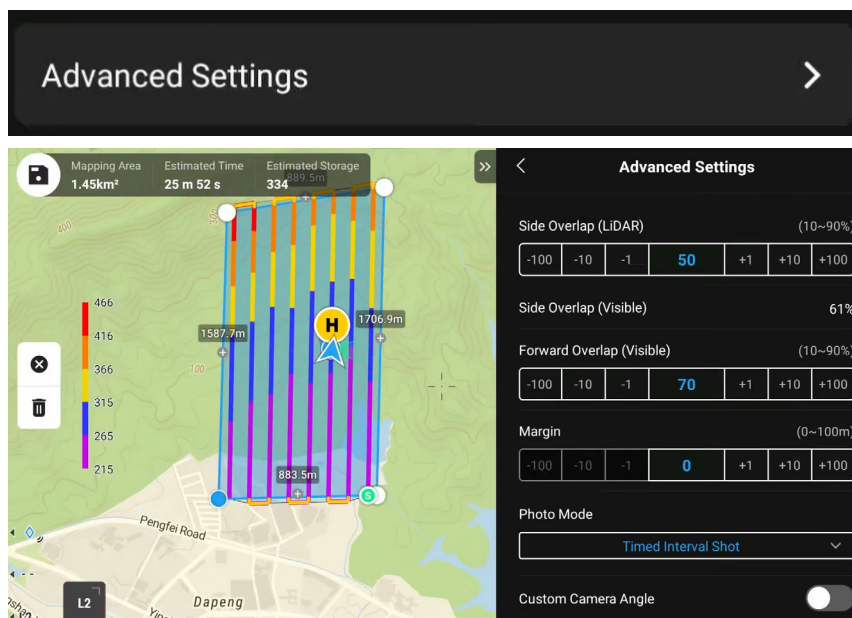

Figure: Overlap settings

17) Use the default values for Margin and Photo Mode.

18) Set Takeoff Speed to the highest speed to improve operating efficiency.
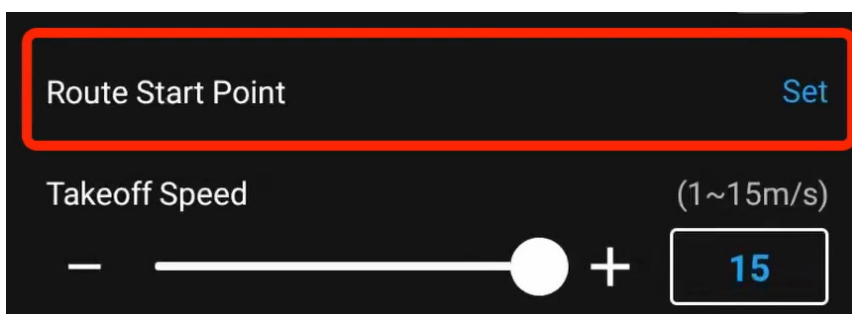

Figure: Highest takeoff speed

19) We recommend that you turn off the Custom Camera Angle switch.

20)You can set the start point of the route as needed. Tap Set in the Route Start Point section and set the fore or aft waypoint of the route as the start point.
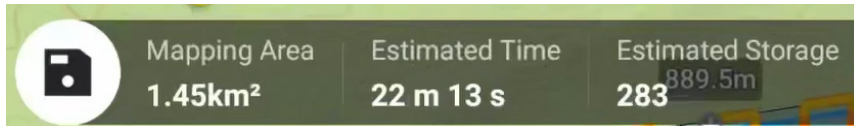
21)Tap the save icon to save the route.

Figure: Route saving

3.1.2.2.4. Recommended Route Parameters in Various Scenarios

Route Parameter	High Accuracy - Plain Areas	High Efficiency - Plain Areas	High Accuracy - Hilly Areas	High Efficiency - Hilly Areas
Altitude	Horizontal flight 80-150 m	Horizontal flight 150-200 m	Network DSM follow 80-150 m	Network DSM follow 150-220 m
Speed	10-12 m/s	12-15m/s	10-12m/s	12-15m/s
Number of Returns	5	3	5	3
Scanning Mode	Repetitive scanning	Repetitive scanning	Repetitive scanning	Repetitive scanning
Side Overlap Ratio	30%	20%	50%	30%
Camera Angle	-90°	-90°	-90°	-90°
Other Settings	1. If you need to obtain more facade information about buildings or stronger penetrability, we recommend that you enable non-repetitive scanning. 2. For forests with high crown densities (greater than 0.7), you can use cross routes to obtain the optimal penetrability. Cross routes can be formed by creating two identical routes and then setting the main course angle of one route to ±90° so that the two routes are perpendicular to each other. Flights along cross routes can effectively boost penetrability in dense forests. 3. For mountainous areas with big altitude differences, we recommend that you set routes vertical to contour lines to ensure the evenness of point clouds. Compared with routes parallel to contour lines, routes vertical to contour lines have lower efficiency but better modeling effects.			

Route Parameter	High Accuracy - Mountainous Areas	High Efficiency- Mountainous Areas	Forests
Altitude	Surveying-based DSM follow 100-200 m	Network DSM follow 200-220 m	Surveying-based DSM follow 80-150 m
Speed	10-12 m/s	12-15 m/s	8-10 m/s
Number of Returns	5	5	5
Scanning Mode	Repetitive scanning	Repetitive scanning	Non-repetitive scanning
Side Overlap Ratio	50%	35-50%	50%
Camera Angle	-90°	-90°	-70°

❶ Plain areas: A plain area is a mapping area whose biggest altitude difference is smaller than 20% of the flight altitude. For example, if the biggest altitude difference of a mapping area is smaller than 20 m and the flight altitude is 100 m, this mapping area is a plain area.

❷ Hilly areas: A hilly area is a mapping area whose biggest altitude difference falls between 20% and 40% of the flight altitude. For example, if the biggest altitude difference of a mapping area is between 20 and 40 m and the flight altitude is 100 m, this mapping area is a hilly area.

❸ Mountainous areas: A mountainous area is a mapping area whose biggest altitude difference is larger than 40% of the flight altitude. For example, if the biggest altitude difference of a mapping area is greater than 40 m and the flight altitude is 100 m, this mapping area is a mountainous area.

3.1.2.3. Flight Data Collection

3.1.2.3.1. Pre-flight Check

On the map view, tap the start icon to enter the pre-flight check screen. Ensure that the remote controller is in N mode, the devices have been sufficiently charged, the RTK status is normal (if PPK technology is used, GNSS can be used), the microSD card has sufficient storage space, the RTH altitude and max altitude are higher than the route altitude, the signal lost action is Return To Home, the Max Flight Distance switch is turned off, and the control stick mode is Mode 2. If the mapping area has strong winds or the batteries cycles are high, we recommend that you set the low battery warning threshold to a higher value and set Obstacle Avoidance to Brake.
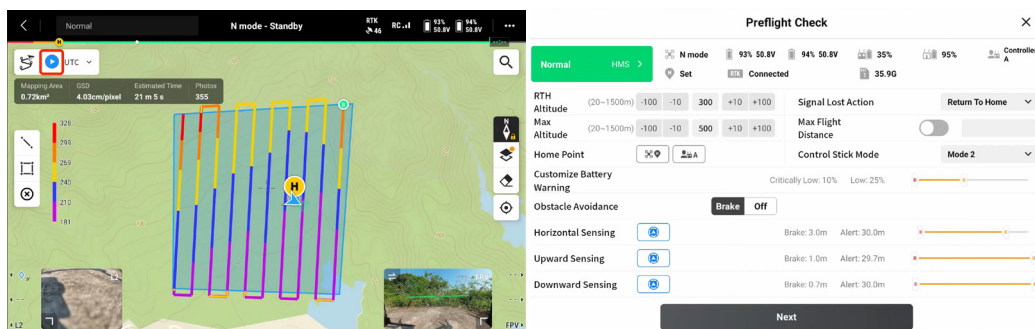

Figure: Pre-flight checklist

Tap Next to set the signal lost action, which is the action performed by the aircraft after signal loss during a route-based flight. You can select Continue or Return To Home, in most cases that return to home settings is recommended. After the check, ensure that the flight site is unobstructed and safe, and then upload the flight task for execution.
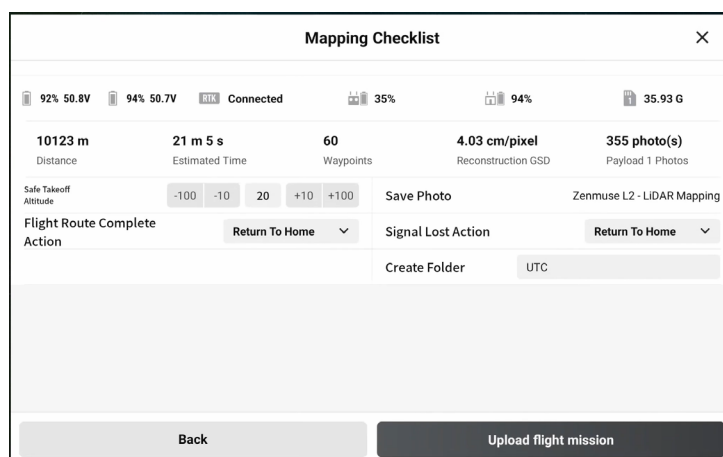

Figure: Route check

3.1.2.3.2. Route-based Operations

Enter the camera view. You can use the side buttons to switch between the LiDAR view and the visible light view. During the flight, keep an eye on the status of RTK and IMU calibration. You can tap the laser ranging icon to view the real-time altitude relative to the ground.

Figure: Side-by-side display of the visible light view and LiDAR view

Press the R3 button on the remote controller to display the FPV view on the screen. Observe the flight environment to ensure flight safety.
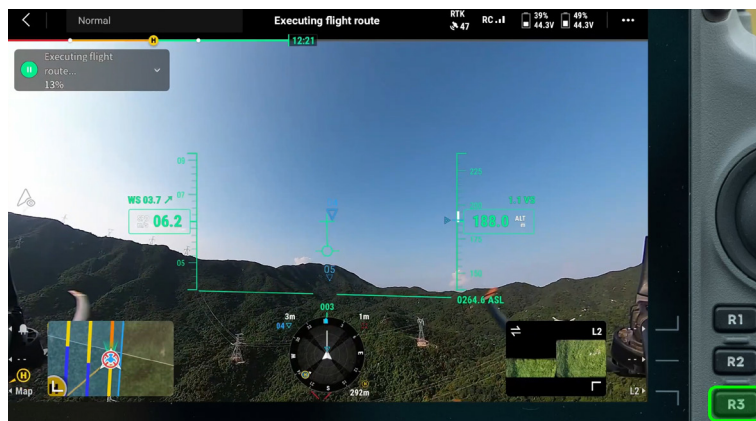

Figure: FPV view

Figure: Battery hot-swapping

If the battery needs to be replaced during the flight, we recommend that you perform battery hot-swapping after RTH. After replacement, tap the blue start icon and select Continue. The aircraft automatically flies to the breakpoint and restores to the status before RTH. After automatic IMU calibration is complete, the aircraft starts point cloud recording and resumes the task.

3.1.2.3.3. Task Quality Report

After a flight ends, DJI Pilot 2 automatically generates a task quality report. Note: After photo shooting or point cloud recording, wait 60 seconds before you power off the device or remove the microSD card. Otherwise, point cloud accuracy may be impaired or files may be damaged.
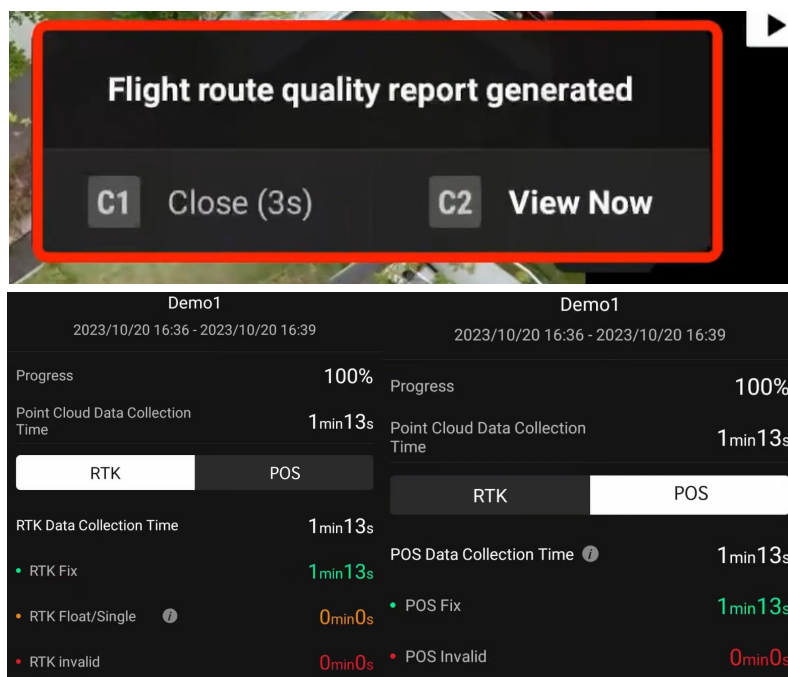

Figure: Task quality report

Tap View Now to view the task quality report. The report contains the task name, start time, end or termination time, and the task progress when the flight ends.

❶ **Point Cloud Data Collection Time:** the duration from start to end of point cloud data collection (excluding the calibration process at the start and end). You can view the RTK or POS status information based on your requirements.

❷ **Tap RTK:** The RTK data collection duration and RTK status are displayed. The RTK

status can be RTK Fix, Float/Single, or RTK Invalid, which are marked in different colors (including both the routes and fonts). If the duration next to RTK Float/Single is long, PPK calculation can be performed during data processing to obtain high-accuracy positioning data.

❸ **Tap POS:** The total duration from the start of IMU calibration before point cloud data collection to the end of IMU calibration after data collection is displayed. The POS status can be POS Fix or POS Invalid.

You can also enter the route library, select an executed route, and then tap View Task Quality Report to view its quality report.
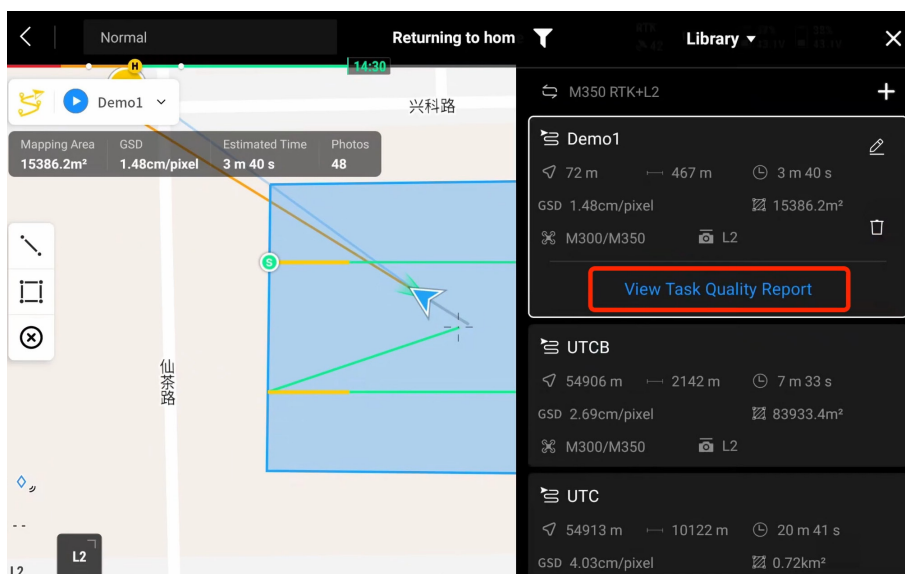

Figure: Task quality report

Power off the aircraft after the task is complete and remove the microSD card from Zenmuse L2. Insert the microSD card into a computer and check the point cloud data and other files in the DCIM folder. The folder contains files with the following suffixes:

CLC (camera LiDAR calibration file)

CLI (LiDAR IMU calibration file)

LDR (LiDAR data)

RTK (RTK data of the main antenna; when visible light data requires PPK calculations, RTK files are used as satellite observation files on aircrafts)

RTL (compensation data of RTK pole)

RTS (RTK data of auxiliary antenna)

RTB (base station RTCM data)

IMU (IMU raw data)

SIG (PPK signature file)

LDRT (point cloud file for playback on the app)

RPT (point cloud quality report)

RPOS (real-time POS solution data)

JPG (photos taken during flight)

Figure: Removing the microSD card for data export after the task ends

3.1.3. Data Processing

3.1.3.1. Data Import

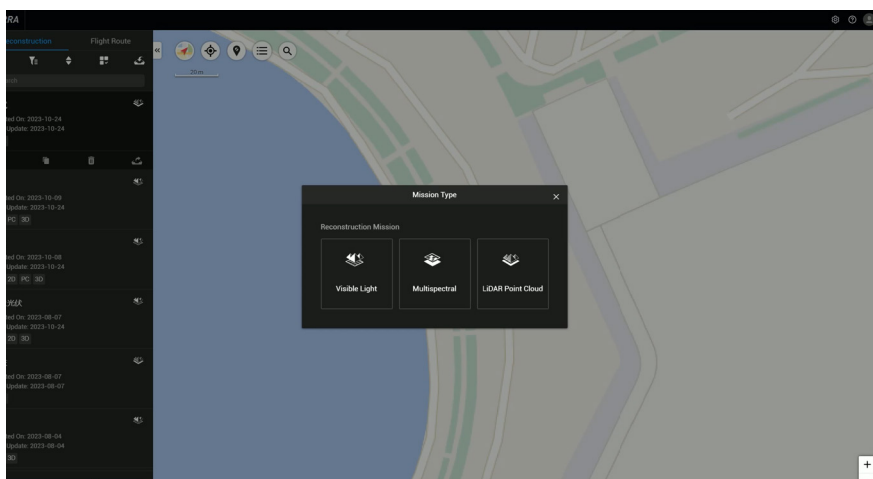Launch DJI Terra, tap New Mission, and create a LiDAR Point Cloud task.

