Drone Lidar Data Processing Protocol

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Scope

This document describes the processing workflow to generate a point cloud from raw data collected using DJI Zenmuse L1 sensor with Matrice 300 (M300) RTK.

DJI Terra setup

DJI Terra software is used to reconstruct the 3D point cloud model (refer to DJI 2022 for hardware requirements). Open DJI Terra and click on the Settings icon. Click on the last icon '…'.

1. Check that 'Reconstruction Parameter Checklist' is enabled.
2. The default Cache directory used to store the LiDAR point cloud results is: C:\Users\<UserName>\Documents\DJI\DJITerra\<DJI account name>\
3. To use a different location, select 'Change' next to 'Cache Directory'. Ensure sufficient storage in the new location. (Any missions stored in the previous cache directory will be transferred and could take a while). Navigate to select a new location.

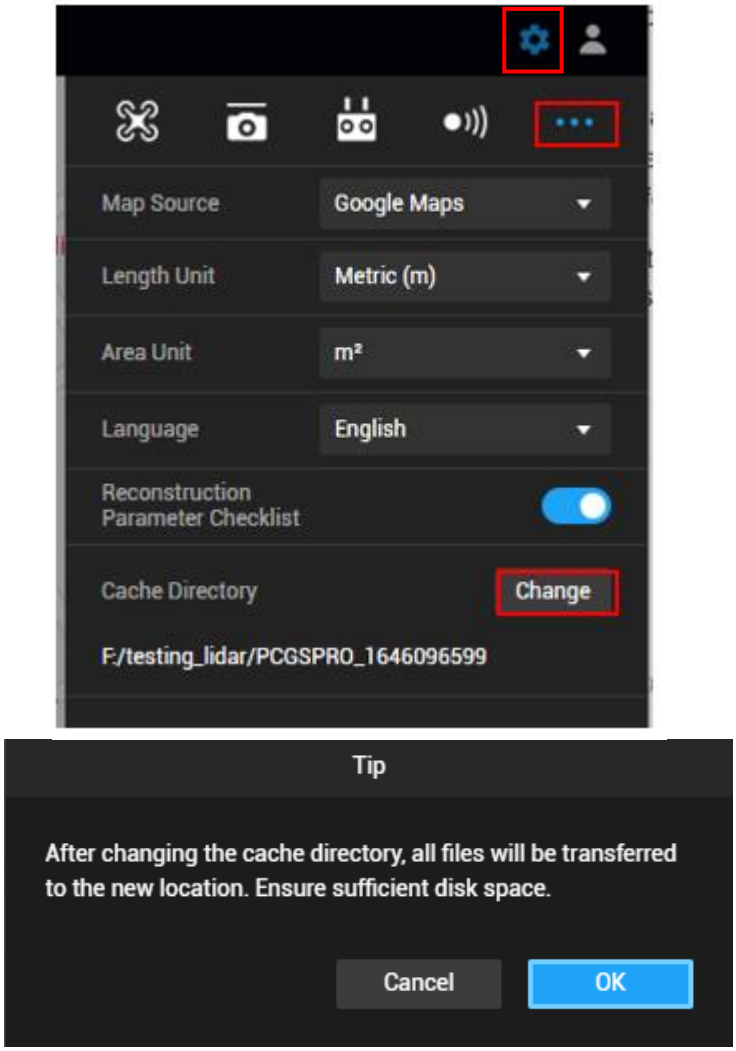


Figure 1: DJI Terra setup

Lidar point cloud reconstruction

1. Open DJI Terra. Click on New Mission. Under Mission Type select ‘LiDAR Point Cloud’. Enter Mission Name in the format ‘YYYYMMDD_SiteName’ and select OK.

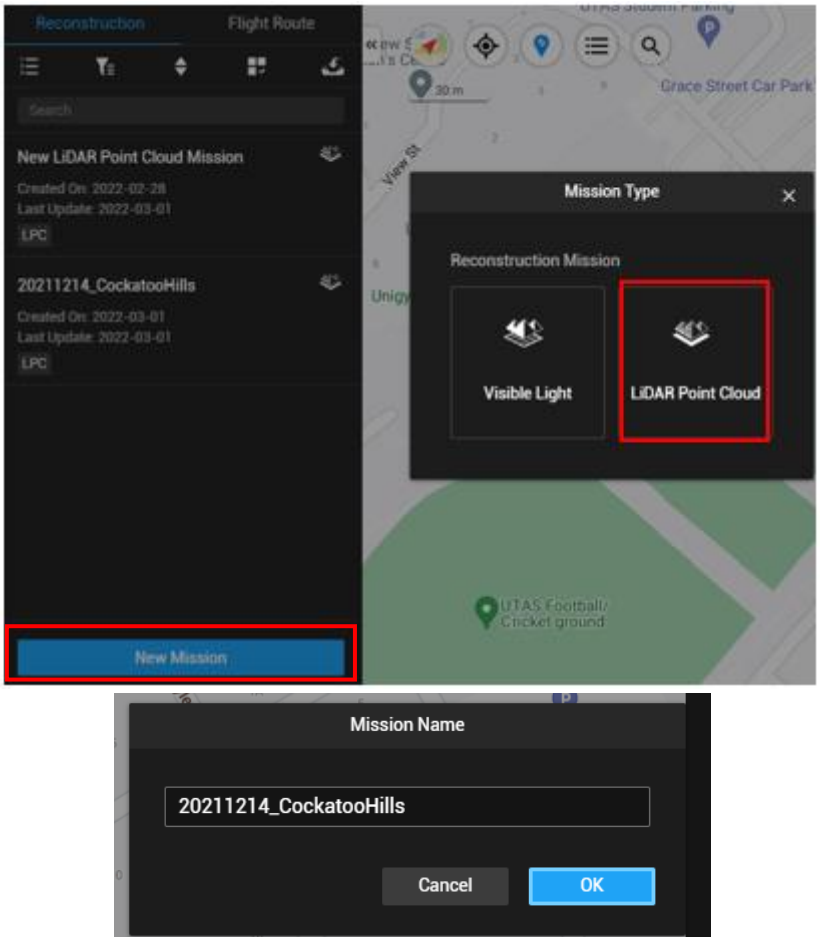


Figure 2: Create a new mission to reconstruct the lidar point cloud.

