



GVI Integrated PPK and Mapping Solution for Phantom 4 RTK

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About

GVI's (GreenValley International) Integrated PPK and Mapping Solution for DJI Phantom 4 RTK (P4R) is a one-stop solution featuring a streamlined workflow to produce mapping results with survey-grade accuracy. This solution consists of a LiPPK software (desktop & cloud) for post-processed kinematic (PPK) differential correction of photo positions and a LiMapper software for photogrammetric processing to generate geospatial products including orthomosaic imagery, Digital Elevation Model (DEM), Digital Surface Model (DSM), dense point cloud, etc. Major features of the integrated solution include:

- **Streamlined and user-friendly workflow.** The PPK and mapping solution is optimized for P4R drone specifications and takes in files collected by the drone seamlessly. Therefore, manual inputs from user are reduced to a minimum level to simplify workflow and reduce operation errors.
- **Automatic lever-arm correction during PPK.** As camera gimble tilts during the flight, offset between GNSS antenna center and camera center changes. LiPPK software adjusts the offset to output the center position for each photo to achieve high geolocation accuracy.
- **Automatic camera calibration during photogrammetric processing.** Each camera of P4R is calibrated to get camera-specific distortion parameters. LiMapper software automatically reads in camera distortion parameters and use them in photogrammetric calculation process to improve mapping accuracy.
- **Big data capability to provide high processing efficiency.** LiMapper generates products of DEM, DSM, orthomosaic imagery, and dense cloud from 400 P4R photos in 120 minutes with an Intel (R) Core (TM) i7-6700 K, 32GB RAM, NVIDIA GeForce GTX 1060 3G computer.
- **Survey-grade accuracy results.** Without using Ground Control Points (GCPs), the absolute horizontal accuracy of result geospatial products is <5 cm and absolute vertical accuracy is <10 cm¹.

¹ The actual accuracy depends on environment lighting conditions, object patterns, aircraft altitude, and other environment and flight condition factors when shooting. This result is validated by vast tests perform under standard surveying operations and ideal flight and shooting conditions.

Components

This integrated solution consists of a LiPPK software (desktop & cloud) for PPK differential correction of photo positions and a LiMapper software for photogrammetric processing to generate geospatial products. A GVI GNSS base station for recording difference reference data can also be added to the solution package. The components function seamlessly with each other as an integrated solution, but they can also be purchased and used independently as complementary tools for your current workflow because they are compatible with output/input files generated by most popular hardware/software in the market.

LiPPK Software (desktop)

The LiPPK software provides a reliable and rigorous PPK differential correction method for improving positioning accuracy of photos captured by P4R drone. The output from LiPPK processing is a .txt file with position information for each photo which can be used in LiMapper for photogrammetric mapping or other photogrammetric software. LiPPK requires two input files from P4R which are stored in the drone's SD card: PPKRAW.bin, Timestamp.mrk, and the data file from base station.

The screenshot displays the LiPPK software's settings window, which is divided into several sections:

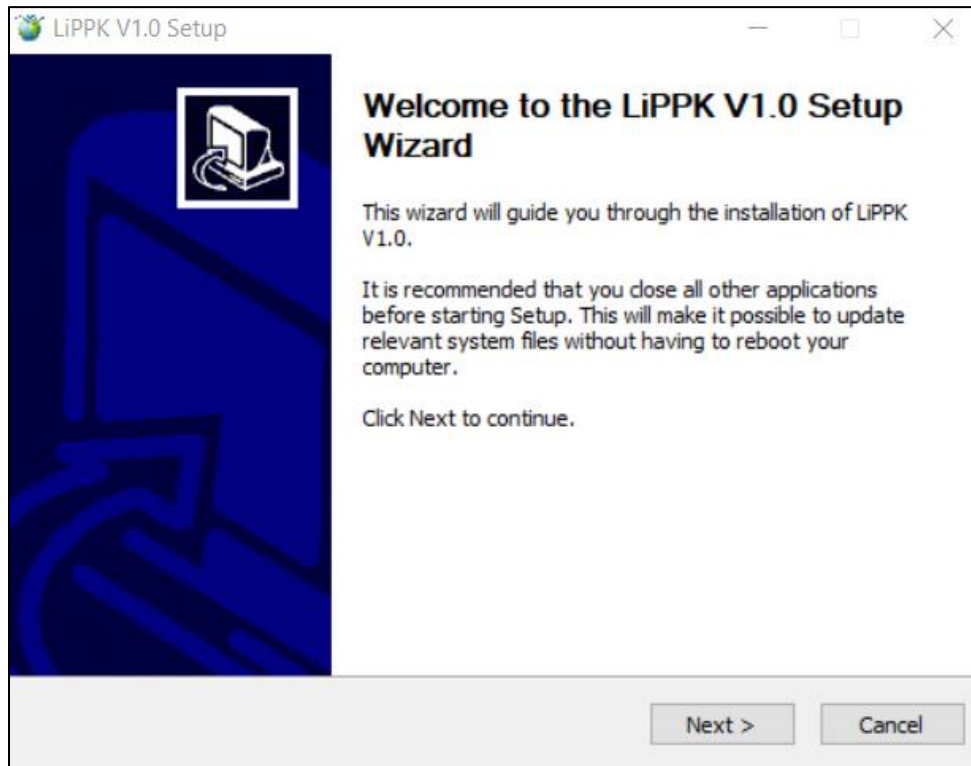
- Settings / Log:** The top navigation tabs.
- Trajectory:** Includes a 'Project' text field with a 'Browser' button and a 'Device Type' dropdown menu currently set to 'DJI P4R Device'.
- Mobile Station:** Includes 'Bin File' and 'Event File' text fields, each with a 'Browse' button.
- Base Station:** Contains radio buttons for 'File Format' (selected: Log, unselected: Rinex+Eph), 'Location Mode' (selected: Auto, unselected: Manual), and 'Unit' (unselected: Degree, selected: DD:MM:SSSS). Below these are input fields for 'GPS Base' (with 'Browse' button), 'Latitude' (with a 'North' dropdown and three '0' input boxes), 'Longitude' (with an 'East' dropdown and three '0' input boxes), 'Altitude Height(m):' (0.0000), and 'Antenna Height(m):' (0.0000).
- Output:** Contains radio buttons for 'Time Format' (selected: UTC, unselected: GPS).

At the bottom right of the window are 'Start' and 'Exit' buttons.

User interface of LiPPK

Software Installation and Licensing

Follow the installation wizard to install.



License activation is required after installation the software. A 15-day free trial license or paid license is available upon request. Follow this instruction to request free trial license or paid license:

1. In the **License Manager** window, under **General Information**, fill in your name and company name.
2. Check on **LiPPK** module.
3. Click **Copy** to copy the information and email info@greenvalleyintl.com for activation code.

License Manager

LiDAR360 Suite

General Information | **Single Use Licensing** | Concurrent Use Licensing

Name(*):

Company(*):

Select Product

LiDAR360 Framework (Perpetual) Terrain (Perpetual) Forest (Perpetual)

LiAcquire

LiBackpack-Desktop (Perpetual)

LiMobile

LiGeoreference (Perpetual) LiPPK

LiMapper (Perpetual)

LiPowerline

Realtime Working Condition Analysis (Perpetual) Early Warning Analysis (Perpetual)

Select All Unselect All

Activation Information:

Name:WZ
Company:GVI
Module List:
LiPPK

Click the [Copy] button to copy the above information and E-mail us to get activation code.

4. Activate online: under **Single User Licensing** tab, select **Online**, and input the activation key received from GVI. Click **Activate**.
5. Activate offline: under **Single User Licensing** tab, select **Offline**.
 - a. Click **Generate Request File** to generate the request file (.req).
 - b. Use a computer connected to the internet to browse to <https://user.bitanswer.cn>, enter the authorization key to log in, click **Update**, upload the request file (.req), and download the generated upgrade file (.upd).
 - c. Go back to the **License Management** tool interface.
 - d. Click **Apply Promote File** and select the downloaded .upd file.