Figure: LiDAR Point cloud process task creation in Terra

LiDAR point cloud data processing occupies a large amount of computer resources. Make sure that the computer configurations are sufficient to process LiDAR point cloud data smoothly.

Available RAM	Max Size of Raw Point Cloud (Version Earlier than Terra v4.0)	Max Size of Raw Point Cloud (Terra v4.0 and Later Versions)
16GB	4GB	15GB
32GB	8GB	30GB
64GB	16GB	60GB
128GB	32GB	120GB

Figure: Correspondence between computer memory and maximum raw point cloud file size

Click the folder icon to import a folder that contains the LiDAR point cloud data collected by Zenmuse L2. (The folder should contain files with the following suffixes: CLC, CLI, CMI, IMU, LDR, RTB, RTK, RTL, and RTS. Any JPEG files in the folder are not required to be imported.)
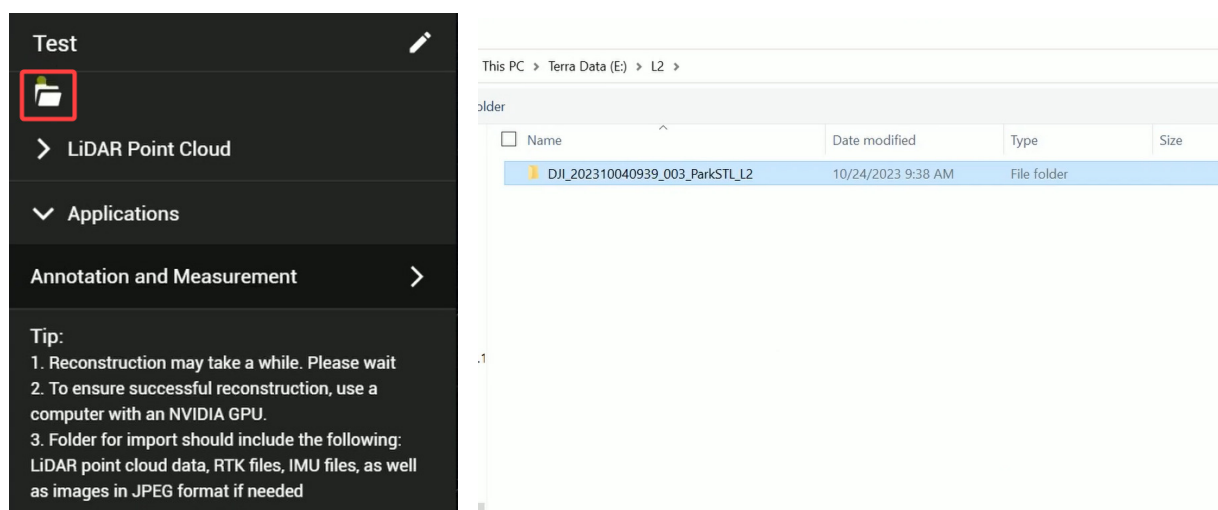

Figure: Point cloud data import

If you need to use the D-RTK 2 Mobile Station or a third-party base station for PPK calculations, you need to confirm the operation time based on the point cloud data files acquired by Zenmuse L2. Search for .DAT format RTCM files with the same timestamp as the stored files of the D-RTK 2 Mobile Station or third-party RTK base station.

If you use the D-RTK 2 Mobile Station, copy the .DAT file with the same timestamp in the rtcmraw folder to the folder of the point cloud data file directory. If you use a third-party

RTK base station, .oem, .ubx, .obs, and .rtcm files are supported. Rename the file the same as the .RTB file in the point cloud data file directory.

Protocol Type	Protocol Version	Message Type	Name Format
OEM	OEM4 / OEM6	RANGE	DJI_YYYYMMDDHHMM_XXX.oem
UBX	-	RAWX	DJI_YYYYMMDDHHMM_XXX.ubx
RINEX	v2.1x / v3.0x	-	DJI_YYYYMMDDHHMM_XXX.obs
RTCM	v3.0	1003/1004/1012/1014	DJI_YYYYMMDDHHMM_XXX.rtcm
	V3.20	MSM4/MSM5/MSM6/MSM7	

Figure: Types and naming rules

Copy the .RTCM file to the folder of the point cloud data file directory. DJI Terra will prioritize files in the following order: .oem > .ubx > .obs > .rtcm.

If you use the D-RTK 2 Mobile Station, you can also directly copy all the base station data files from that day to DJI Terra. DJI Terra automatically recognizes the data files.
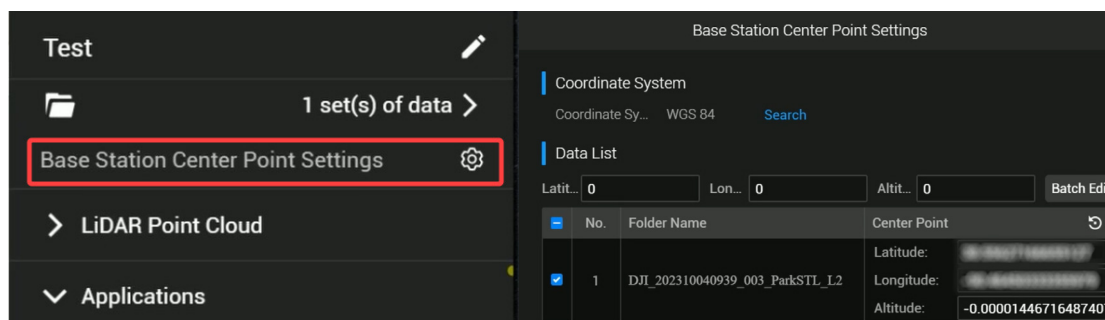

Figure: RTK base station data

After the import, if no center point coordinates are set for the base station or the original self-convergent coordinates of the base station need to be replaced, you need to modify the center point coordinates in the Base Station Center Point Settings section as instructed in the figure below.

Procedure

1. After importing the data, click Base Station Center Point Settings.
2. Enter the Base Station Center Point Settings, and click to search for and set the base station's central point coordinate system as the one used when setting up the base station's central point during operation.
3. The data list displays the serial number, folder name, and central point latitude (X), longitude (Y), and altitude (Z).
4. Individual edit: Input data in the fields for central point latitude, longitude, and altitude to modify.
   Note that individual edit:
   a. Supports cut and paste;
   b. Supports the pasting of latitude, longitude, and altitude, leaving the software to auto-fill the data (separate the values with a space and tab);
   c. Click "Reset" to reset the base station data.
5. Batch edit: Check the box before the serial number and input/paste the data into the fields for latitude (X), longitude (Y), and latitude (Z), then click "Batch Edit."
6. Click "Save" to replace the original base station coordinates.

3.1.3.2.Basic Parameters

You can set Point Cloud Density by percentage or by distance. This parameter allows you to adjust the number of point clouds to be processed. If you need fast processing or computer performance is insufficient, set a small percentage or a large distance.
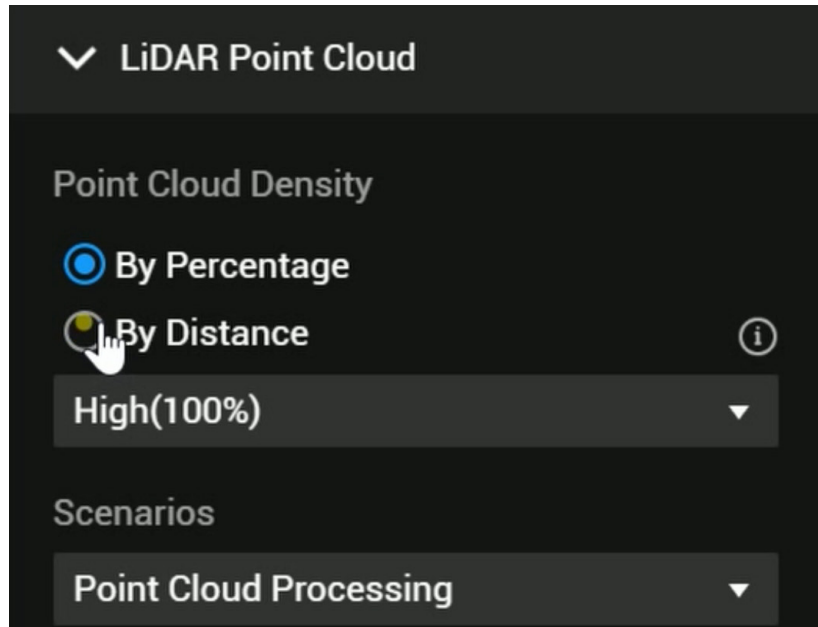

Figure: Point cloud density selection

By Percentage: High density refers to the original sampling rate, which uses 100% of the point cloud data for processing. The processing results will be of the highest quality but will take the longest amount of time to process. Medium density uses 25% of the point cloud data for processing. The processing results will be of medium quality and will take an average amount of time to process. Low density uses 6.25% of the point cloud data for processing. The processing results will be of lower quality but will take the shortest amount of time to process.

By Distance: When the point cloud density is uneven (e.g., if the point cloud overlaps area is too thick), you can set the sample distance to select some points within this distance range for calculation, which reduces the amount of points and makes the point cloud density more even.

Select Point Cloud Processing for the Scenarios option.

3.1.3.3. Point Cloud Processing
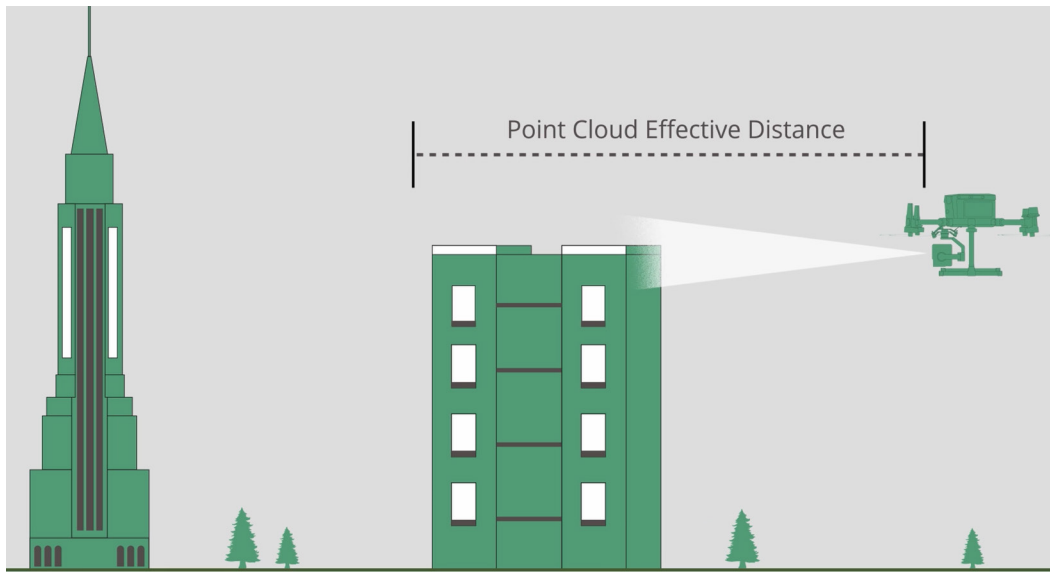
❶ **Point Cloud Effective Distance Range:** It refers to the effective distance between the point cloud and the LiDAR for point cloud processing. If the points captured by the LiDAR exceed the effective distance, the points will be filtered out during processing. You can set an effective point cloud distance if you need to reconstruct a shorter target range but will inevitably capture the background in the distance.

❷ **Optimize Point Cloud Accuracy:** This feature optimizes the adjustment of the point clouds scanned at different times during point cloud processing to improve their overall accuracy. We recommend that you enable this feature.

❸ **Smooth Point Cloud:** This feature reduces the point cloud thickness to remove discrete noise, make local structure clearer, and improve the effects of ground point extraction. If you need to retain the slight elevation changes (smaller than 5 cm) on the object surface, or if you have low vegetation, uneven ground, buildings with facade details, we recommend that you disable this feature.

❹ **Ground Point Classification:** If this feature is enabled, ground points would be classified from non-ground points. Ground points can be used for generating a topographic map for the mapping area.
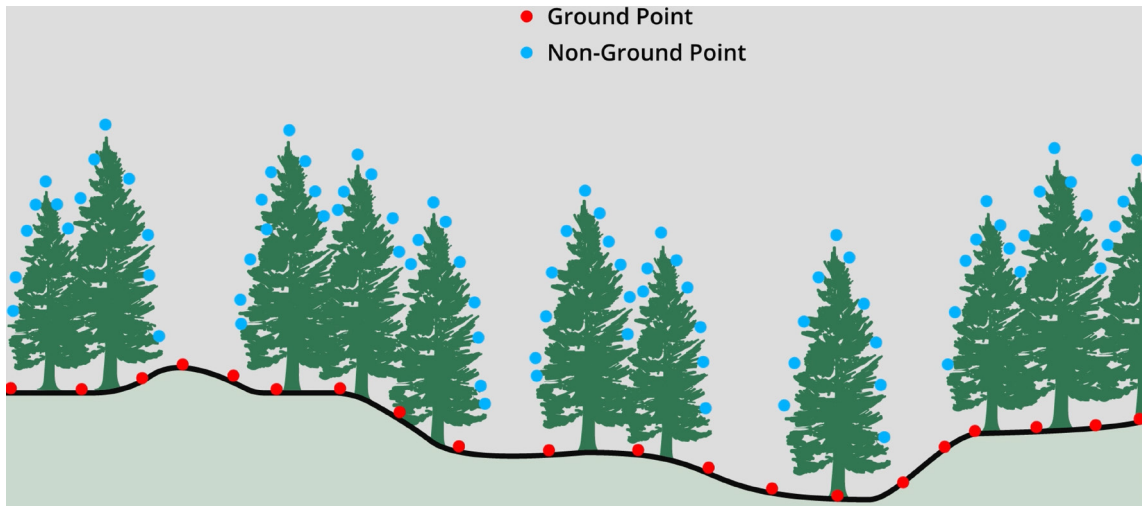
Figure: Ground points and non-ground points

Select the Ground Point Classifcation based on actual needs. Flat Ground is suitable for areas with dense buildings or plains. Gentle Slope is suitable for areas such as common mountains and hills. Steep Slope is suitable for areas with great elevation changes such as high mountains and valleys.
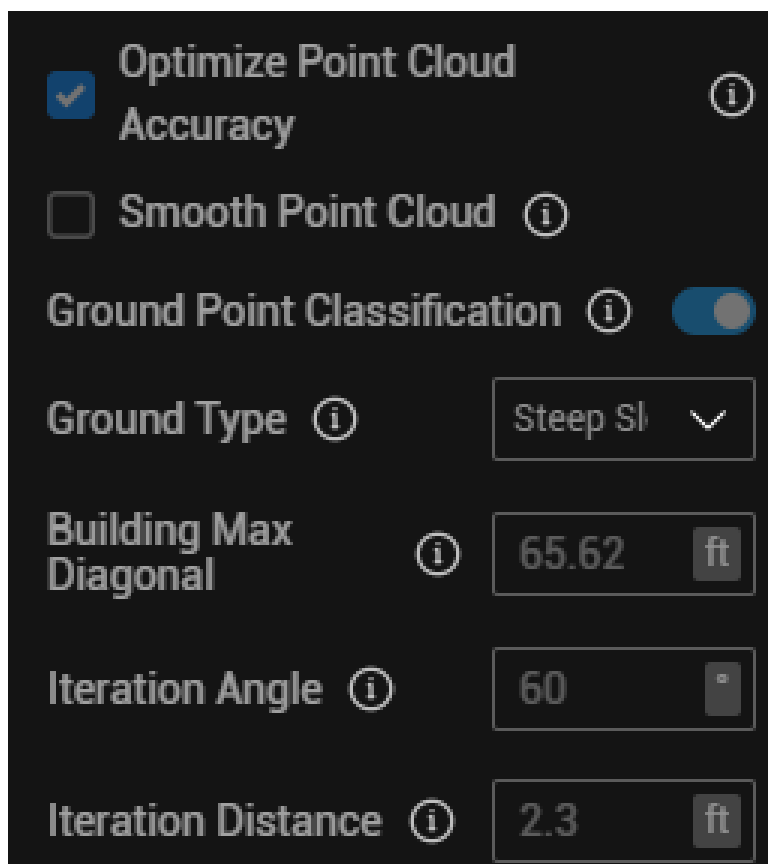

Figure: Ground Point Classification should be enabled before task reconstruction

The ground point classification algorithm of DJI Terra uses the specified building dimensions to set evenly distributed seed points in the mapping area and then connects the seed points to form an initial triangle network.
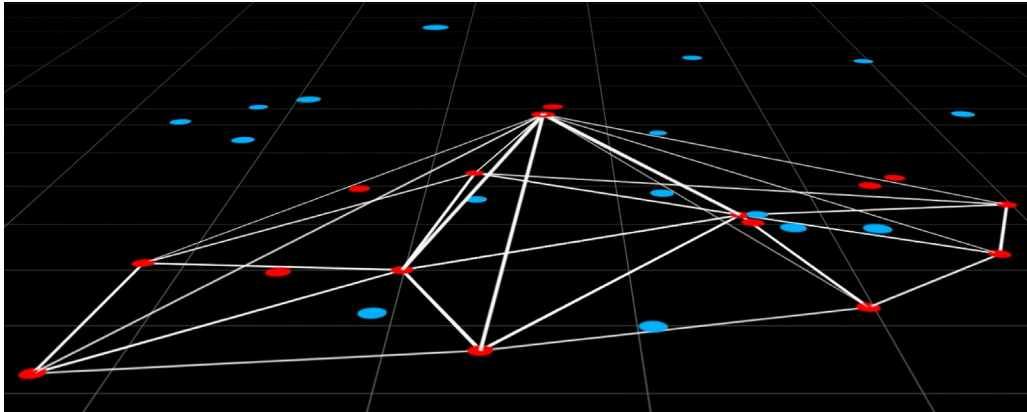

Figure: Ground point classification

Whether a laser point is a ground point can be determined by calculating the angle formed between the laser point and the vertex of the triangle where it is located and the distance from the laser point to the plane where the triangle is located.