2. Add input folder(s) containing the raw data from the L1 sensor.
    - The raw data folder is by default named ‘DJI_<datetime>…Zenmuse-L1-mission’ and contains the raw lidar data, RTK/IMU files and images in jpeg format from the lidar mission. (As per the Data Collection protocol, raw lidar data is saved in <plot>/<YYYYMMDD/lidar/level0_raw/ folder).
    - Note that a new folder is created on every flight. If there were errors during the flight, or if more than one lidar mission was flown for other reasons, ensure that the correct raw data folder is selected as the input.

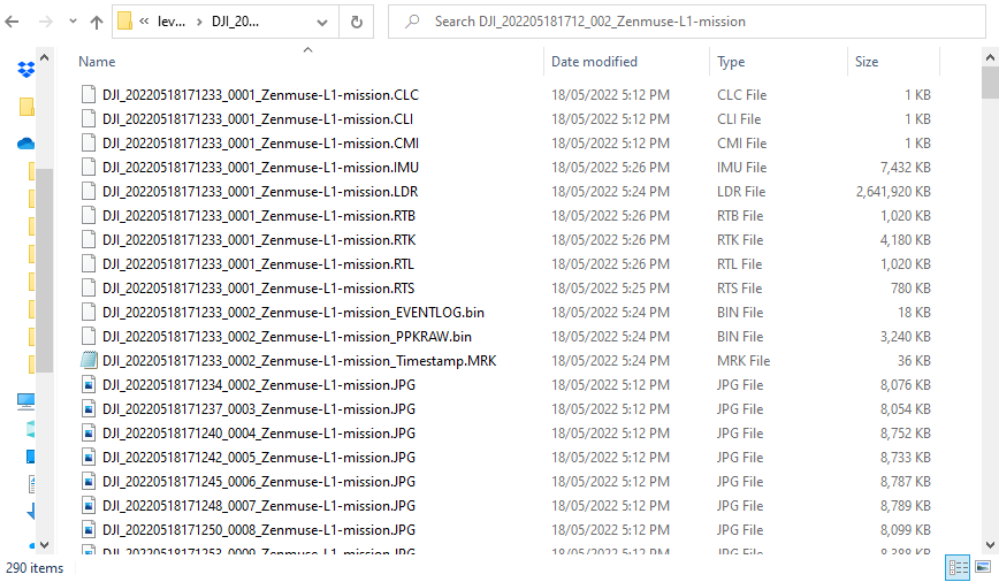


Figure 3: Example of a folder containing raw data from a lidar mapping mission.

- Click on the Folder icon in the top right of the screen and select the folder(s) containing the raw data.
- When this is complete, the display will be updated to show how many folders (sets of data) were added.