User Interface

Settings

The screenshot shows the LiPPK Settings window. It includes a 'Settings' tab and a 'Log' button. The 'Project' section contains a 'Project Name' text box with a 'Browse' button and a 'Device Type' dropdown menu set to 'DJI P4R Device'. The 'GNSS Rover' section has 'Bin File' and 'Event File' text boxes, each with a 'Browse' button. The 'Base Station' section includes 'File Format' radio buttons for 'NovAtel' (selected) and 'Rinex+Eph', a 'GNSS Base' text box with a 'Browse' button, 'Location Mode' radio buttons for 'Auto' (selected) and 'Manual', 'Unit' radio buttons for 'Decimal Degrees' and 'DD:MM:SSSS' (selected), and input fields for Latitude (North, 0, 0, 0.0000000000) and Longitude (East, 0, 0, 0.0000000000). It also has 'Ellipsoid Height(m): 0.0000' and 'Antenna Height(m): 0.0000' text boxes. The 'Output' section has 'Time Format' radio buttons for 'UTC' (selected) and 'GPS'. 'Start' and 'Exit' buttons are located at the bottom right of the window.

Project

- **Project Location:** User defined directory and name of the project results.
- **Device Type:** Drone and camera device. Currently only DJI P4R Device is supported.

GNSS Rover

- **Bin File:** the PPKRAW.bin file from P4R, an RTCM3.2 MSM5 format file that stores satellite observation data and ephemeris data.
- **Event File:** the Timestamp.mrk file from P4R, an ASCII format that stores exposure and time stamp.

Base Station

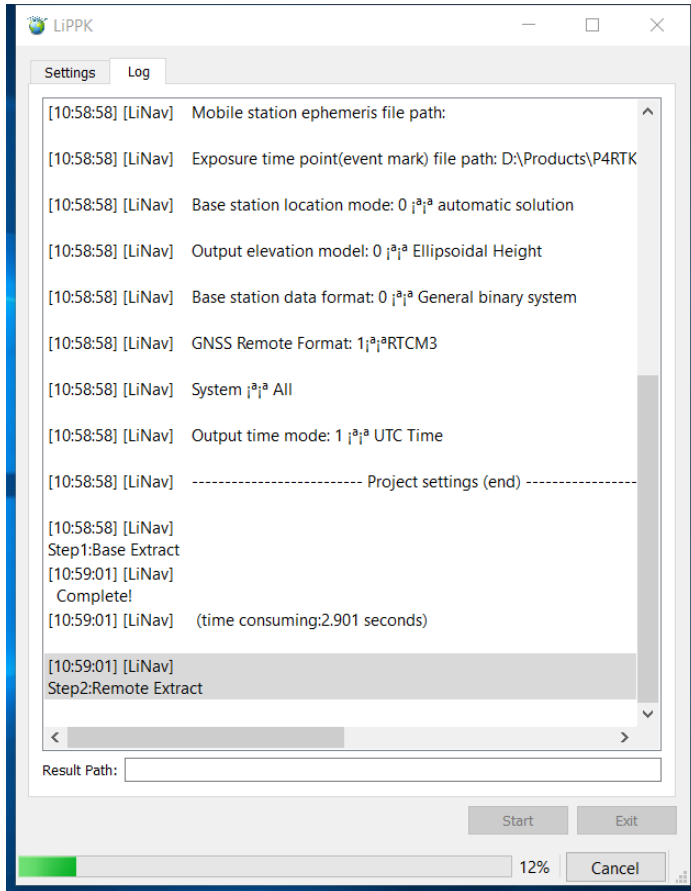
- **File Format:** NovAtel and Rinex+Eph formats are supported. The format for GVI's base station is NovAtel. Base station file generated by non-GVI equipment that are in NovAtel or converted to Rinex format is supported in LiPPK.
- **GNSS Base:** browse and input the base station file.
- **Location Mode:**
 - Auto: Automatic calculation of the base station's location. This mode generates reliable result if the base station is kept static recording data for more than 5 hours.
 - Manual: the location of the base station should be manually typed in by the user. The accuracy of the location directly influences the accuracy of position processing result.
- **Unit:** Decimal Degrees and DD:MM:SS formats are supported.
- **Latitude:** Latitude in WGS 1984 (EPSG:4326) geographic coordinate system.
- **Longitude:** Longitude in WGS 1984 (EPSG:4326) geographic coordinate system.
- **Ellipsoid Height(m):** Altitude height in WGS 1984 ellipsoid height in the unit of meters.
- **Antenna Height(m):** Antenna height in the unit of meters.

Output

- **Time Format:** Select UTC time or GPS time as format for output data.