If the angle and the distance are smaller than the values set for the Iteration Angle and Iteration Distance parameters, the point is identified as a ground point and the triangle mesh is updated. This process is repeated until all ground points in the mapping area are identified.
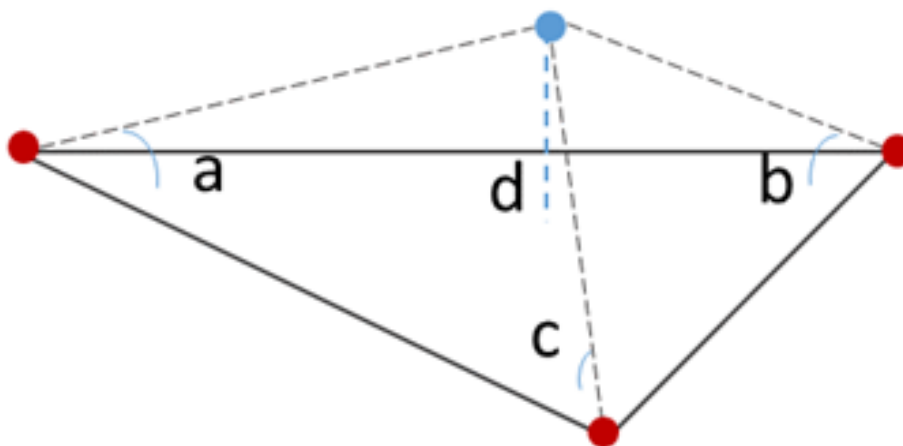

Figure: Ground point classification

- Building Max Diagonal: Set this parameter based on the largest building in the mapping area. If this parameter is set to a small value, rooftops may be recognized as ground.

- **Type of Terrain:** DJI Terra provides preset parameters for different types of terrain such as Flat Ground, Gentle Slope, and Steep Slope. The default parameters suit most common scenarios. If a mapping area has large undulations, you can increase the iteration angle and distance as needed.

- **Generate DEM:** If this feature is enabled, DEM data in TIFF format will be generated based on the point cloud data of ground points. The following scales are supported for DEM results: 1:500, 1:1000, and 1:2000. You can also set a DEM result resolution based on the GSD.

- **Contour:** When the contour option is enabled and reconstruction completes, user can obtain contour output from project path /lidats/terra_contour and import the output file to a third party software to view and edit.

3.1.3.4. Advanced Settings

❶ Accuracy Control and Check:

Tap the import icon to import checkpoints or control points. Note that the coordinate system should be the geodetic coordinate system or projected coordinate system, whichever is consistent with the point cloud coordinate system. After the import, select a checkpoint or control point and tap Start Processing. Control points can be used to optimize the elevation accuracy of point cloud results and checkpoints can be used to check the accuracy of point cloud results.
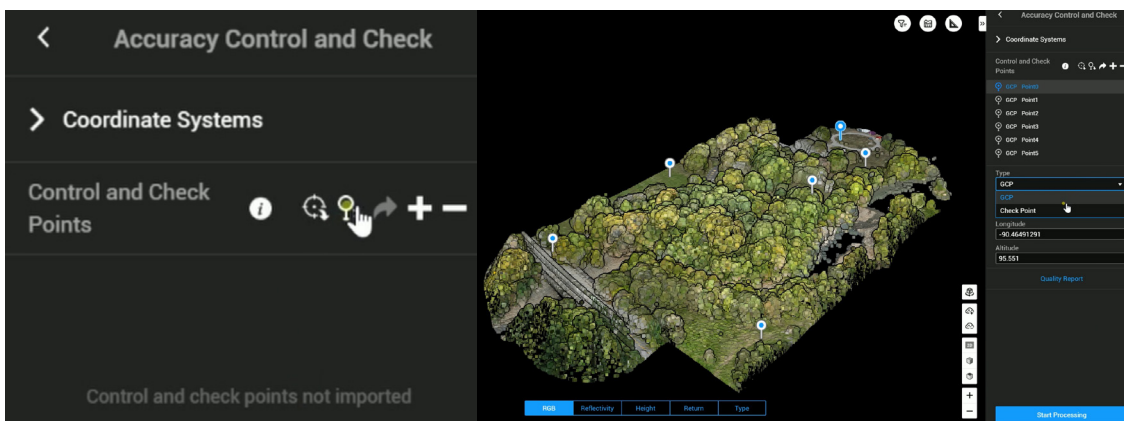

Figure: Import of checkpoints and control points

❷ Set the coordinate system and point cloud results according to the result requirements.

The default format of LOD point cloud files is PNTS.

1) LAS refers to the ASPRS LASer format for 3D point cloud files.

2) PLY refers to the PLY format for non-LOD 3D point cloud files. Files in this format can be viewed using MeshLab.

3) PCD refers to the PCD format for non-LOD 3D point cloud files, which is used in Point Cloud Library. Files in this format can be viewed using third-party software such as CloudCompare.

4) S3MB refers to the s3mb format for LOD 3D point cloud files.

Figure: Point cloud model output format

If the selected point cloud format is LAS, PLY, or PCD, you can enable the Merged Output feature to merge the point cloud output into a single file.

3.1.3.5. Data Processing and Viewing

Click Start Processing. Check the settings in the pop-up reconstruction parameter checklist.

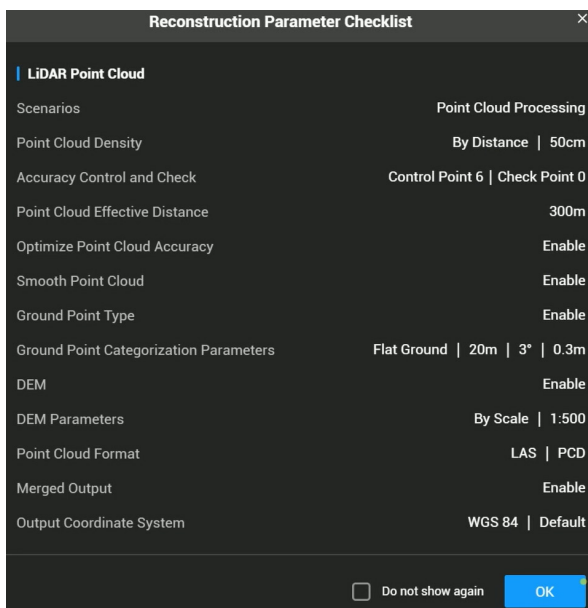| Reconstruction Parameter Checklist	✕
❙ LiDAR Point Cloud	
Scenarios	Point Cloud Processing
Point Cloud Density	By Distance	50cm
Accuracy Control and Check	Control Point 6	Check Point 0
Point Cloud Effective Distance	300m
Optimize Point Cloud Accuracy	Enable
Smooth Point Cloud	Enable
Ground Point Type	Enable
Ground Point Categorization Parameters	Flat Ground	20m	3°	0.3m
DEM	Enable
DEM Parameters	By Scale	1:500
Point Cloud Format	LAS	PCD
Merged Output	Enable
Output Coordinate System	WGS 84	Default

Figure: Reconstruction parameter checklist

After the reconstruction is complete, you can move, zoom in or out, or rotate the result. You can choose to display the output in different modes at the bottom of the screen. Select RGB to display the output with true colors.

Select Reflectivity to display the corresponding color based on the object's reflectivity, in the scale of 0-255. The range of 0-150 corresponds to diffuse reflective objects with a reflectivity of 0-100%, while 151-255 corresponds to fully reflective objects.
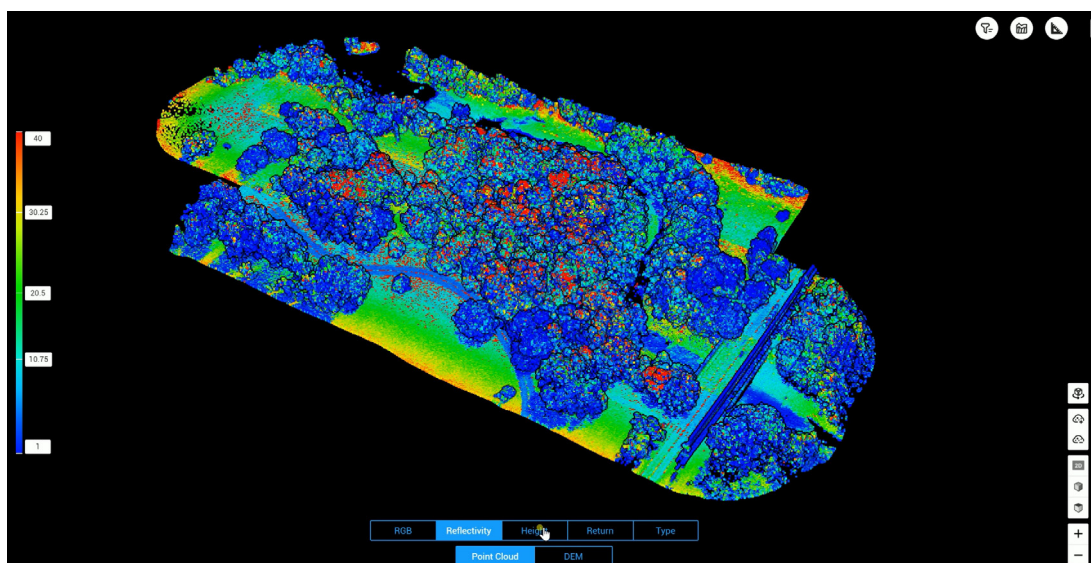

Figure: Display in Reflectivity mode

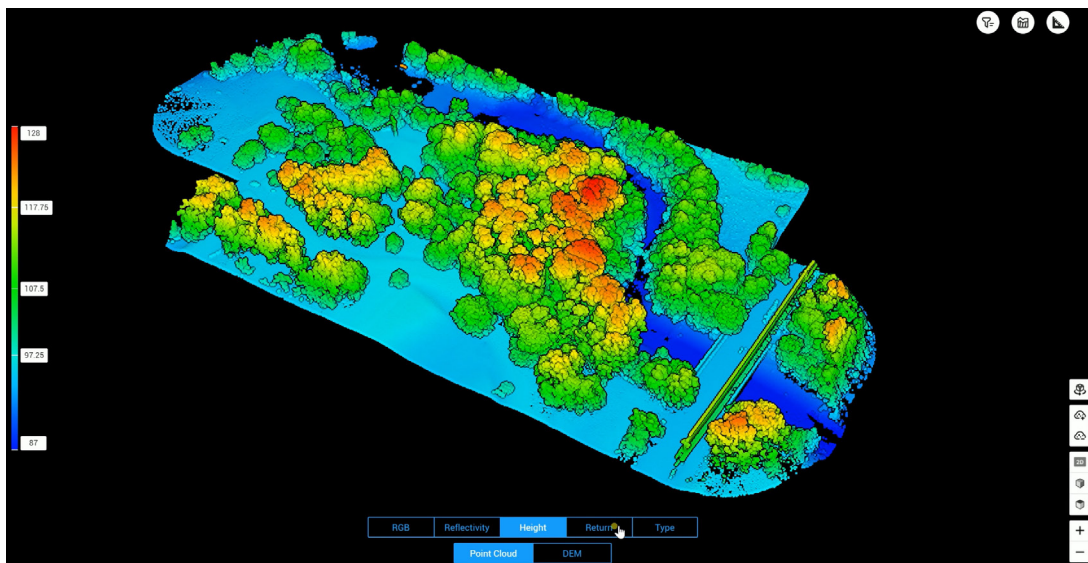Select Height to display different colors for different altitudes of the point cloud.

Figure: Display in Height mode

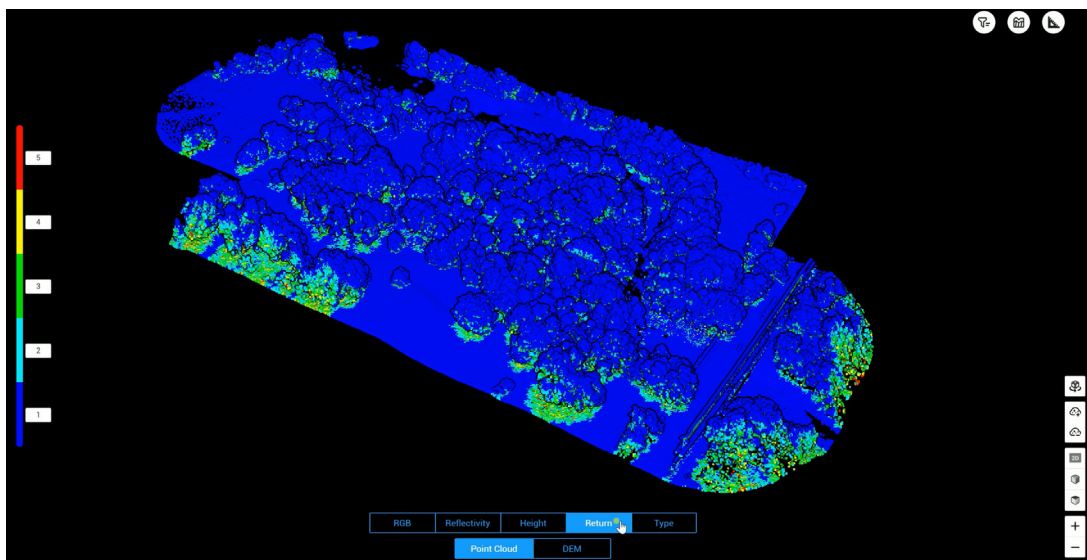Select Return to display the corresponding color according to the number of returns when collecting data.

Figure: Display in Return mode

Click the profile icon to open the Profile panel. Vertical Profiles help quickly recognize elements such as vegetation and ground. Select a desired start point on the model and draw a profile line by left-clicking your mouse on the model, moving the cursor, and then right-clicking your mouse. At the top of the Profile panel, set the profile width. The default profile width is 5 m.

Figure: Vertical Profile feature

On the reconstruction screen, you can press Ctrl+Alt+F to open the current task folder. You can view and save the report in HTML format. The report contains relevant information about the raw data, software parameters, output format, and point cloud processing time. Refer to the document How to Read a DJI Terra Quality Report on DJI official website for more information.
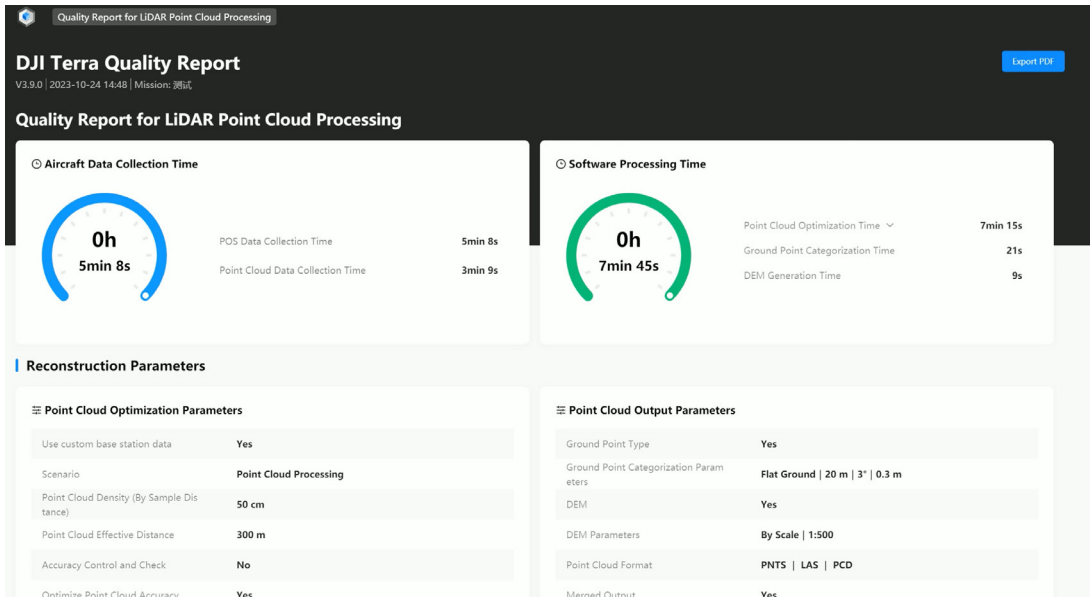

Figure: Quality report for point cloud processing

3.1.4. Manual Flights

The manual flight feature can apply to manual scans of individual buildings among other scenarios.