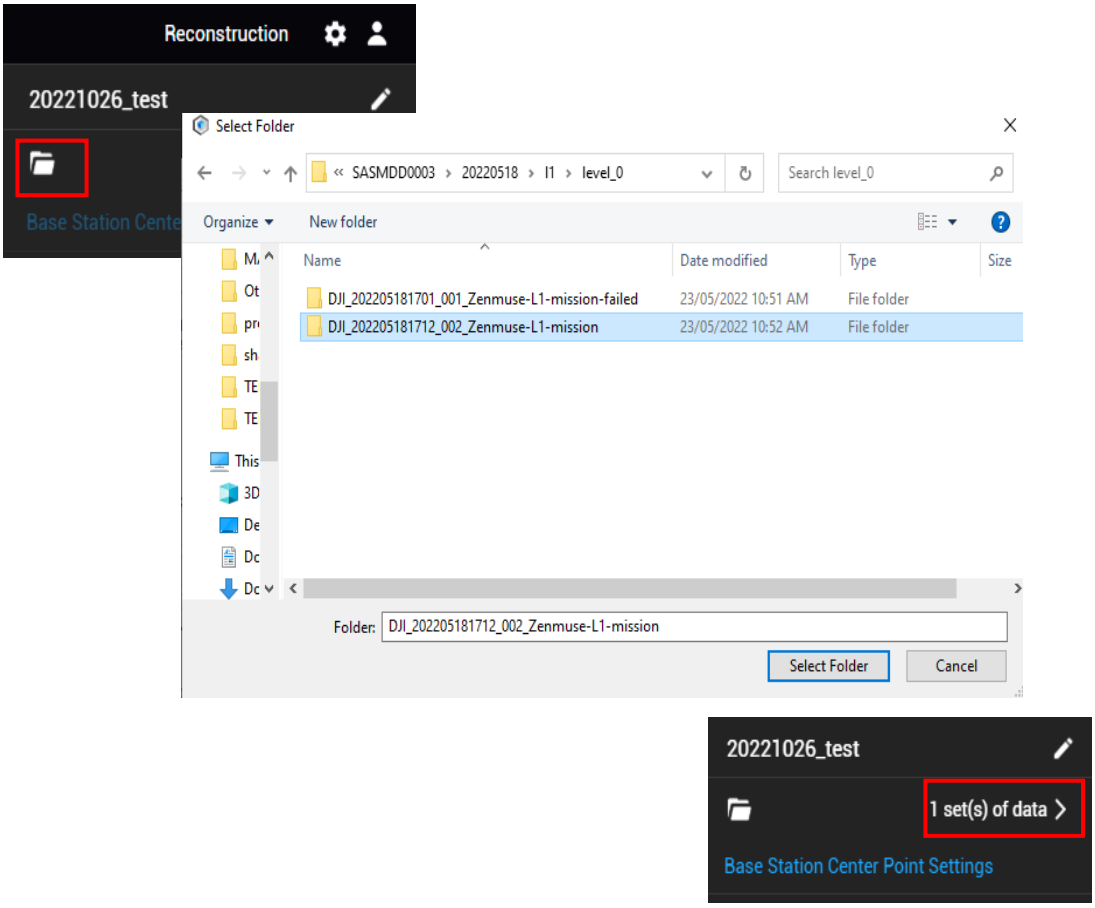


Figure 4: Click on the folder icon and select the folder containing the raw data for the mission. If more than one mission was required to map the plot, ensure that all relevant folders are selected in this step. Note that the display is updated to show how many folders (sets of data) were added.

3. If **Base Station coordinates** are to be post-processed:
   - Follow the steps in the Drone RGB and Multispectral Data Processing Protocol (Appendix 3) to process and submit base station data to AUSPOS.
   - When the AUSPOS report is available, follow the steps in 'Appendix: Update Base Station Settings in DJI Terra' to update Base Station settings on DJI Terra.
4. **LiDAR Point Cloud**
   Point cloud reconstruction settings are summarised in Figure 7. Update the settings as follows:
   - Point Cloud Density: Use the default settings. 'By Percentage', **High (100%)**
   - Scenarios: **Point Cloud processing**

   Advanced:

   - Point Cloud Effective Distance: **250 m** (see To do list)
   - **Optimise Point Cloud Accuracy:** This setting is only available in DJI Terra Pro (licensed) version. It has been found that optimising point cloud accuracy can lead to mixed results. For example, in some datasets, raw data from adjacent flight lines have been processed without issues on the free version of DJI Terra. Whereas on other datasets without Optimize point cloud accuracy, there is an obvious height offset between flight lines and they appear layered along the edges. This has been observed even in sites with no large elevation difference. This setting hence needs further testing (see To do list).
   - **Output Coordinate System**: Follow the steps below (also shown in Figure 6 and Figure 6) to select the output coordinate system for the point cloud.
     1) Select '**Known Coordinate System**'.
     2) **Horizontal Datum Settings**: from the drop-down list select 'Horizontal Coordinate System Database'. Enter the EPSG code and select the coordinate system from the results. Click OK.
        Note: The recommendation in previous versions of this protocol was to output the point cloud in the GDA2020 datum based projected coordinate system, there is a bug in recent versions of DJI Terra. This bug results in a shift in the horizontal position in the point cloud when using the GDA2020 datum. Based on communication with DJI Support there is no indication of when a fix is likely to be available. Hence the current suggestion in this workflow is to use the default output coordinate system on Terra, WGS84 (EPSG: 4326) geographic coordinate system. Open-source tools like pdal can be used to later reproject the point cloud to the required system based on GDA2020 datum (following section).
     3) **Geoid** Settings: from the drop-down list select 'Vertical Coordinate System'. In the search box, type AHD.
        - From the list of Coordinate Systems, select 'AHD height' (EPSG: 5711).
        - From the Geoid drop-down list, select 'au_ga_AUSGeoid2020_20180201.tif'
        - Click OK
     4) Height Offset: 0 m
   - **Output format**: Point Cloud. Ensure 'LAS' is selected. (PNTS is enabled by default and is used to display the point cloud in DJI Terra).
   - **Merged Output**: enable the checkbox to generate a single merged output point cloud from multiple flights (more than 1 folder of input data).