Log

The log interface records processing status and logs for the project.



Execute Buttons

Start: Start processing the project.

Exit: Exit the software.

Cancel: Stop and cancel the processing.

Output

Two folders will be generated in the output project folder: Extract, POSProc.

Extract

The Extract folder holds the GNSS remote rover data and base station data converted to Rinex format.

POSProc

The POSProc folder holds the project results and log. These are the three important output files:

- **LiNav_GNSS_Extraction:** position data for each photo. The columns in sequence are: Time stamps, longitude (WGS 1984), Latitude (WGS 1984), Ellipsoid Height (m), Standard Deviation of Longitude, Standard Deviation of Latitude, Standard Deviation of Height, Quality (1: fixed, 2: float).
- **Report:** quality report.

- **Log:** log file of the project.

LiCloud PPK Module (cloud)

LiCloud is the online geospatial data processing platform served by GreenValley International (GVI). It also provides a module for processing camera positions for photos.



LiCloud requires an account and membership enrollment to process. Please sign up for an account: <https://lidar360online.com/signup>, and [contact us](#) to inquiry trial version and paid membership.

The parameter definitions are the same as LiPPK.


Trajectory

Project name	Phantom4RTK PPK (#86)
Device type	DJI P4R

Mobile Station

Bin file	Not uploaded	
Event file	Not uploaded	

Base Station

File format	<input checked="" type="radio"/> Log	<input type="radio"/> Rinex+Eph
Log file	Not uploaded	
Location mode	<input checked="" type="radio"/> Auto	<input type="radio"/> Manual

Output

Time format	<input checked="" type="radio"/> UTC time	<input type="radio"/> GPS time
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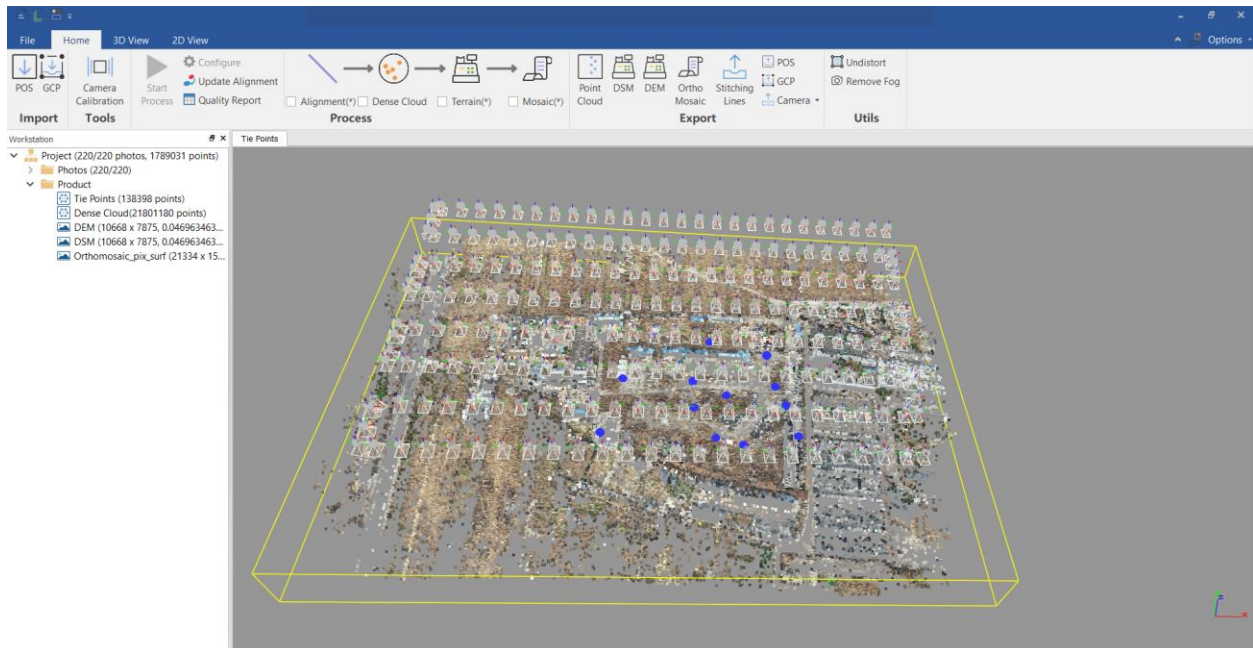
Imagery PPK module in LiCloud