3.1.4.1. Flight Safety

Control the aircraft takeoff and keep the flight within a visual line of sight. Fly the aircraft below 120 m (400 ft). Any flight altitude higher than that may violate local laws and regulations. Make sure you understand and comply with the local laws and regulations before flying. Make sure to read the Safety Guidelines before flight to ensure the safe use of the product.

3.1.4.2. Parameter Settings

On the camera view, switch the camera mode to Record Point Cloud.

Figure: Enable point cloud recording

For manual flights, select the non-repetitive scanning mode and the triple return mode, enable RGB Coloring. Make sure that the network RTK is properly connected or an RTK base station has been set up.

The RGB coloring feature controls whether the visible-light camera takes photos during LiDAR point cloud data collection. We recommend that you keep RGB coloring enabled except in nighttime operations.

3.1.4.3. IMU Calibration

Manual IMU Calibration: To ensure consistent inertial navigation accuracy, IMU calibration is required before and after data collection and after 200 seconds of flight at a consistent speed. Fly the aircraft to an appropriate altitude, switch to the camera view, and then click the Calibrate button. A calibration area (a 30 m route) appears. The aircraft automatically flies back and forth along the route for three times, finally stopping at the start point. (Ensure that no obstacle exists along the 30 m route and the obstacle avoidance system is turned on.)

Figure: IMU calibration

Be sure to perform a manual IMU calibration after data collection to avoid possible accuracy issues with the result. Zenmuse L2 automatically records the IMU raw data within about 2 minutes after the point cloud recording ends, for the purpose of difference calculations by DJI Terra.

3.1.4.4. Laser Rangefinder and PinPoint Adding

The cross hair in the center of the live view will turn red, which means the laser rangefinder (RNG) is pointing at the subject and measuring the distance between the subject and the aircraft, as well as the altitude, latitude, and longitude of the subject. Press the L3 button on

the remote controller to add a PinPoint in the center of the screen.
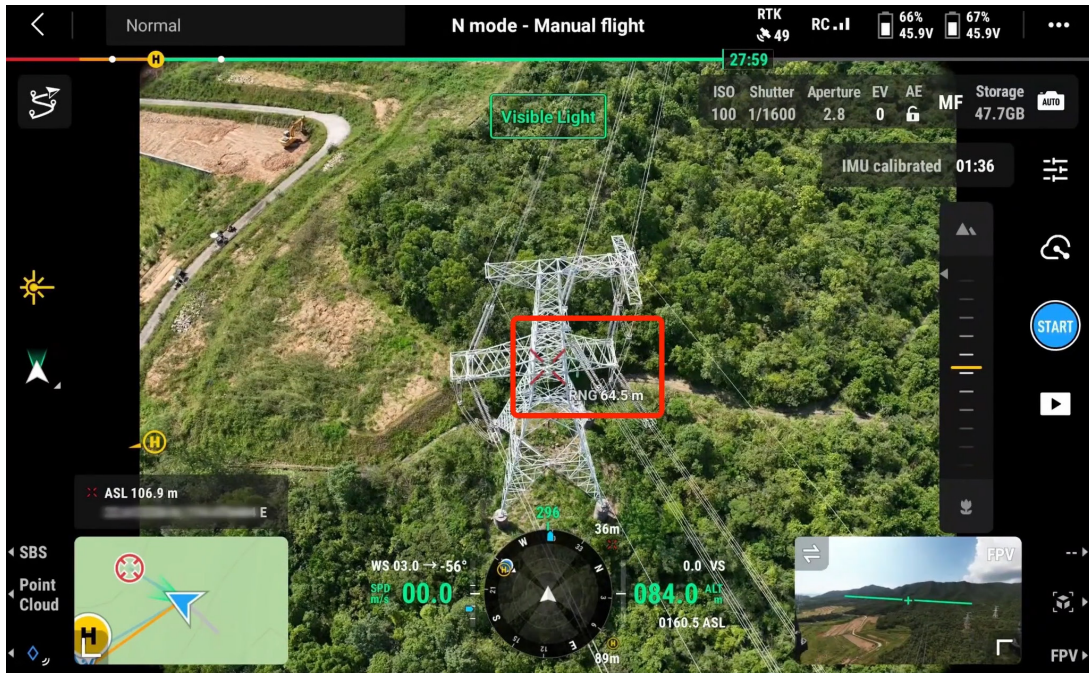

Figure: Laser ranging

Zenmuse L2 supports a detection range of 250 m under 100 klx when the measured subject's reflectivity is 10%. In actual use, vertical distance changes at different scan angles should also be considered. The recommended vertical distance between the payload and the recorded subject is between 20 m and 150 m.
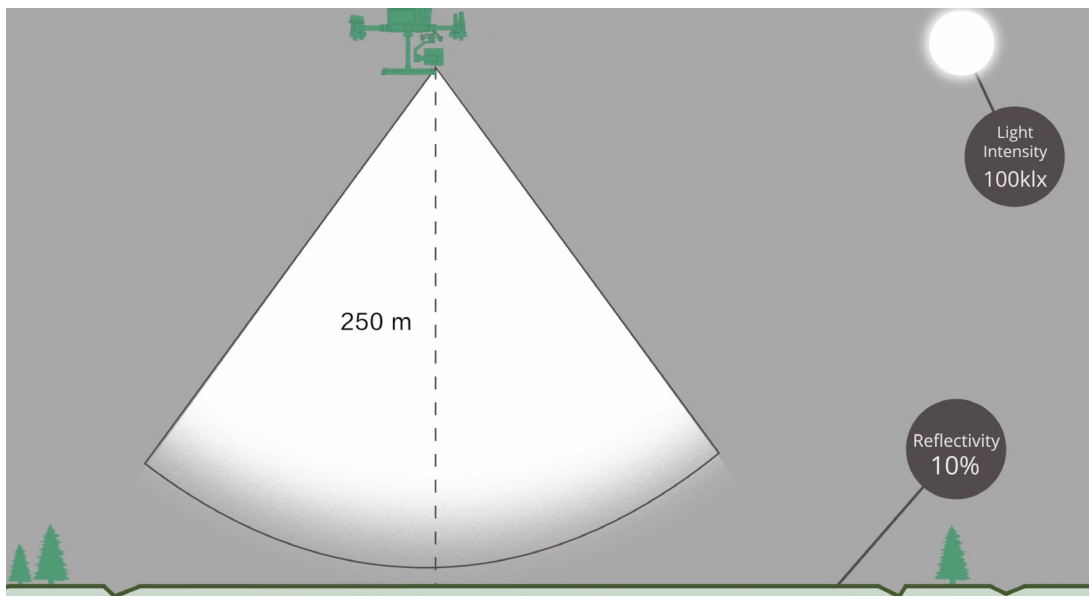

Figure: Detection range

Note: It is not recommended to use Zenmuse L2 in scenarios as described below.

Otherwise, the detection range and accuracy of LiDAR may be reduced, leading to point cloud noise or voids.

❶ Conditions with low visibility such as rainy or foggy weather.

❷ Surfaces with strong reflectivity such as water or transparent surfaces, or fully reflective objects or street signs in a close range (<20 m).

❸ The distance between Zenmuse L2 and the subject is less than 30 m in scenarios that need high-precision modeling.

❹ The distance varies depending on the environment and accuracy requirement. For example, point cloud data of power line scenarios can be recorded from 10 to 30 m.

3.1.4.5. Data Collection

Fly the aircraft near the subject and adjust the gimbal to a proper angle for data collection by observing the camera view. Click the point cloud recording button to start recording. During a manual flight, the recommended speed is 8-12 m/s and the recommended distance from the subject is 50-100 meters. You can pause or start point cloud recording any time during collection. After the aircraft flies at a consistent speed for 200 seconds, click Calibrate option to calibrate the IMU.

Figure: Enable point cloud recording

Press the L1 button on the remote controller to switch to the side-by-side display of the visible light view and LiDAR view.
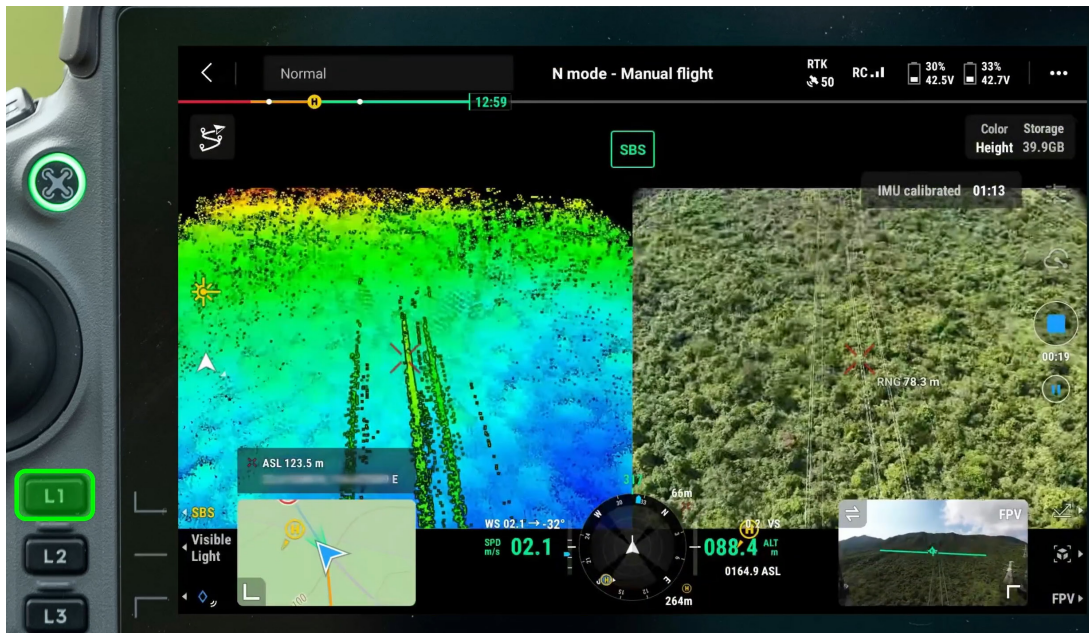

Figure: Side-by-side display of the visible light view and LiDAR view

Press the L2 button on the remote controller to switch between the visible light view and the LiDAR view.

Figure: Display of the visible light view

Press the R1 button on the remote controller to switch between the following coloring modes in the LiDAR view: reflectivity, height, distance, and RGB (requiring enabling the RGB coloring feature).

Figure: Switch coloring coding

Press the R2 button on the remote controller to preview the model recorded. Tap to view the point cloud model from above or in the direction of north, east, south, or west.
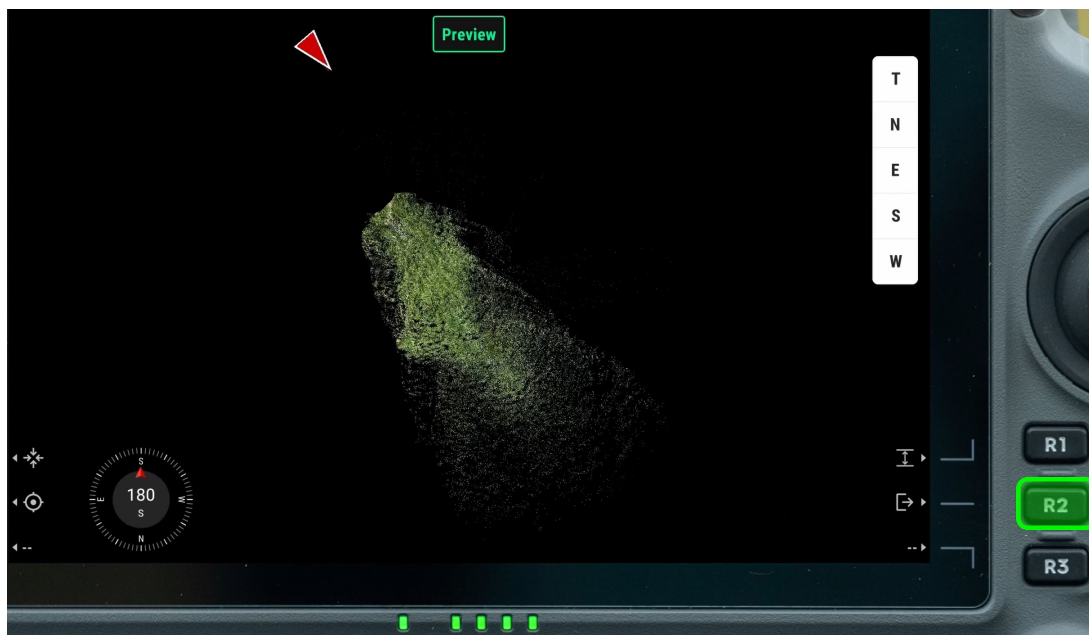

Figure: Model preview

When previewing a model, press the L1 button on the remote controller. The model recenters. Zoom in or out to display the whole model.

When previewing a model, press the L2 button on the remote controller to view the point cloud model beneath the aircraft.

Press the R2 button on the remote controller to exit the preview.

Note that recording while hovering is prohibited and re-calibration based on calibration status reminders is required. Make sure there are no obstacles within a 30 m radius of the start and end points.

Click the point cloud recording button again to finish recording. It is recommended to perform another IMU calibration.

(Note: After photo shooting or point cloud recording, wait 60 seconds before you power off the device or remove the microSD card. Otherwise, point cloud accuracy may be impaired or files may be damaged.)

3.1.4.6. Point Cloud Playback

Tap the playback icon and select Point Cloud in the top bar.
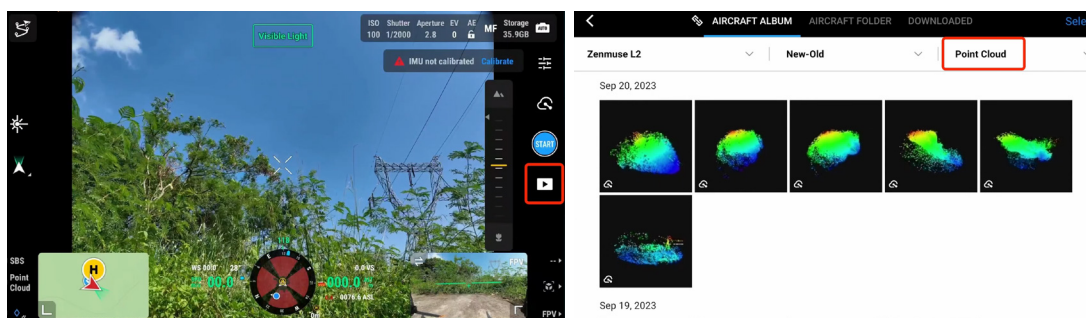

Figure: Filter point clouds

Recorded point cloud files and photos are displayed (The RGB coloring feature needs to be enabled). You can select one or more point cloud files and download them to the

remote controller. (Make sure that the remote controller has sufficient storage space before the download.)
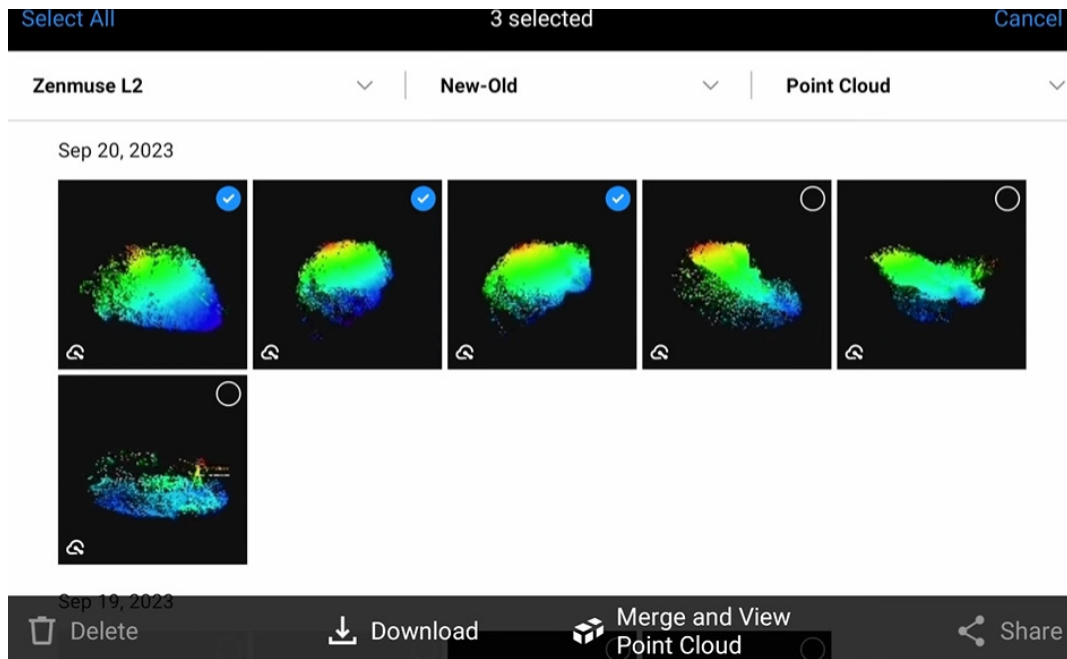