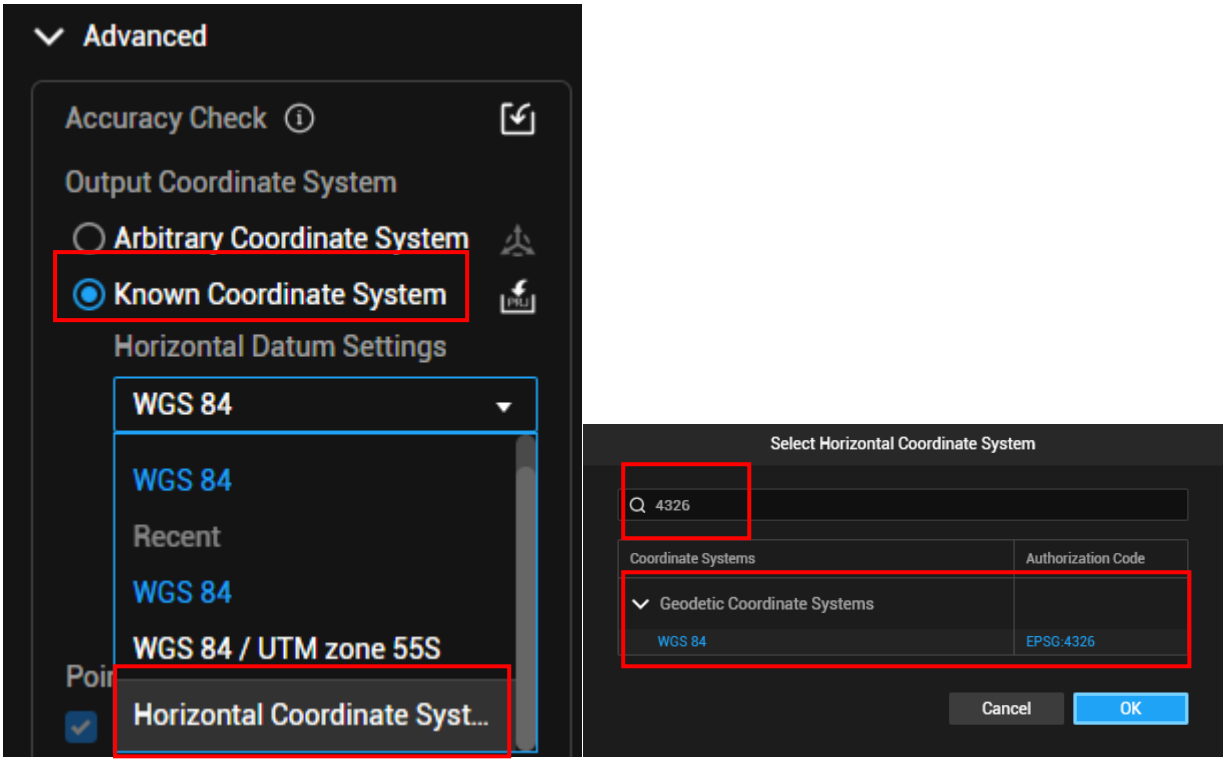


Figure 5: Update Horizontal Datum Settings. Select Horizontal Coordinate System from dropdown list, then search using EPSG code of output projected coordinate system.

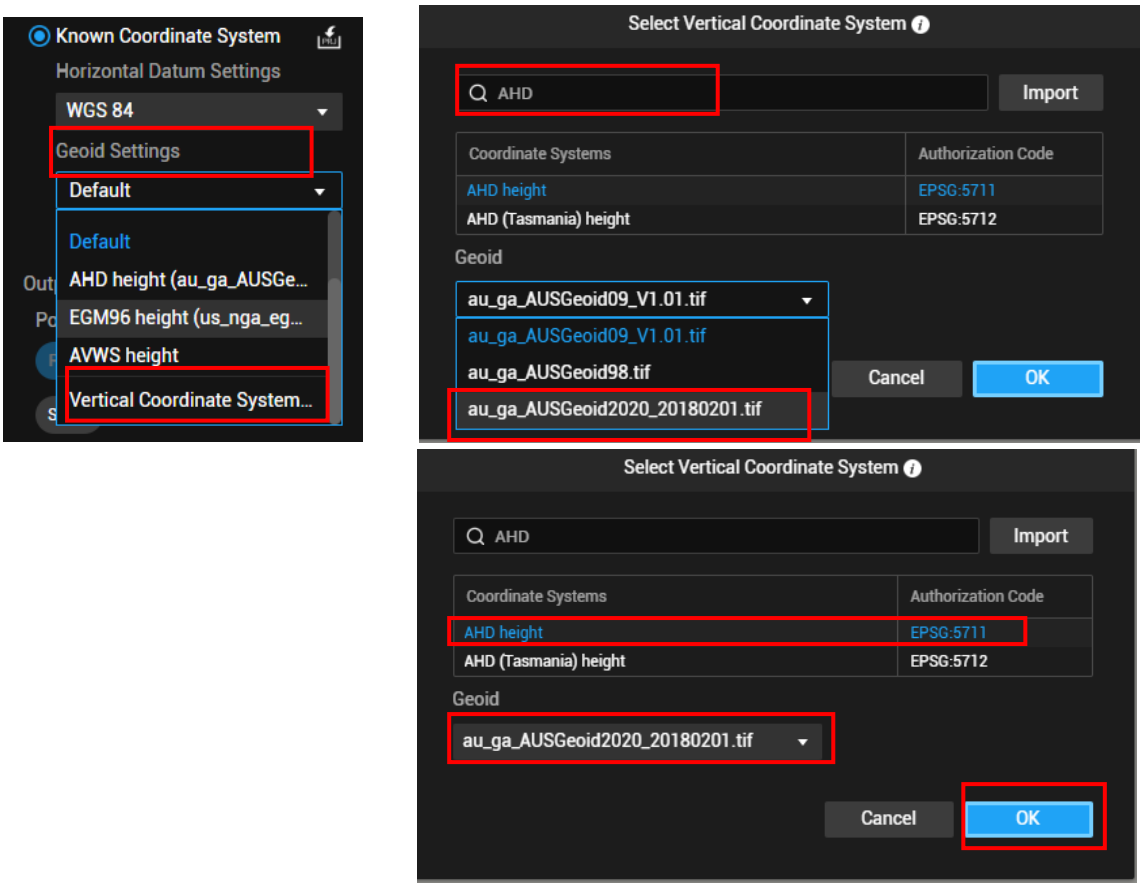


Figure 6: Update Geoid Settings. Select Vertical Coordinate System from dropdown list. Select AHD coordinate system, and Geoid as shown above.

5. Select ‘Start Processing’ (**Error! Reference source not found.**). In the **Reconstruction Parameter Checklist** dialog, check the settings and select OK.
6. Note that reconstruction can take several minutes or more depending on the size of the dataset. When ‘Reconstruction complete’, click OK.

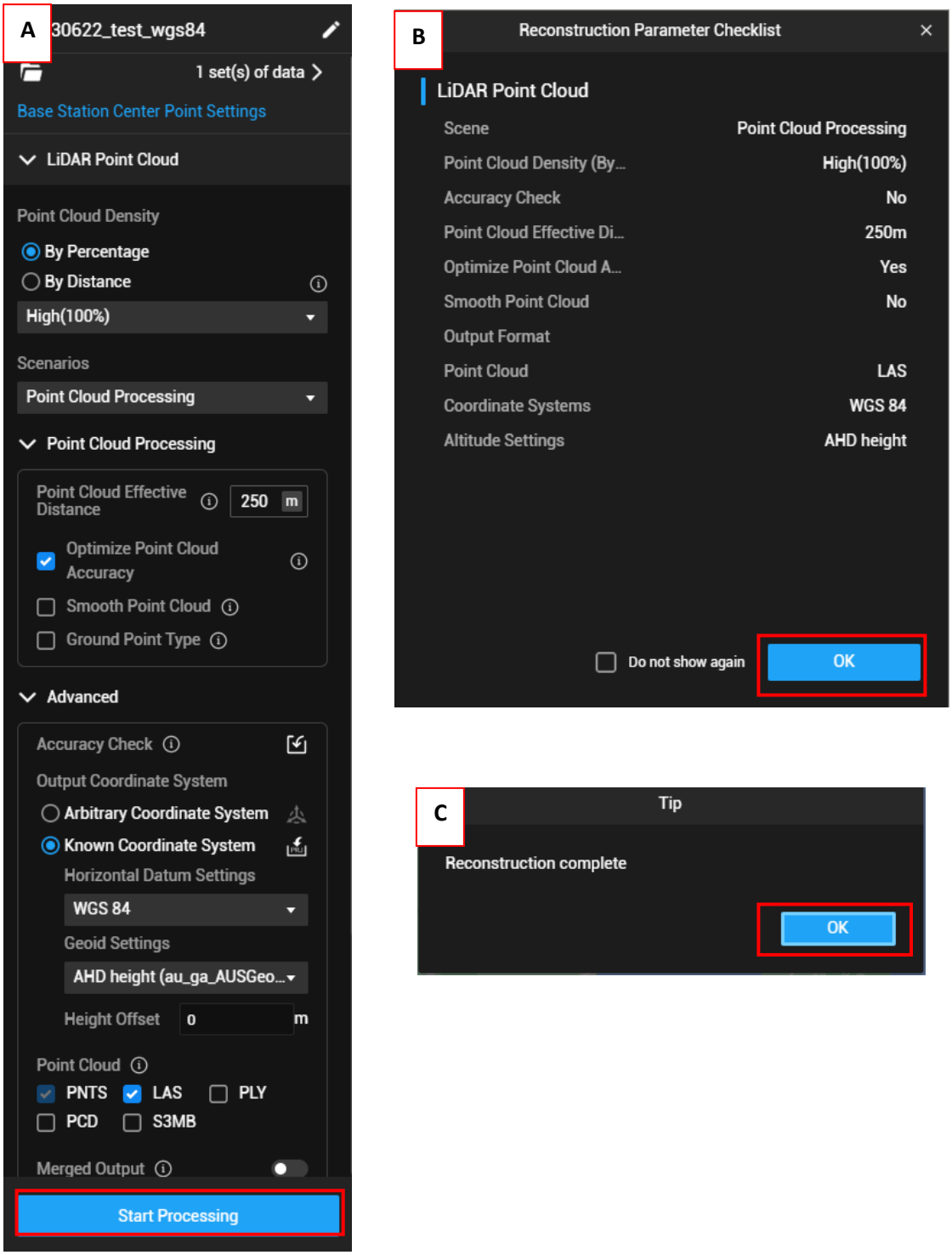


Figure 7: A: Summary of settings used for lidar point cloud reconstruction. Option to ‘Optimise Point Cloud Accuracy’ is available only on DJI Terra Pro version. B: Reconstruction Parameter Checklist. C: Reconstruction can take several minutes depending on the volume of data.

Point cloud visualisation and export

1. On the main screen the point cloud can be visualised by RGB, Reflectivity, Height or Return (Figure 8).
2. Click on 'Quality Report' to save a report (includes overview of data, processing settings and reconstruction times).

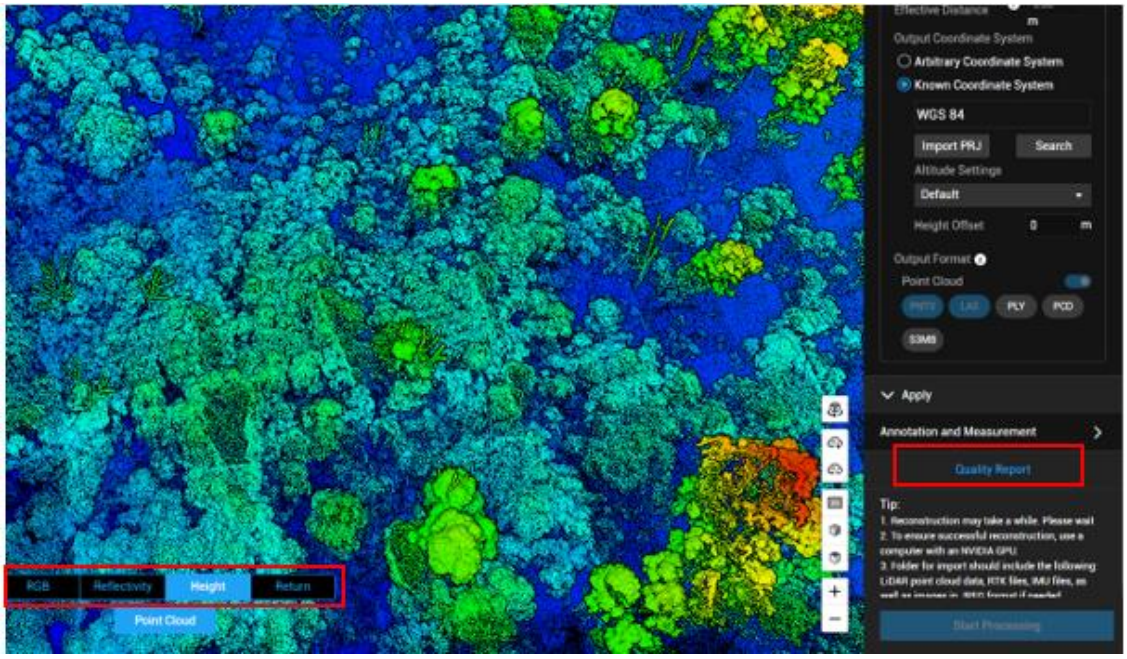


Figure 8: The point cloud can be visualised using RGB, Reflectivity, Height or Return number.