Figure: Select and download point clouds

After the download is complete, tap to preview the point cloud files. Tap the playback icon to view model details. You can move the model on the screen with one finger. You can tap and hold with two fingers to rotate the model (slide up or down to rotate the model around the x-axis; slide left or right to rotate the model around the z-axis). You can also slide diagonally with two fingers to zoom the model in or out.
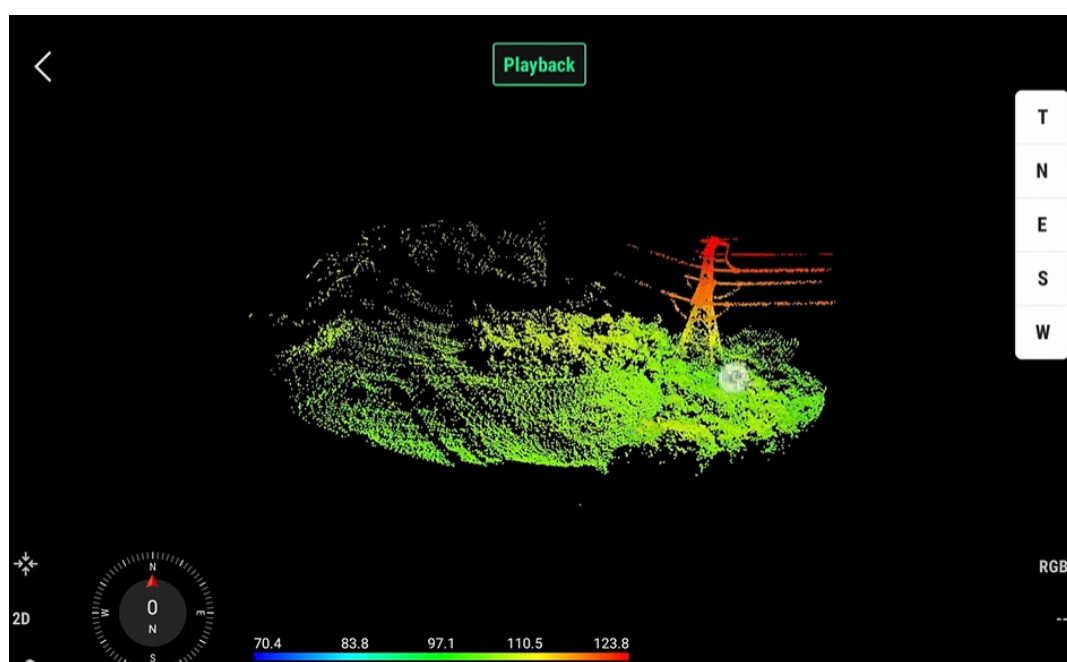

Figure: Model preview

Press the L3 button on the remote controller to enter the model selection screen. Select and download multiple point cloud files and merge the files. Then, you can quickly view the overall effect of the merged files and locate the positions where the cloud point effects are poor.

Make sure the aircraft and the remote controller are connected when viewing the point cloud models. A point cloud file less than 2 KB in size cannot be processed. Make sure that point cloud models are effective.

To clear the cache, enter the album to select and delete the downloaded files or tap Data and Privacy on the homepage and then tap DJI Pilot Cache Management to clear all downloaded point cloud data files.

3.2. Power Line Scenarios

Zenmuse L2 can apply to acquisition of the point cloud of power lines of the main grid and the distribution grid to serve tree barrier analysis or inspection route planning. If coordinates and heights of towers are unknown, you need to manually set points to determine the coordinates of the electrical towers, and then carry out the scan.

3.2.1. Preparation

3.2.1.1. Device Updates

Please confirm that your device's firmware version is not earlier than the versions specified in the session "1. Applicable Versions" above.

3.2.2. Route Planning

Select a route planning method:

❶ In complex environments or scenarios where accurate coordinates cannot be obtained, waypoint setup on aircrafts via a network RTK is recommended.

❷ In flat and open areas with accurate coordinate readings, you can directly use coordinates to plan routes.

❸ In special areas, you can use third-party software for route planning or manually reshoot the areas.

Route Planning Method	Main Grid	Main Grid with Big Altitude Differences	Distribution Grid	Cross Routes
Waypoint Setup on Aircraft		✓	✓	
Route Generation based on Known Coordinates	✓			
Manual Flights				✓

3.2.2.1. Waypoint Setup on Aircraft

Check the aircraft status. You can use Matrice 350 RTK, Matrice 30 series, Mavic 3 Enterprise Series, or another model with a built-in RTX. In this example, Matrice 350 RTK is used. Open DJI Pilot 2 and click Route-based Flight > Waypoint Flight > Live Mission Rec.
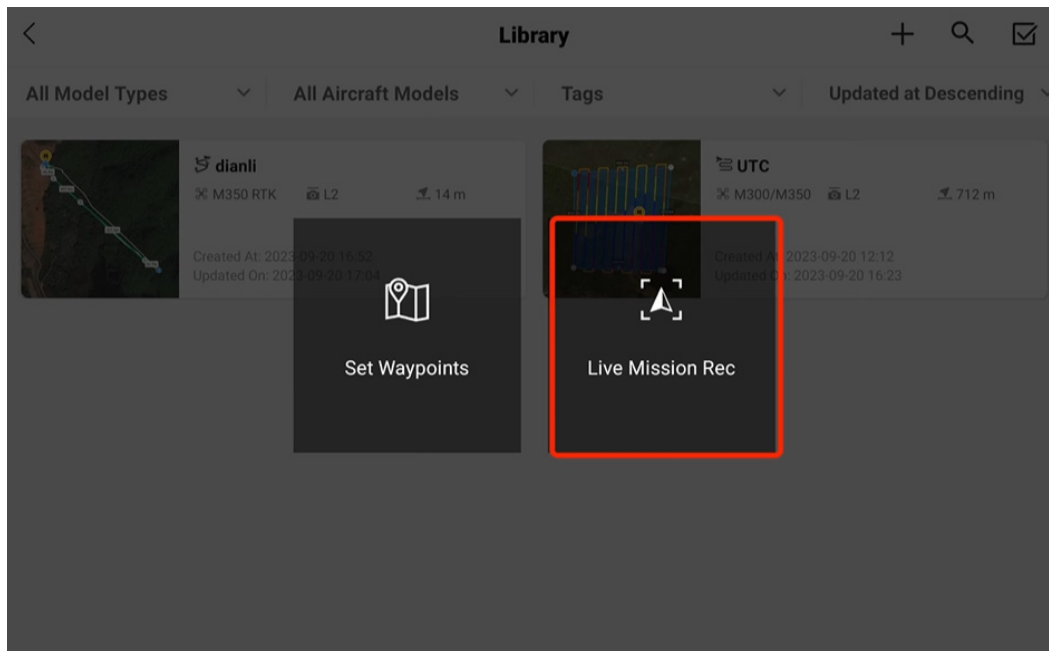

Figure Live task recording

Enable the network RTK feature and select an appropriate coordinate system. (DJI Terra supports reconstruction of LiDAR point cloud data collected by using the WGS84 geodetic coordinate system.) Before takeoff, make sure the RTK status of the aircraft is FIX and you hear a voice prompt reading "RTK connection successful. The absolute altitude of the aircraft will be recorded" if the controller's sound is on.

Special circumstance: If the mapping area has no network signal but coordinates are known, you can set up the D-RTK 2 Mobile Station in a position with known coordinates to achieve high-precision positioning or switch Zenmuse L2 to the GNSS flight mode for point cloud data collection and reconstruction.
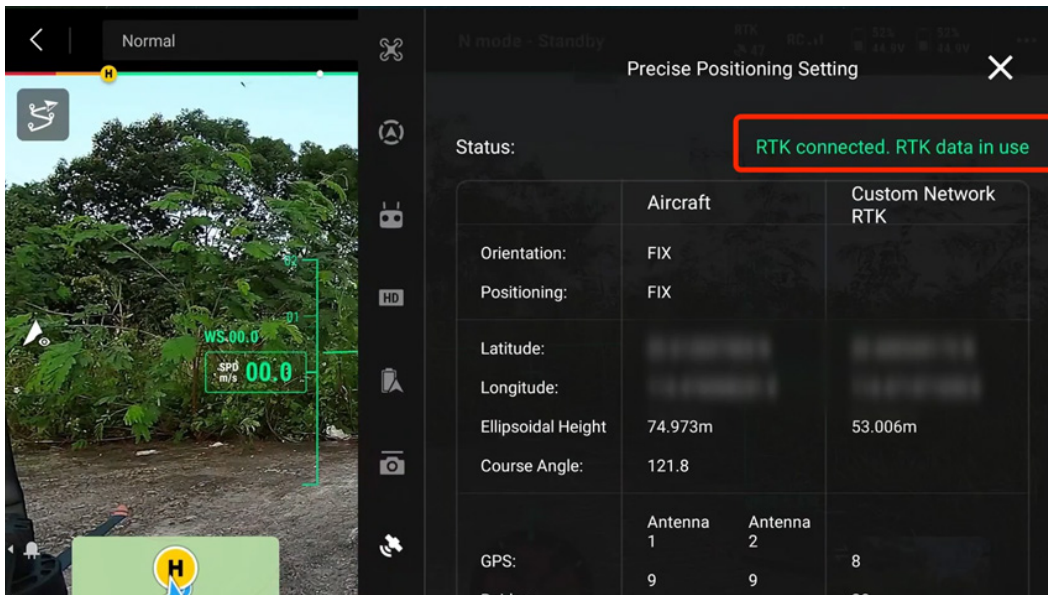
Figure: RTK connection status

Top waypoints: Tap the record button to add a waypoint and snap a photo when the aircraft is over the top of the tower at a proper altitude. To ensure the integrity of the tower on the map, you are recommended to set the waypoint at an altitude twice the tower height, usually 20-30 meters (65 to 100 feet). You can adjust the aircraft's downward obstacle avoidance range to 30 meters and confirm the aircraft's distance from the tower top with the help of the obstacle avoidance alerts.

Figure: Record a waypoint

If the distance between the current waypoint and the next waypoint is longer than 10 m, the aircraft adjusts the yaw angle at the current waypoint to align with the route before heading for the next waypoint. To improve flight efficiency, we recommend that you always orient the aircraft towards the next base power during waypoint setup to create an optimal route.

For reference: For common power transmission lines, it is discovered about the RGB mapping camera of Zenmuse L2 that when the gimbal yaw recenters, the gimbal pitch is -90°, and the two auxiliary vertical lines overlap the guiding lines on the upper left and upper right, high-quality point cloud data can be collected at the route altitude.
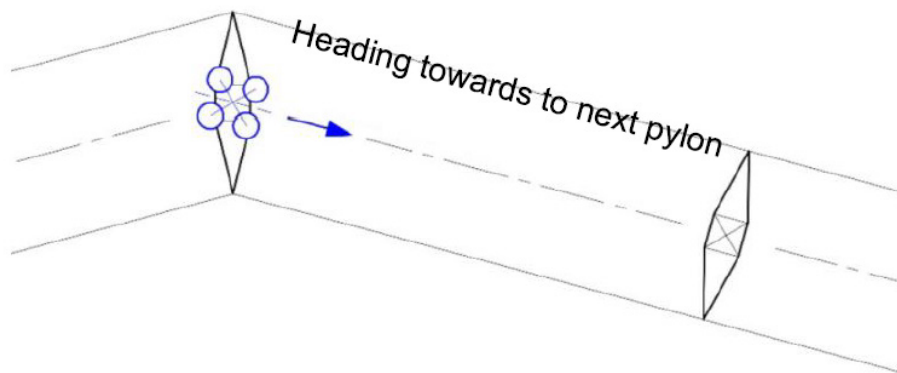
Sag waypoints accounting for line sag: For steps with a larger sag (for example, when the drop exceeds 50 meters), we recommend that you add a waypoint at a proper altitude (such as 30 meters) over the top of the largest sag point to ensure better reconstruction quality for this step.
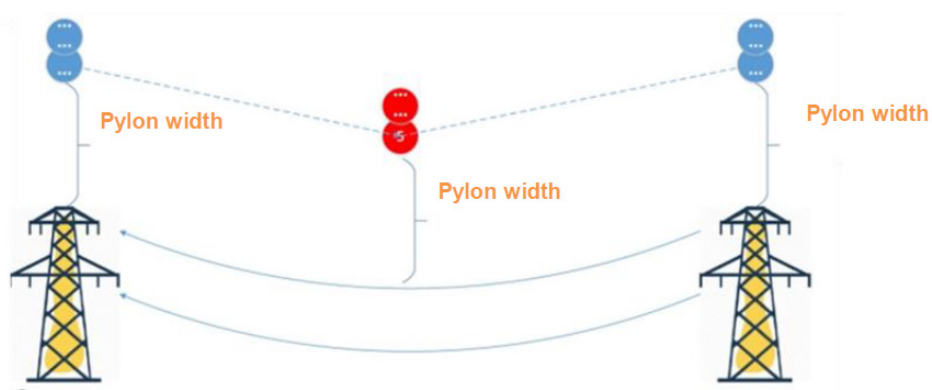

Figure: Top and sag waypoints of tower

Fore and aft waypoints: Add an auxiliary waypoint at a proper altitude over the lines around 50 meters horizontally away from the fore and aft towers (on the farther side of the operational segment) to ensure adequate collection of point cloud data at the fore and aft towers and adequate distance for IMU calibration (IMU calibration requires a distance of at least 30 meters, so the distance between the first and the second waypoints and between the last and the second to last waypoints should be at least 30 meters).
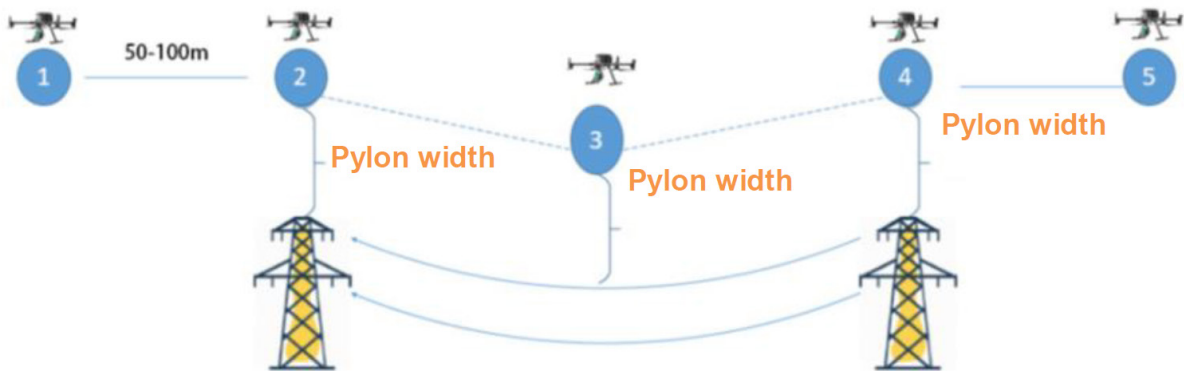

Figure: Adding a route at the fore and aft towers

1. Flight Route Settings (Global):

❶ Speed: Speed is inversely proportional to point cloud density. We recommended that you set Speed to about 15 m/s to ensure both efficiency and effectiveness.

❷ Altitude: Use the default value and do not modify it.

❸ Aircraft Yaw: Set it to Along Route.

❹ Gimbal Control: Set it to Manual Control by RC. Adjust the gimbal pitch angle based on the task type.

❺ Waypoint Type: Set it to Straight route. Aircraft stops.

❻ IMU Calibration: Turn it on.

❼ Power Saving Mode: Turn it off.

❽ Finish Action: We recommend that you set it to Return To Home.

Figure: After IMU Calibration is enabled, Zenmuse L2 automatically calibrates the inertial navigation system based on the route, without the need for operators' intervention

2. Waypoint Settings:

First waypoint: Start executing Zenmuse L2's data collection task. Add Gimbal Pitch Rotation(°) as the first action at the waypoint and set the pitch angle to -75°. Then, add Start point cloud modeling recording as the second action.
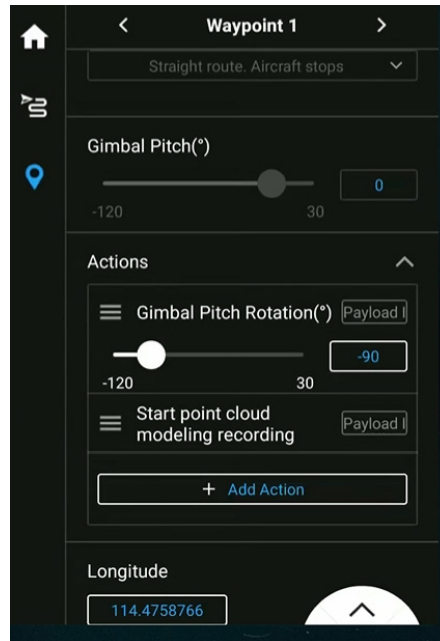

Figure: Parameter settings of the first waypoint

Last waypoint: End the task.

Add Finish point cloud modeling recording as the action at the waypoint.

Select Follow Route for all waypoints' speed, aircraft yaw angle, and waypoint type, and deselect Follow Route for all waypoints' altitude.
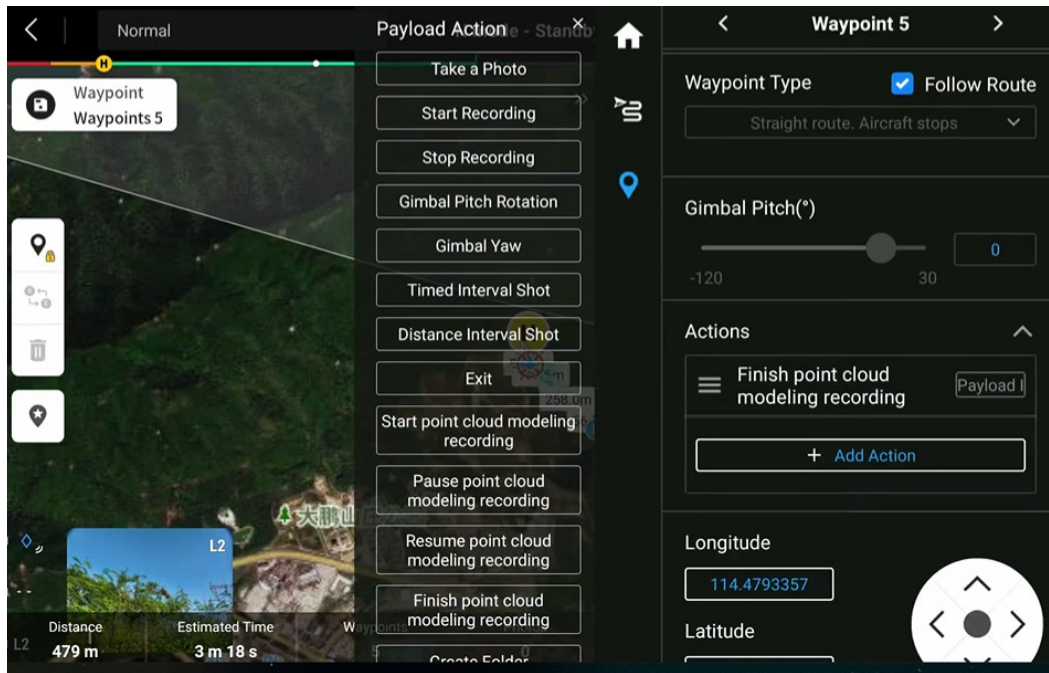
Figure: Parameter settings of the last waypoint

Follow the steps above to collect the coordinates of all waypoints on the route and save the task. Then, you can export route files in KMZ format to the microSD card for archiving and backup. KMZ route files archived for backup or from other sources can be imported as follows: Open the DJI Pilot 2 app, tap Flight Mission, and then select Import Route (KMZ/KML).

3.2.2.2. Manual Flights

The route planning method above has been verified in a large number of applications, which can cover most power transmission line construction scenarios. Collection of point cloud data by manually flying aircraft is not recommended. If manual flights are required, pay attention to parameters such as the flight altitude relative to the tower top and flight speed, and perform regular IMU calibrations during the flight.

3.2.3. Field Point Cloud Data Collection

Operation Mode	Application Scope
Network RTK	Mobile network signal Network RTK signal Strong image transmission signal
GNSS	No network RTK or weak image transmission signal

3.2.3.1. General Settings

3.2.3.1.1. Basic Settings for Flight Safety

❶ RTH Altitude (30 meters higher than the height of obstacles)

❷ Out of Control Action (RTH)

❸ Smart RTH (enabled)

3.2.3.1.2. RTK Settings

For the purpose of point cloud data processing, Zenmuse L2 needs to have centimeter accurate positioning data in place for calculations. You can connect Zenmuse L2 to a network RTK and keep the network RTK in the FIX state throughout the process. Alternatively, you can adopt the GNSS operation mode in which you need to set up the D-RTK 2 Mobile Station and perform post-processing.

You can connect to a network RTK, such as Matrice 350 RTK's built-in network RTK, or connect to a custom network RTK by entering an NTRIP account number. If the aircraft is connected to the RTK and the RTK outputs a fixed solution throughout the flight, the base station file will be automatically saved in Zenmuse L2's result file.

3.2.3.2. Network RTK Operation Mode - Field Operation Procedure

3.2.3.2.1. Parameter List (Can Be Printed and Used as a Checklist)

	Parameter Name		Parameter Value
Flight Controller Settings	RTH Altitude	☐	30-50 meters higher than the obstacles in the RTH segment of the route
	RC Signal Lost	☐	RTH
	Obstacle Sensing Settings	☐	On
	Smart RTH	☐	On
	RTK Positioning	☐	On
	RTK Type and Status	☐	Network RTK or Custom Network RTK RTK connected. RTK data in use.
Route Homepage Settings	Select Aircraft	☐	Matrice 350 RTK
	Select Payload	☐	Gimbal 1: Zenmuse L2
	ASL/ALT	☐	ASL (EGM96)
Payload Settings	Return Mode	☐	Dual
	Sampling Rate	☐	240 kHz
	Scanning Mode	☐	Non-repetitive
	RGB Coloring	☐	On

	Parameter Name		Parameter Value
Route Global Settings	Speed	☐	Transmission Grid: 15 m/s Distribution Grid: 12-15 m/s
	Altitude	☐	Use the default value and do not modify it.
	Aircraft Yaw	☐	Along Route
	Gimbal Control	☐	Manual Control by RC
	Waypoint Type	☐	Straight route. Aircraft stops
	IMU Calibration	☐	On
	Power Saving Mode	☐	Off
	Finish Action	☐	Return To Home
Waypoint Settings	Speed	☐	Follow Route
	Altitude	☐	Does not follow route
	Aircraft Yaw	☐	Follow Route
	Waypoint Type	☐	Follow Route
	Action at the first waypoint	☐	Gimbal Pitch: -75° Start point cloud modeling recording
	Middle Waypoint	☐	Use the default value and do not modify it.
	Action at the last waypoint	☐	Finish point cloud modeling recording
	Latitude and Longitude	☐	Use the default values and do not modify them.

3.2.3.2.2. Flight Mode

A route can be split and contain multiple takeoff and landing points based on the actual situation. At each takeoff and landing point, point cloud data within about five kilometers (3 miles) on both the left and right sides of the route is collected. The route length should be determined based on the terrain, wind speed, RTH obstacles, and RTH altitude.

Select positions with clear line of sight and less signal blockage as takeoff and landing points.
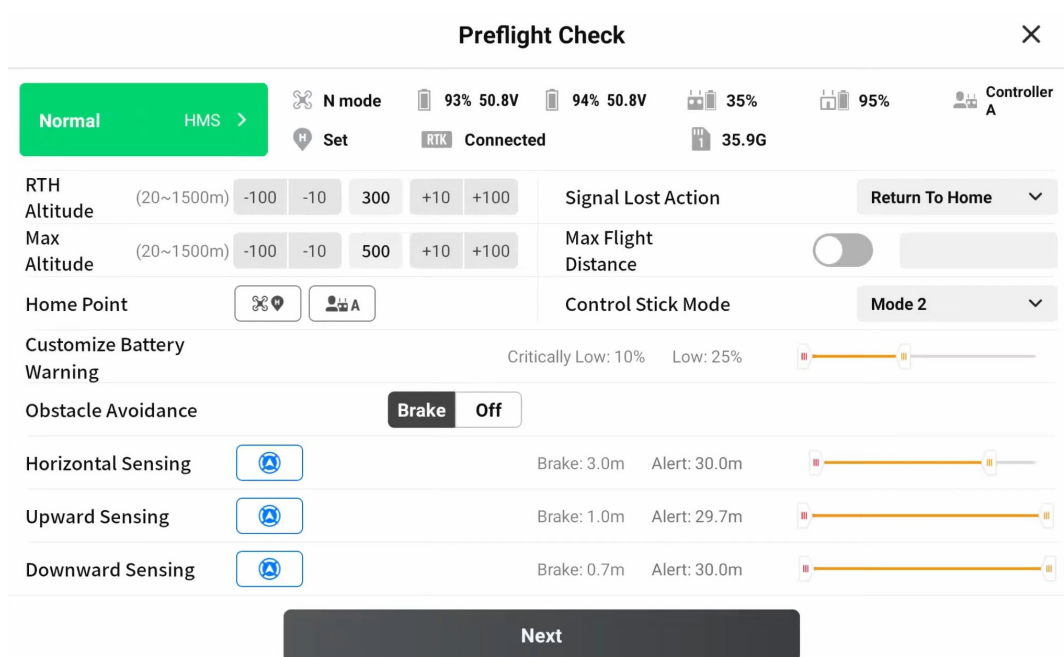
3.2.3.2.3. Task Execution

a) Mount a payload and power on the aircraft. The aircraft should be in a normal state without any warnings after it is powered on.

b) Confirm the RTK status. Ensure that the RTK status is FIX and that the RTK port uses WGS 84. (If a custom network RTK is used, refer to the appropriate parameter settings. A port that uses WGS 84 is preferred. If you need to output the results in other coordinate systems, you can configure the output coordinate system in DJI Terra.)

c) Upload the route task and start point cloud data collection in an open area.

d) Check the waypoint actions again and start execution.

Mapping Checklist   ✕

92% 50.8V	94% 50.7V	RTK Connected	35%	94%	35.93 G

10123 m	21 m 5 s	60	4.03 cm/pixel	355 photo(s)
Distance	Estimated Time	Waypoints	Reconstruction GSD	Payload 1 Photos

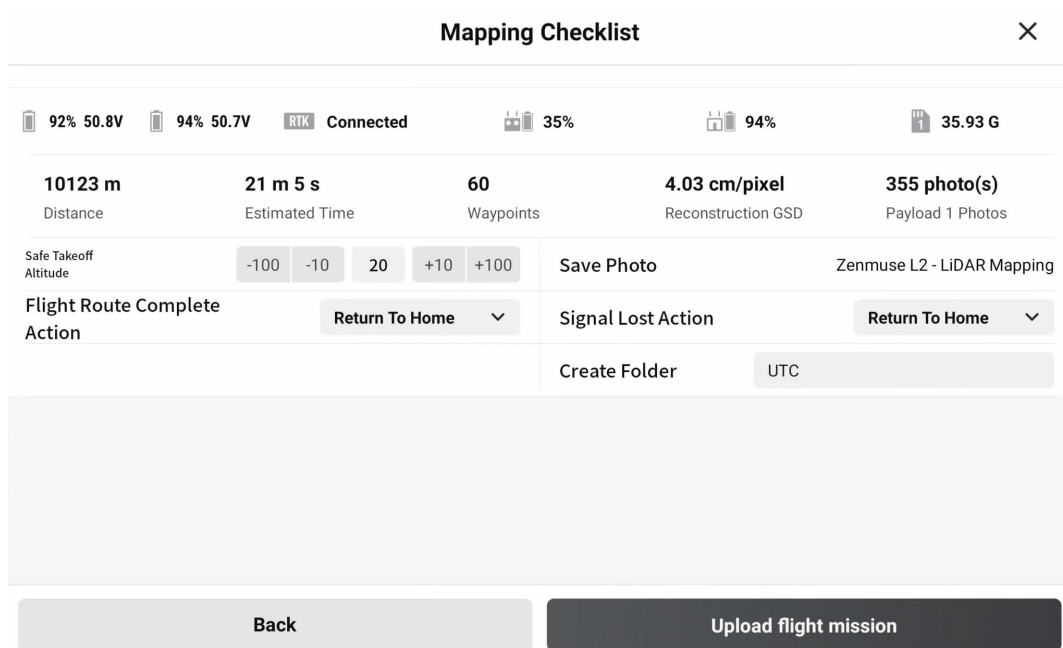| Safe Takeoff Altitude	-100	-10	20	+10	+100	Save Photo	Zenmuse L2 - LiDAR Mapping
Flight Route Complete Action	Return To Home ⌄					Signal Lost Action	Return To Home ⌄
						Create Folder	UTC

Back	Upload flight mission

Figure: Route parameter check

e) When the aircraft reaches the first waypoint, it automatically starts IMU calibration. At this time, do not pause or interfere with the aircraft operations. Instead, wait until the IMU calibration is complete.
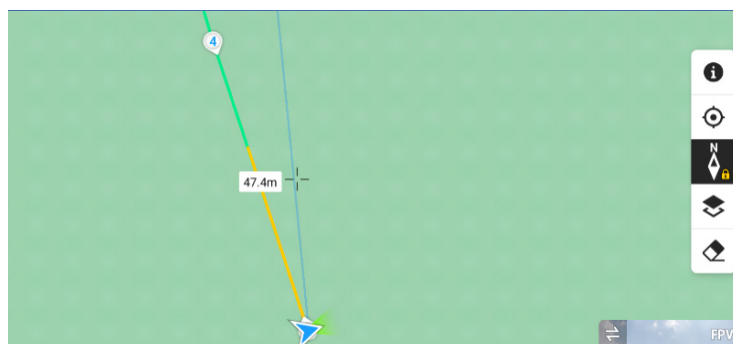

Figure: IMU calibration

The yellow segment indicates the route segment for IMU calibration. The aircraft will fly backward and forward along this route segment while accelerating and decelerating, for three times.

f) After IMU calibration, the aircraft adjusts the pitch angle at the first waypoint and starts point cloud data collection and photo snapping. During task execution, you can switch between Point Cloud and SBS views to view the point cloud effect in real time.
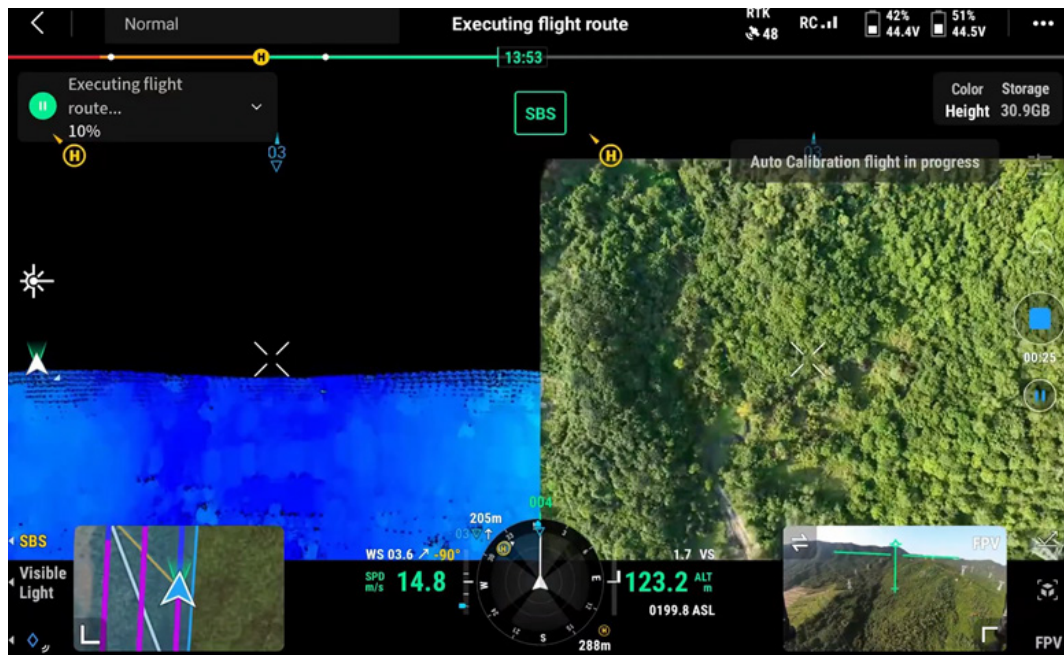
Figure: Side-by-side display of the visible light view and LiDAR view

g) If IMU calibration is enabled in route settings, the aircraft automatically performs IMU calibration in the following two situations:

❶ When the aircraft needs to fly for over 200 seconds from a waypoint to the next, it automatically adds the IMU calibration action to this route segment. If the aircraft can reach the next waypoint within 200 seconds, it will not add the IMU calibration action. (In Straight route. Aircraft Stops mode, the acceleration and deceleration process at each waypoint can be considered as calibration to a certain degree.)