3. Click on the Home button to see the list of missions (Figure 9).
4. Select the folder icon ('Open Folder') to explore the results.
5. The results are organised in 2 subfolders: AT (aerotriangulation), and lidars. **The folder lidars/terra_las/ contains the output point cloud in las format**.
6. To export the contents in a zip folder, click on the export icon (Figure 9). Save the zip file in level1_proc/ folder within the lidar/ collection.

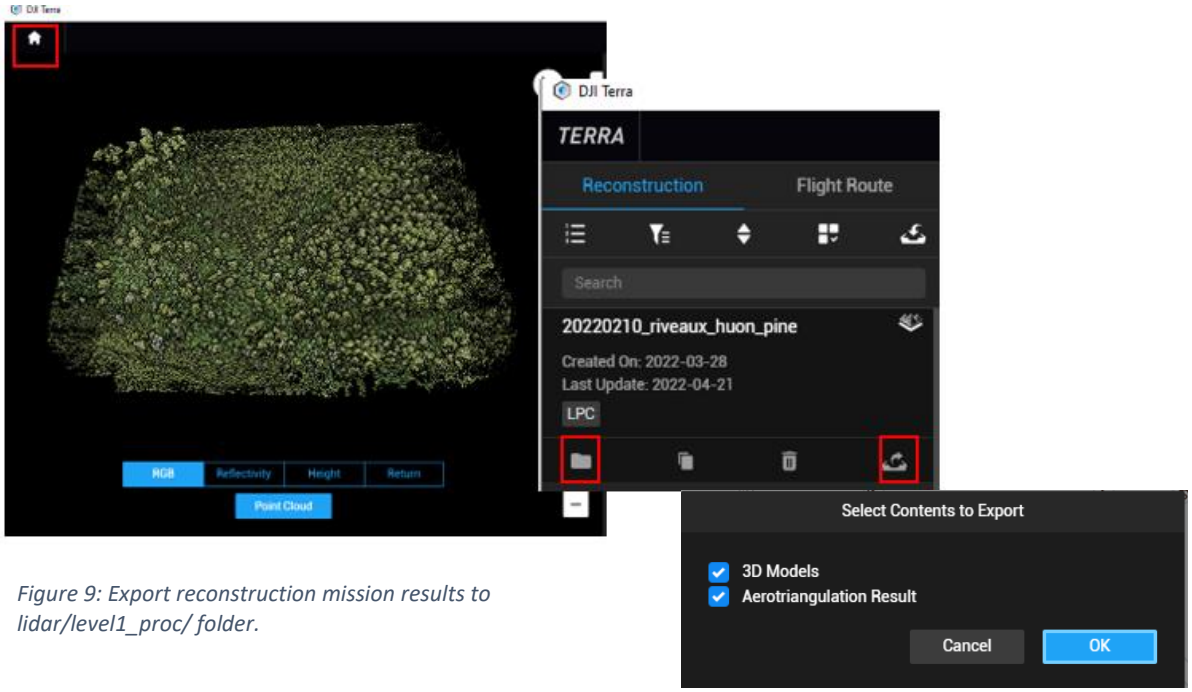


Figure 9: Export reconstruction mission results to lidar/level1_proc/ folder.

Reprojecting the point cloud

Due to an issue in implementation of GDA2020 datum in DJI Terra (versions 3.5.0 and later) the default geographic coordinate system WGS84 was used to project the point cloud. Open-source tools like pdal can be used to reproject the point cloud to the required coordinate system.

1. If Anaconda or Miniconda is installed on the machine, pdal can be using the following command on the conda prompt:

   conda create --yes --name pdal_env --channel conda-forge pdal

   This will create a new conda environment (pdal_env) and install pdal package from conda-forge.

2. Activate the environment using:

   conda activate pdal_env

3. Use the following command to reproject the point cloud. Replace the EPSG code in out_srs to the code of the required output coordinate system <add link to EPSG>:

*pdal translate input.las output_gda2020.las reprojection --filters.reprojection.in_srs="EPSG:4326+5711" --filters.reprojection.out_srs="EPSG:**7855**+5711"*

where input.las is the name of the las file generated from DJI Terra, and is saved in lidars/terra_las/ folder, and output_gda2020.las is the name of the reprojected las file. Replace “7855” above which refers to GDA2020 MGA Zone 55 with the EPSG code of the required horizontal projected coordinate system.

Lidar data products

An example of an open source lidR based workflow is shared on the TERN GitHub repo to process the lidar point cloud exported from DJI Terra. following are the main steps covered in the current workflow. Note that parameters that are hardcoded (catalog chunk size, resolution, algorithm settings) must be tested and updated depending on the study site and requirements.

- Ground classification using Cloth Simulation Filter (CSF)
- Generate Digital Terrain Model
- Normalise heights using ground points
- Generate Canopy Height Model
- Canopy Cover, Canopy Density
- Exploratory plots

- Standard area-based metrics

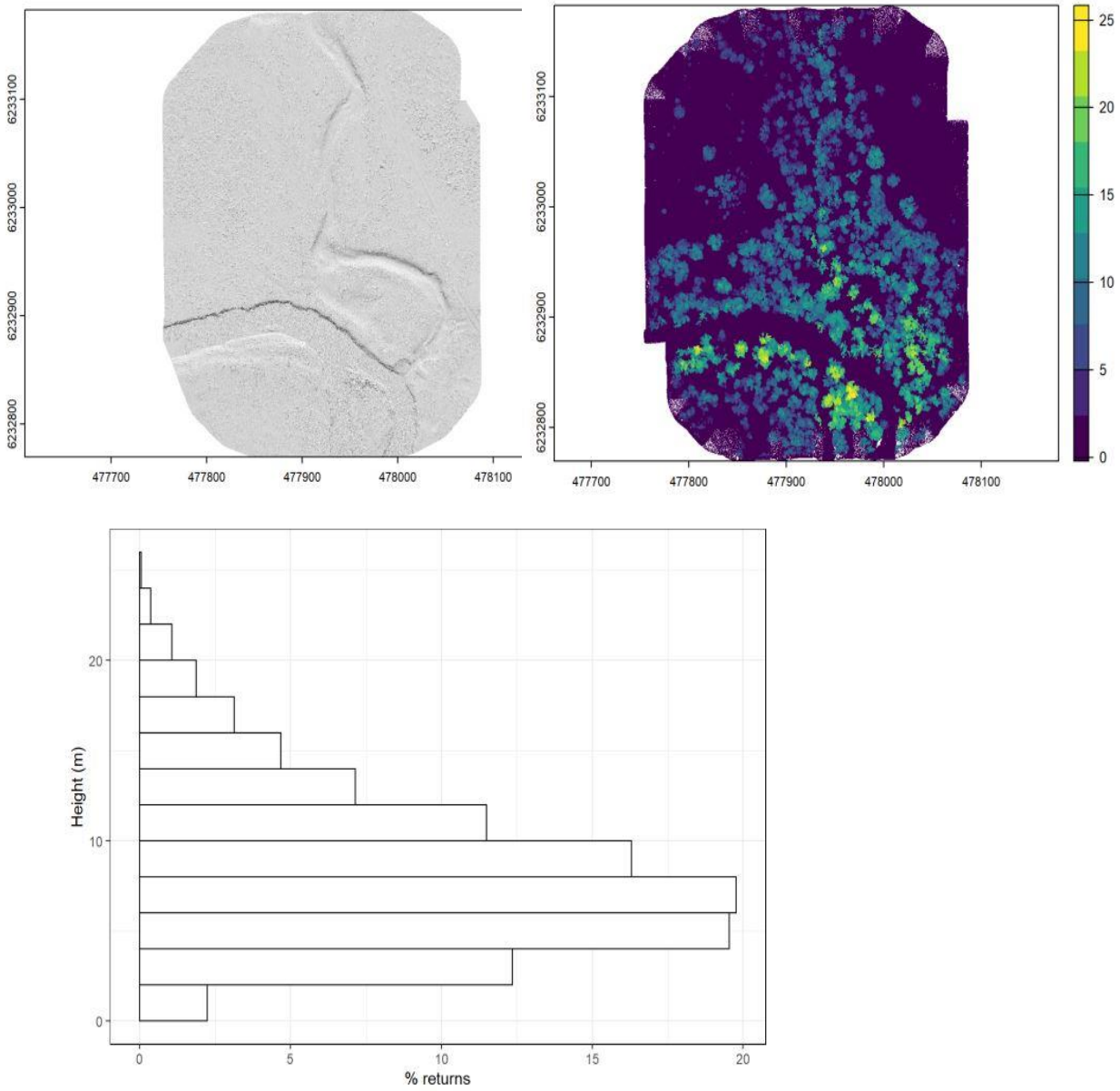


Figure 10: Examples of outputs from the automated lidR workflow: digital terrain model, canopy height model, vertical profile

To do list

1. Test Optimise Point Cloud Accuracy (pro version) – mixed results with this setting. Requires further testing.
2. Point Cloud Effective Distance: impact of this setting? Set to 100 m?

References

DJI 2022, *DJI Terra – User Manual 3.6,* DJI, Australia, viewed 09 May 2023, <https://www.dji.com/au/downloads/products/dji-terra>

Appendix: Update Base Station Settings in DJI Terra

See Appendix 3 in the Drone RGB and Multispectral Data Processing Protocol for the steps to process and submit base station data to AUSPOS.

When the AUSPOS report is available, open the mission on DJI Terra and select Base Station Center Point Settings to enter the updated coordinates from the AUSPOS report.

1. Click on 'Base Station Center Point Settings' (top right on screen).

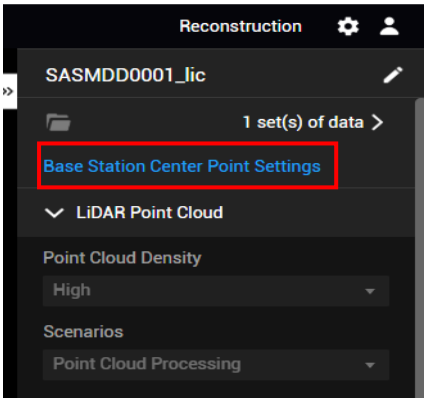


Figure 11: Update Base Station settings.

2. Under Coordinate System, click 'Search'. Enter the EPSG code of the coordinate system in which base station coordinates are available. **Note:** The recommendation in previous versions of this protocol was to output the point cloud in the GDA2020 datum based projected coordinate system, there is a bug in recent versions of DJI Terra. As there are issues in the implementation of GDA2020 datum in Lidar mission processing in Terra, the current suggestion in this workflow is to enter the updated Base Station Center Point coordinates in the default coordinate system on Terra, WGS84 coordinate system.