❷ When the aircraft resumes the flight at the first or last waypoint or at a breakpoint, it automatically performs IMU calibration at the waypoint. After the flight task is complete, the aircraft automatically performs IMU calibration at the last waypoint. At this time, do not interfere with the aircraft operations. Instead, wait until the calibration is complete and you hear a prompt tone, and then make the aircraft return to home for landing.

h) Note: During IMU calibration, the aircraft suspends point cloud data collection. At this time, do not interfere with the aircraft operation. Instead, wait until the calibration is complete and the aircraft will automatically resume point cloud data collection and continue with the flight task.

i) If the battery needs to be replaced during the flight, we recommend that you tap the

red stop button on the left side of the screen in the DJI Pilot 2 app for the aircraft to return to home for landing and then perform battery hot-swapping to maintain the RTK status. After replacement, tap the blue start icon and select Continue. The aircraft automatically flies to the breakpoint and restores to the status before RTH (with the gimbal tilt angle at -75°). After automatic IMU calibration is complete, the aircraft starts point cloud recording and resumes the task.

3.2.3.3. GNSS Operation Mode - Field Operation Procedure

In GNSS operation mode, you need to check the ambient conditions of the route in advance. U-shaped routes are recommended and generally the flight radius should not exceed 6 kilometers in plain areas.
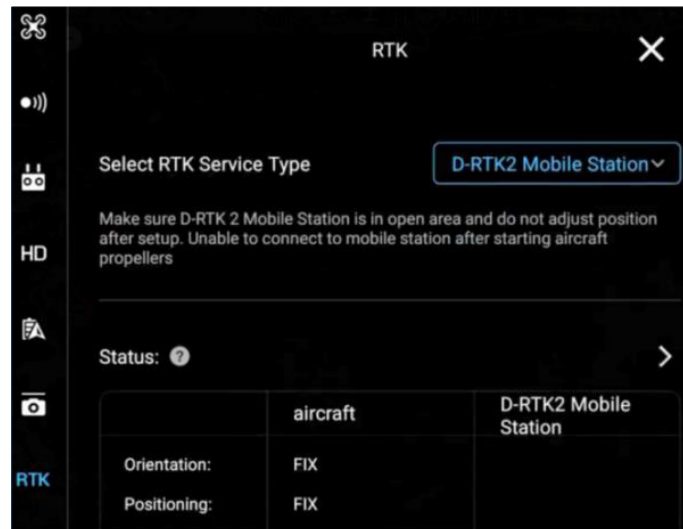
3.2.3.3.1. D-RTK 2 Mobile Station Setup and Configuration

   a) Set up and level the D-RTK 2 Mobile Station (as shown in the pictures below).
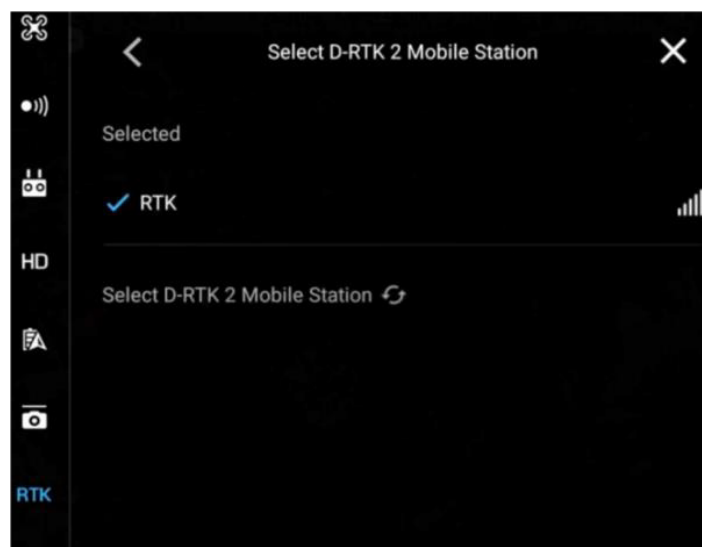

   b) Switch the mode of the D-RTK 2 Mobile Station to Mode 5 (with the green light flashing for five consecutive times).
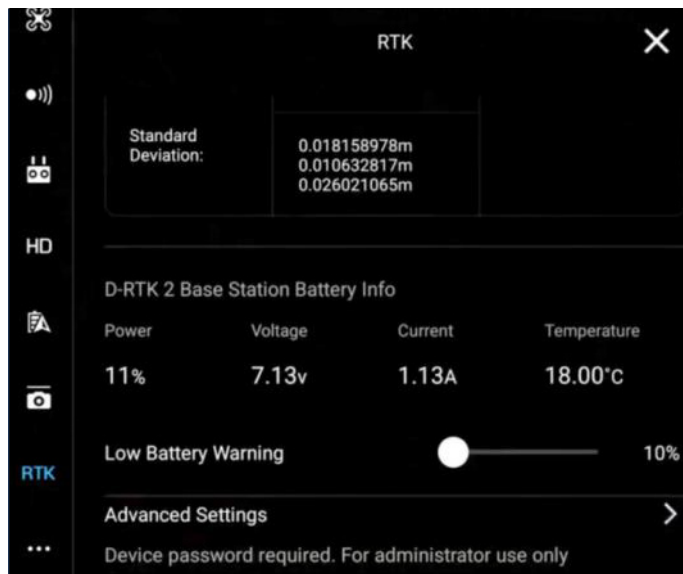
c) Go to the RTK settings screen in the DJI Pilot 2 app and select D-RTK 2 Mobile Station for the Select RTK Service Type parameter.
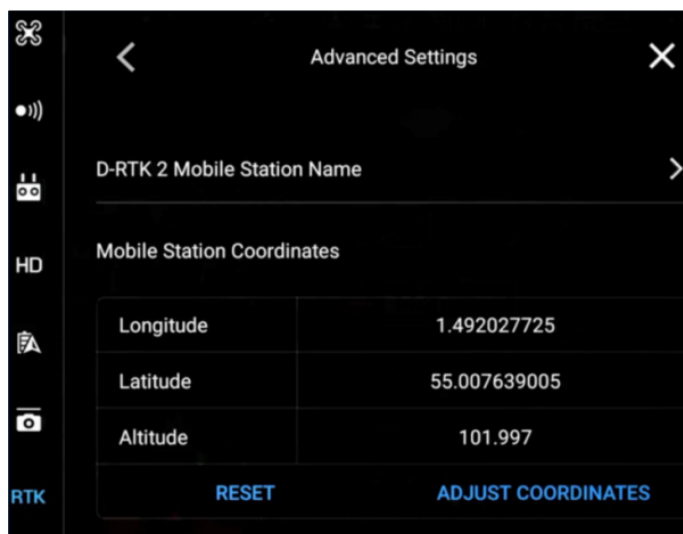

d) Select D-RTK 2 Mobile Station for connection.

e) Return to the RTK settings screen and slide to the bottom. Tap Advanced Settings and enter the default password 123456.

f) Set Longitude, Latitude, and Altitude for the D-RTK 2 Mobile Station.

g) On the RTK settings screen, disable the RTK Positioning feature. Do not move the D-RTK 2 Mobile Station throughout the flight and make sure that it stays in a normal state.

3.2.3.3.2. Parameter List (Can Be Printed and Used as a Checklist)

	Parameter Name		Parameter Value
Flight Controller Settings	RTH Altitude	☐	30-50 meters higher than the obstacles in the RTH segment of the route
	RC Signal Lost	☐	RTH
	Obstacle Sensing Settings	☐	On
	Smart RTH	☐	On
	RTK Positioning	☐	Off
Route Homepage Settings	Select Aircraft	☐	Matrice 350 RTK
	Select Payload	☐	Gimbal 1: Zenmuse L2
	ASL/ALT	☐	ASL (EGM96)
Payload Settings	Return Mode	☐	Dual
	Sampling Rate	☐	240 kHz
	Scanning Mode	☐	Non-repetitive
	RGB Coloring	☐	On

	Parameter Name		Parameter Value
Route Settings	Speed	☐	Main Grid: 15 m/s Distribution Grid: 12-15 m/s
	Altitude	☐	Use the default value and do not modify it.
	Aircraft Yaw	☐	Along Route
	Gimbal Control	☐	Manual Control by RC
	Waypoint Type	☐	Straight route. Aircraft stops
	IMU Calibration	☐	On
	Power Saving Mode	☐	Off
	Finish Action	☐	Return To Home
Waypoint Settings	Speed	☐	Follow Route
	Altitude	☐	Does not follow route
	Aircraft Yaw	☐	Follow Route
	Waypoint Type	☐	Follow Route
	Action at the first waypoint	☐	h) Gimbal Pitch: -75° i) Start point cloud modeling recording
	Middle Waypoint	☐	Use the default values and do not modify them.
	Action at the last waypoint	☐	Finish point cloud modeling recording
	Latitude and Longitude	☐	Use the default values and do not modify them.

3.2.3.3.3. Task Execution

Make sure the payload is mounted in place. After the aircraft is powered on, the aircraft should be in a normal state without any warnings in the DJI Pilot 2 app.

Confirm the RTK status. Make sure that the RTK status is Off.

Upload the route task and start point cloud data collection. Set the Out of Control Action parameter to Continue.

Check the waypoint actions again and start execution. When the aircraft reaches the first waypoint, it automatically starts IMU calibration. At this time, do not pause or interfere with the aircraft operations. Instead, wait until the IMU calibration is complete.

During task execution, you can switch between Point Cloud and SBS views to view the point cloud effect in real time.

If IMU calibration is enabled in route settings, the aircraft automatically performs IMU calibration in the following two situations:

   ❶ When the aircraft needs to fly for over 200 seconds from a waypoint to the next, it automatically adds the IMU calibration action to this route segment. If the aircraft can reach the next waypoint within 200 seconds, it will not add the IMU calibration action. (In Straight route. Aircraft Stops mode, the acceleration and deceleration process at each waypoint can be considered as calibration to a certain degree.)

   ❷ When the aircraft resumes the flight at the first or last waypoint or at a breakpoint, it automatically performs IMU calibration at the waypoint. After the flight task is complete, the aircraft automatically performs IMU calibration at the last waypoint. At this time, do not interfere with the aircraft operations. Instead, wait until the calibration is complete and you hear a prompt tone, and then make the aircraft return to home for landing.

Note: During IMU calibration, the aircraft suspends point cloud data collection. At this time, do not interfere with the aircraft operation. Instead, wait until the calibration is complete and the aircraft will automatically resume point cloud data collection and continue with the flight task.

If the battery needs to be replaced during the flight, we recommend that you tap the red stop button on the left side of the screen in the DJI Pilot 2 app for the aircraft to return to home for landing and then perform battery hot-swapping to maintain the RTK status. After replacement, tap the blue start icon and select Continue. The aircraft automatically flies to the breakpoint and restores to the status before RTH (with the gimbal tilt angle at -75°). After automatic IMU calibration is complete, the aircraft starts point cloud recording and resumes the task.
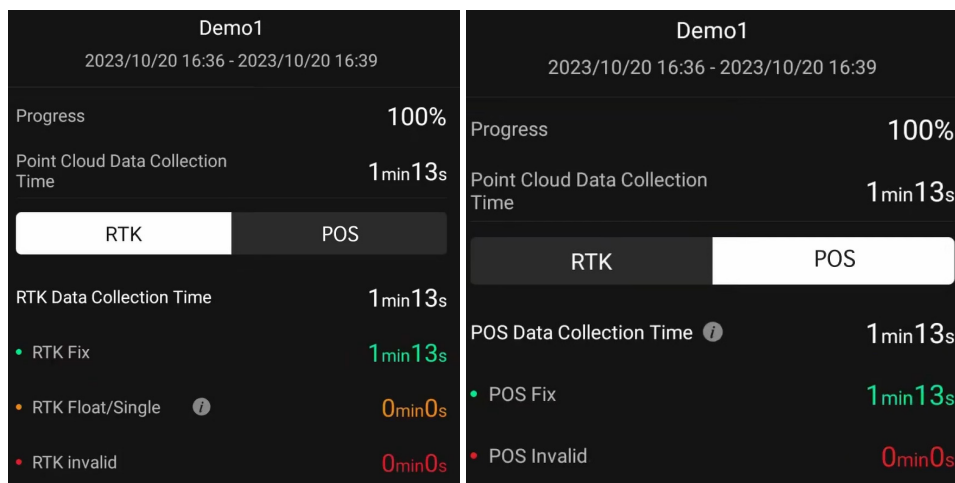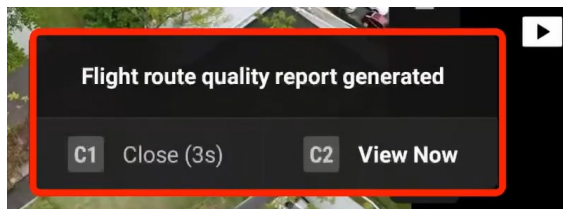
3.2.3.4. Task Quality Report

Figure: Content of the task quality report

After a flight ends, DJI Pilot 2 automatically generates a task quality report. Note: After photo shooting or point cloud recording, wait 60 seconds before you power off the device or remove the microSD card. Otherwise, point cloud accuracy may be impaired or files may be damaged.

Tap View Now to view the task quality report. The report contains the task name, start time, end or termination time, and the task progress when the flight ends.

❶ Point Cloud Data Collection Time: the duration from start to end of point cloud data collection (excluding the calibration process at the start and end). You can view the RTK or POS status information based on your requirements.

❷ Tap RTK: The RTK data collection duration and RTK status are displayed. The RTK status can be RTK Fix, Float/Single, or RTK Invalid, which are marked in different colors (including both the routes and fonts). If the duration next to RTK Float/Single is long, PPK calculation can be performed during data processing to obtain high-accuracy positioning data.

❸ Tap POS: The total duration from the start of IMU calibration before point cloud data collection to the end of IMU calibration after data collection is displayed. The POS status can be POS Fix or POS Invalid.
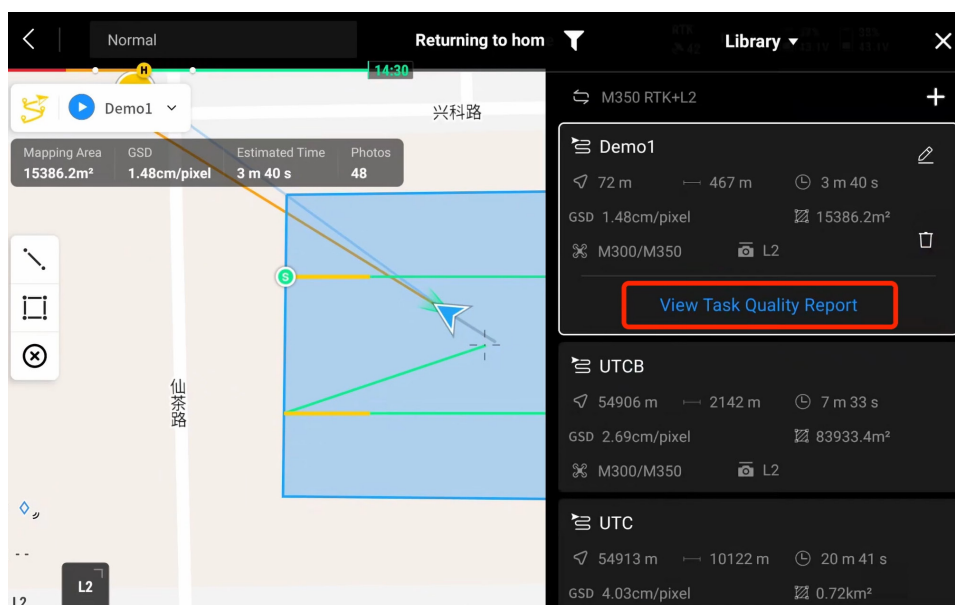

Figure: Task quality report

You can also enter the route library, select an executed route, and then tap View Task Quality Report to view its quality report.

3.2.3.5. Point Cloud Playback

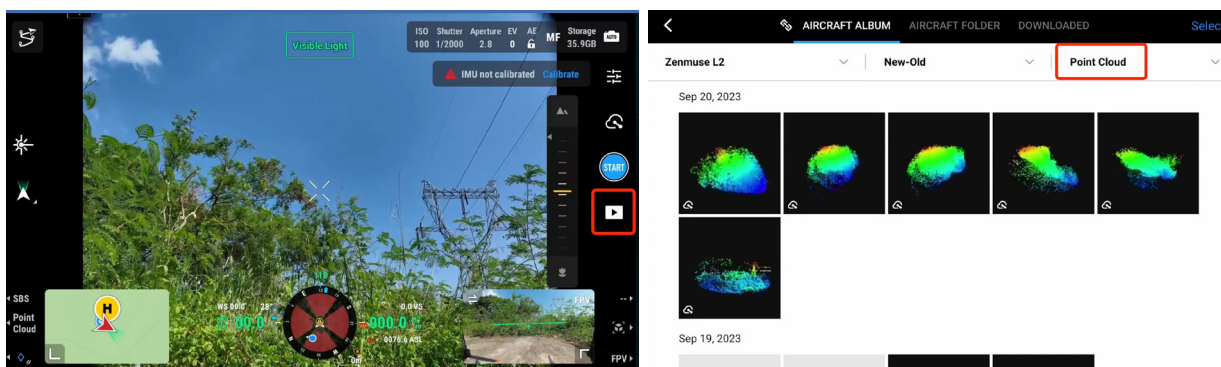Tap the playback icon and select Point Cloud in the top bar.

Figure: Filter point clouds

Recorded point cloud files and photos are displayed (The RGB coloring feature needs to be enabled). You can select one or more point cloud files and download them to the remote controller. (Make sure that the remote controller has sufficient storage space before the download.)