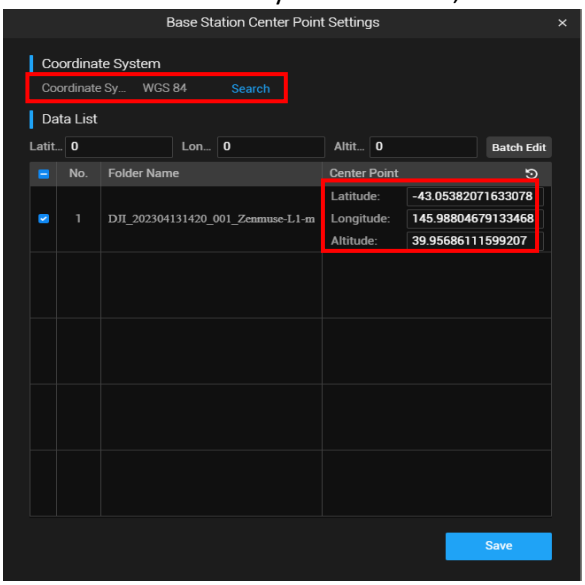


Figure 12: Use the default WGS 84 (EPSG; 4326) coordinate reference system to enter updated base station center settings.

3. Raw data folders that were added earlier are displayed under Data List with the base station center point settings recorded in the field. The base station coordinates must be replaced with those from the AUSPOS report. The base station coordinates in the AUSPOS report are

in degrees, minutes, seconds, and must be converted to decimal degrees for entry in DJI Terra. Use an online calculator to convert Lat/Lon in degrees minutes seconds to decimal degrees.

4. Copy Lat/Lon coordinates in decimal degrees and paste in the 'Latitude' and Longitude fields under the Center Point column.

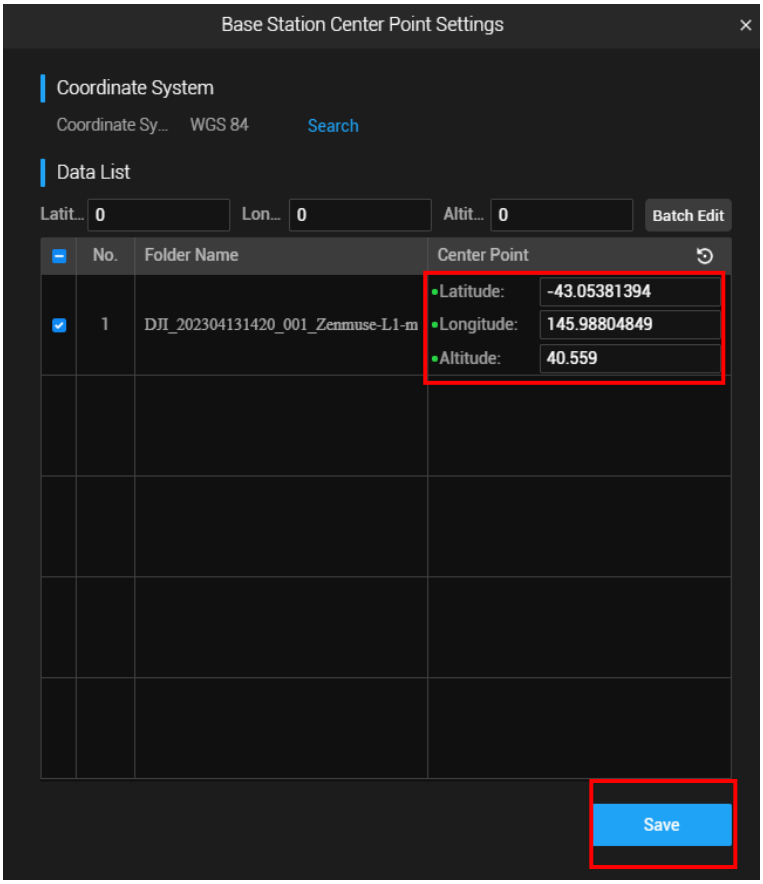


Figure 13: Update the values for Latitude, Longitude and Altitude either through Batch Edit or directly for each input folder.

5. Enter updated ellipsoidal height from the AUSPOS report in 'Altitude'.
   Note on Altitude: The height entered here is the Ellipsoidal height above the ground plus the antenna height of 1.8 m. The assumptions here are: i) the D-RTK base station was setup as per the Drone Data Collection Protocol, so the antenna rod height (1.8 m) is already part of the base station Altitude coordinate. And ii) the base station data was submitted to AUSPOS as described in Appendix 3 in the Drone RGB and Multispectral Processing Protocol. So, the Ellipsoidal height from the AUSPOS report already includes the antenna height (1.8 m), hence the antenna height must not be explicitly added here.
6. If there is more than one input folder, enter updated values in the Latit/Lon/Altit fields at the top of the table instead and click on 'Batch Edit' to update coordinates for all folders.
   Note: in the above steps the assumption is that the base station coordinates for all datasets are the same. However, when base station coordinates are different for datasets (e.g., if the D-RTK2 battery was changed, or the base station was moved to a different location), the coordinates must be updated separately for each folder.
7. Check that the coordinates have been updated. Click Save.
8. Complete the rest of the steps as per the main document ('Lidar point cloud reconstruction') and process the data.

Revision History

Date	Revision	Changes
28/02/2022	1.0	Initial version
21/04/2022	1.1	Screenshots for point cloud export
11/05/2022	1.2	Updated on review by Arko Lucieer
02/08/2022	2.0	Updated following Calperum campaign in May 2022.
26/10/2022	2.1	Updated following DJI Terra update (coordinate system selection)
03/11/2022	3.0	Fix formatting and cross-references
19/05/2023	3.1	Updated coordinate system settings due to GDA2020 implementation issue in DJI Terra v3.5.0+