After the download is complete, tap to preview the point cloud files. Tap the playback icon to view model details. You can move the model on the screen with one finger. You can tap and hold with two fingers to rotate the model (slide up or down to rotate the model around the x-axis; slide left or right to rotate the model around the z-axis). You can also slide diagonally with two fingers to zoom the model in or out.
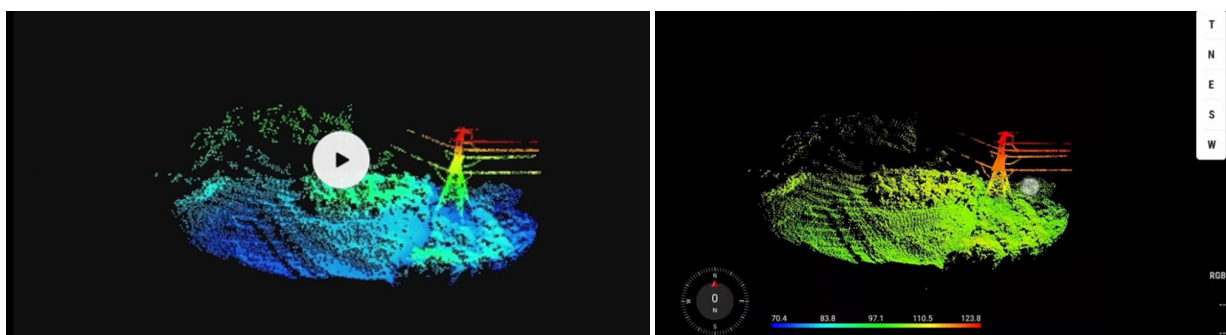

Figure: Model viewing

Press the L3 button on the remote controller to enter the model selection screen. Select and download multiple point cloud files and merge the files. Then, you can quickly view the overall effect of the merged files and locate the positions where the cloud point effects are poor.

Make sure the aircraft and the remote controller are connected when viewing the point cloud models. A point cloud file less than 2 KB in size cannot be processed. Make sure that point cloud models are effective.

To clear the cache, enter the album to select and delete the downloaded files or tap Data and Privacy on the homepage and then tap DJI Pilot Cache Management to clear all downloaded point cloud data files.

3.2.3.6. Merging of Point Cloud Models

Point cloud 3D models collected from multiple flight tasks can be merged as follows: Press the L3 button on the remote controller to enter the model selection screen. Select and download multiple point cloud files and merge the files. Then, you can quickly view the overall effect of the merged files and locate the positions where the cloud point effects are poor to determine the flight task quality.

❶ Point cloud models collected from up to 12 flight tasks can be merged.

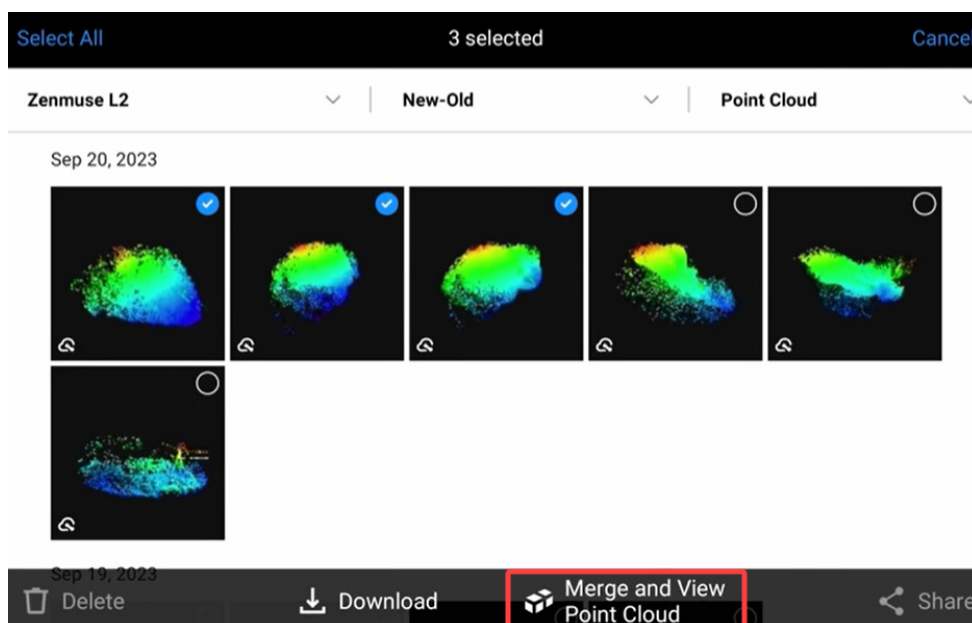❷ Point cloud models collected within an area of up to 100 km × 100 km can be merged.

Figure: Merging of point cloud models collected from multiple flight tasks

3.2.4. Data Processing

3.2.4.1. Data Confirmation

3.2.4.1.1. Zenmuse L2 Data Confirmation

Remove the microSD card from Zenmuse L2. Insert the microSD card into a computer and check the files. In the DCIM folder, the folder of each task contains files with the following suffixes. Check whether all the files are contained.

File Suffix	File Type
CLC	Camera LiDAR calibration file
CLI	LiDAR IMU calibration file
CMI	Visual calibration data
IMU	IMU raw data
LDR	LiDAR point cloud raw data
MNF	Visual data
RTB	RTK base station data
RTK	RTK data of main antenna
RTS	RTK data of auxiliary antenna
RTL	Compensation data of RTK pole
JPG	Visible light data

3.2.4.1.2. D-RTK 2 Mobile Station - PPK Data Confirmation

In PPK operation mode, you need to connect the D-RTK 2 Mobile Station to a computer. Copy the base station file with a suffix of .DAT for the corresponding time slot, and paste the file in the same folder as the raw point cloud data. DJI Terra can then calculate the difference automatically during data post-processing.

3.2.4.2. Point Cloud Reconstruction - Operations in DJI Terra
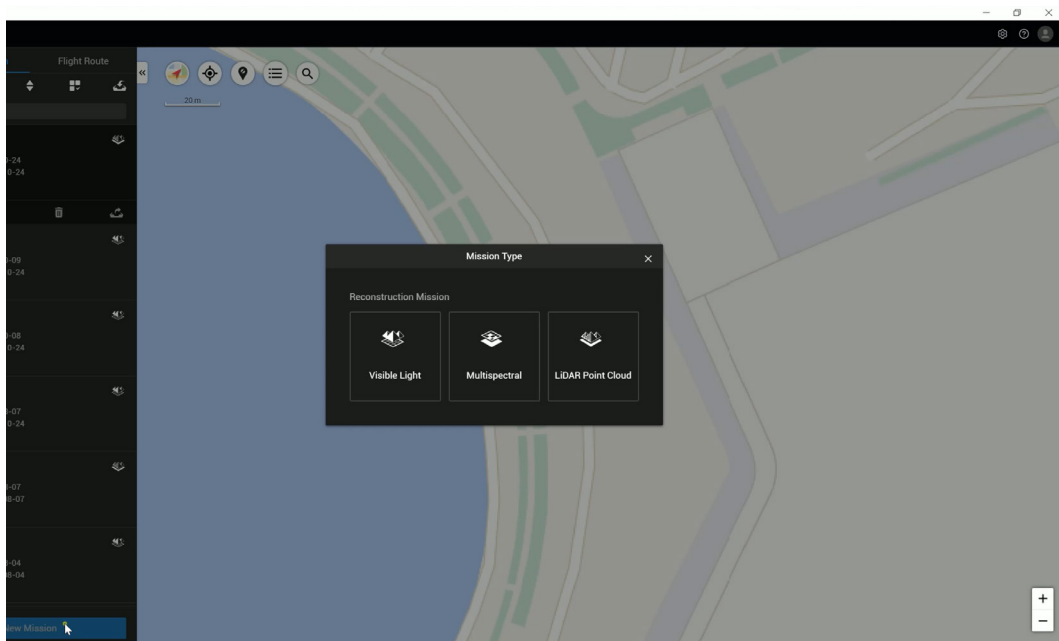
1. Create a LiDAR Point Cloud task.

Figure: LiDAR point cloud processing task

2. Click the grey folder icon.

To import multiple LiDAR point cloud data files of Zenmuse L2, you can put the files in the same folder and directly import the folder. Alternatively, you can import the files one by one.

Note: Please make sure that the folder name doesn't have any special characters such as "," or "*", otherwise there might be an issue in the processing.

3. Set Point Cloud Density (By Percentage).

Select a percentage indicating a high point cloud density. High, medium, and low point

cloud density correspond to the values of 100%, 25%, and 6.25%, respectively. Point cloud density affects only the number of result points, and will not impact the result accuracy much.

4. Set Output Coordinate System.

5. Set Geoid Settings.

Use the default option (the default option is Ellipsoidal Height, while the EGM96 height and other options all refer to the altitude above the sea level).

6. Set Point Cloud Effective Distance.

Use the default value (250 m) and do not modify it.

7. Set Optimize Point Cloud Accuracy.

Disable this feature. This feature optimizes the adjustment of the point clouds scanned at different time points during point cloud processing to improve their overall accuracy. For low-overlap power line scenarios, point cloud accuracy optimization may also cause negative phenomena such as layering. For this reason, we recommend that you disable this feature.

8. Set Reconstruction Output Format.

3D point clouds of the PNTS (the format used for display in Terra) and the LAS format (the standard format of airborne radar output) will be output by default. You can also choose to output the point cloud in a PLY (can be opened in MeshLab), PCD (can be opened in CloudCompare), and S3MB (can be opened in SuperMap).

9. Click Start Reconstruction.

Click Start Processing to start reconstruction. During processing, you can click Stop to pause the process and the software will save the current progress. If you resume the progress, the software will continue data processing from the breakpoint.

10. Start multiple reconstruction tasks.

You can start multiple point cloud processing tasks at the same time. Before the task that is first started is completed, the other tasks will be pending in the queue. Tasks are processed in the order they were started and will be started one by one after their previous task is completed.

3.2.4.3. Reconstruction Output

3.2.4.3.1. Browse

By using the toolbar on the right side of the modeling homepage, you can move, zoom, rotate, or perform other actions on the result. In the toolbar, you will find the following icons from top to bottom: automatic rotation, point cloud granularity adjustment, 2D pitch angle, 3D viewing angle, and model zooming.

Figure: Point cloud model browsing

3.2.4.3.2. Display Mode (Coloring)

1. RGB:

Display the result in their true colors.

2. Reflectivity:

Display the result based on the reflectivity received by the radar. The reflectivity is graded

on a scale of 0-255, where 0-150 corresponds to diffuse reflection objects with a reflectivity of 0-100%, and 151-255 corresponds to fully reflective objects. Since the reflected light by the same object may be received by the LiDAR at different angles, it is possible that the reflectivity values of the same ground object vary as shown on the reflectivity map. This is a normal phenomenon.

3. Altitude:

Display different colors for different altitudes of the point cloud.

4. Return:

Display different colors for different numbers of returns of the result data.

3.2.4.3.3. Result Data Export

In the task bar, click the export icon to export result files. The result files output by DJI Terra include an LAS point cloud result and an OUT trajectory file.
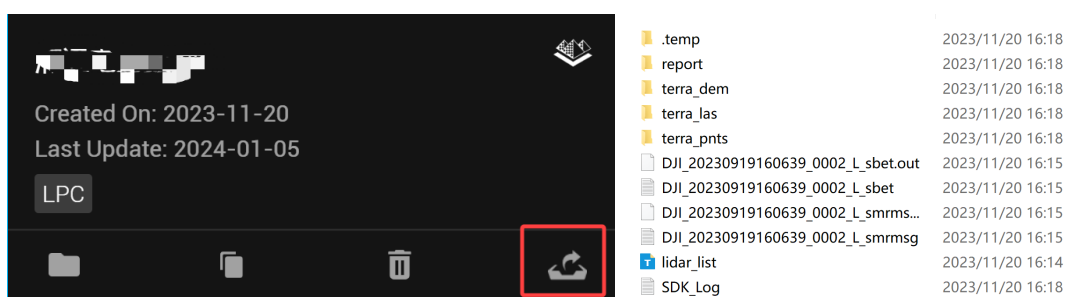

Figure: Result files output by DJI Terra

3.2.4.3.4. Quality Report

On the reconstruction screen, you can press Ctrl+Alt+F to open the current task folder.

You can view and save the report in HTML format. The report contains relevant information about the raw data, software parameters, output format, and point cloud processing time. Refer to the document How to Read a DJI Terra Quality Report on DJI official website for more information.

3.2.4.3.4. Quality Report

On the reconstruction screen, you can press Ctrl+Alt+F to open the current task folder.
You can view and save the report in HTML format. The report contains relevant information about the raw data, software parameters, output format, and point cloud processing time. Refer to the document How to Read a DJI Terra Quality Report on DJI official website for more information.
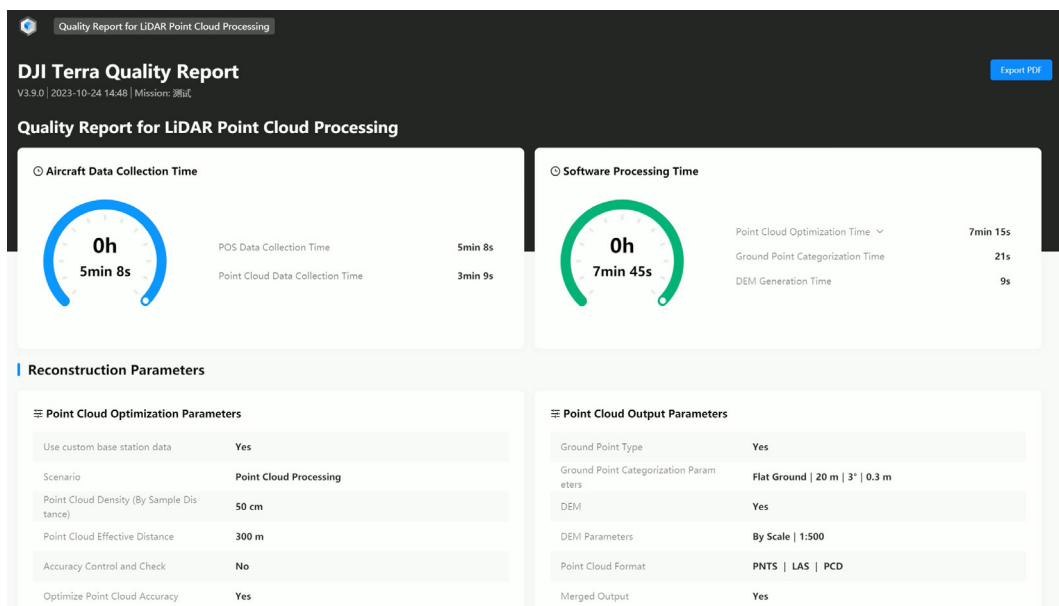

Figure: LiDAR point cloud report

04 | Application of Point Cloud Results

Content: List some typical back-end analysis software and common applications, such as Point Cloud Automata and Lidar360 for terrain extraction, single-tree segmentation, and tree barrier analysis purposes. For more details about how to use the back-end analysis software, please contact the corresponding manufacturer to learn more.

The main applications of a LiDAR LAS point cloud include the following.

Surveying and mapping: topographic map surveying and mapping, engineering surveying, earthwork surveying, river course surveying, emergency surveying and mapping, and others. Zenmuse L2 features multiple returns and can "penetrate" the edge of vegetation to obtain the ground point. It can output DEM, contour lines, and other results.

Forestry: single-wood segmentation. Thanks to its multi-return characteristics, Zenmuse L2 can extract the information of each tree for single-tree segmentation, statistics of the stand origin, diameter at breast height, average tree height, stand density, stand volume, stand yield rate of wood, and other forestry survey statistics.

Powerline: tree barrier analysis or provision of a point cloud model for offline refined inspections. Based on the data contributed by Zenmuse L2 and by using third-party software, you can directly output a tree barrier analysis report. You can also scan the poles and towers to get their accurate coordinates and then utilize the Refined inspection module of DJI Terra to perform refined inspections on power transmission towers.

Others: Zenmuse L2 can also be applied to the emergency field to quickly perform terrain detection, geological disaster mapping, landslide monitoring, infrastructure digitization, and other actions.

Common point cloud analysis software includes TerraSolid, Point Cloud Automata, LiDAR-DP, LidarMate, LiDAR360, Point Cloud Magic, and Tovos Powerline.

05 | Other reference material

Common point cloud analysis software includes TerraSolid, Point Cloud Automata, LiDAR-DP, LidarMate, LiDAR360, Point Cloud Magic, and Tovos Powerline.

Title	Link
DJI Zenmuse L2 Accuracy Analysis and use case exploration	https://enterprise-insights.dji.com/l2accuracy-analysis-whitepaper
DJI L2 Release Notes and User Manual	https://enterprise.dji.com/zenmuse-l2/downloads
LiDAR Basic Guide	https://enterprise-insights.dji.com/blog/lidar-basic-guide

Visit the official website of DJI Zenmuse L2

https://enterprise.dji.com/zenmuse-l2?site=enterprise&from=nav to get more information, including the quick start guide, user manual, firmware, the latest version of the installer of DJI Terra, and technical parameters of products.