LiMapper

LiMapper is a professional photogrammetric software. With its state-of-the-art photogrammetry and computer vision algorithms, LiMapper automatically generates industry-standard products such as dense cloud, orthomosaic imagery and DEM/DSM. These are the major features of LiMapper in processing P4R photos:

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- LiMapper has the capability of automatically identify P4R photos and read in the unique camera calibration parameters as intrinsic for your drone, and use them in the photogrammetric calculation process to improve the result accuracy.
- A template with customized parameter setup for P4R drone can be saved and reused for processing photos of different projects collected by the same system, which reduces workload and the risk of human errors during parameters setup.
- POS accuracy of the photos, which plays as a Weight Factor in bundle adjustment, can be specified to match PPK/RTK accuracy of your project, under the purpose of increasing robustness in photogrammetric processing. For P4R photos processed by PPK or RTK, the POS accuracy is usually about 5 centimeters.
- GCP/MTP window supports using GCPs to further improve absolute accuracy of the result, using MTPs (Manual Tie Points) to manually register photos in hard-to-match areas, and using Check Points to generate quality report with absolute accuracy.



Workflow Guide

Record Base Station Data

Set up the base station and start recording data. The base station has to start recording data 20 minutes earlier than the rover starts recording, and stop recording 20 minutes after the rover stops. Once base station data recording has started, do not move the GNSS antenna during the entire data recording session.

Please follow the instruction from your base station manufacturer to record base station data.

Photo Collection

Plan flight path and fly the P4R drone to collect photos, following DJI's instruction. In Camera Settings, disable Distortion Correction. According to DJI manual, 'if distortion correction is enabled, the image quality may be lower due to processing. It is recommended to disable this option when original images are needed for post processing'.



PPK corrections Using LiPPK

For PPK differential corrections of photos, GVI provides a LiPPK desktop software and a PPK module on LiCloud, the cloud platform. Here are the steps to process using the LiPPK desktop software.

1. Launch LiPPK.
2. Select project directory and fill in project name under **Project** section.
3. Select PPKRAW.bin file for **Bin File**, and Timestamps.mrk file for **Event File** under GNSS Rover section.
4. Specify **File Format** and select base station data file under **Base Station** section.
5. Select **Auto** or **Manual** mode for base station location. If **Auto** is selected, no manual input is needed for Latitude, Longitude, Ellipsoid Height, and Antenna Height. If **Manual** is selected, select **Decimal Degrees** or **DD:MM:SS Unit** format, and input Latitude, Longitude, Ellipsoid Height, and Antenna Height.
6. Select **Time Format, UTC** or **GPS**, under **Output** section.
7. Click **Start** to run process.
8. Once finished, exit the software.
9. The output position file is in the POSProc folder: LiNav_GNSS_Extraction.txt.

PPK Corrections Using LiCloud

Follow these steps to process photo positions in LiCloud:

1. Create an account on LiCloud: <https://lidar360online.com/signup>.
2. Follow this [instruction](#) to add credits and enroll membership, or [contact us](#) for a trial version.
3. In the [Home](#) page, click **Projects** on the upper right.
4. Click **New Project** .
5. Enter project **Name** and select **Device type**: DJI P4R. Click **OK**.
6. In the **Projects** page, under **Trajectory** section, click  to create a new PPK project.
7. Follow the same steps and parameter settings as LiPPK illustrated above to set up and process the project.
8. When finished, under Result section, click on the file name LiNav_GNSS_Extraction.txt to download the position data.

Create Orthomosaic and Surface Models Using LiMapper

A complete guide for LiMapper is available here: <https://greenvalley.gitlab.io/LiMapper-Doc/latest/en/>. Please search for in-depth introductions of the software using keywords at the page. Here is a workflow guide to create orthomosaic and surface models using the photos captured by P4R and position data generated by LiPPK or LiCloud.

Download and Install

LiMapper is a software included in GVI's LiDAR360 Suite. Please download LiDAR360 from GVI website <http://www.greenvalleyintl.com/software/software-downloads/> and install. A 30-day free trial is available after activation. Please [contact us](#) for paid license.

Create Project Template

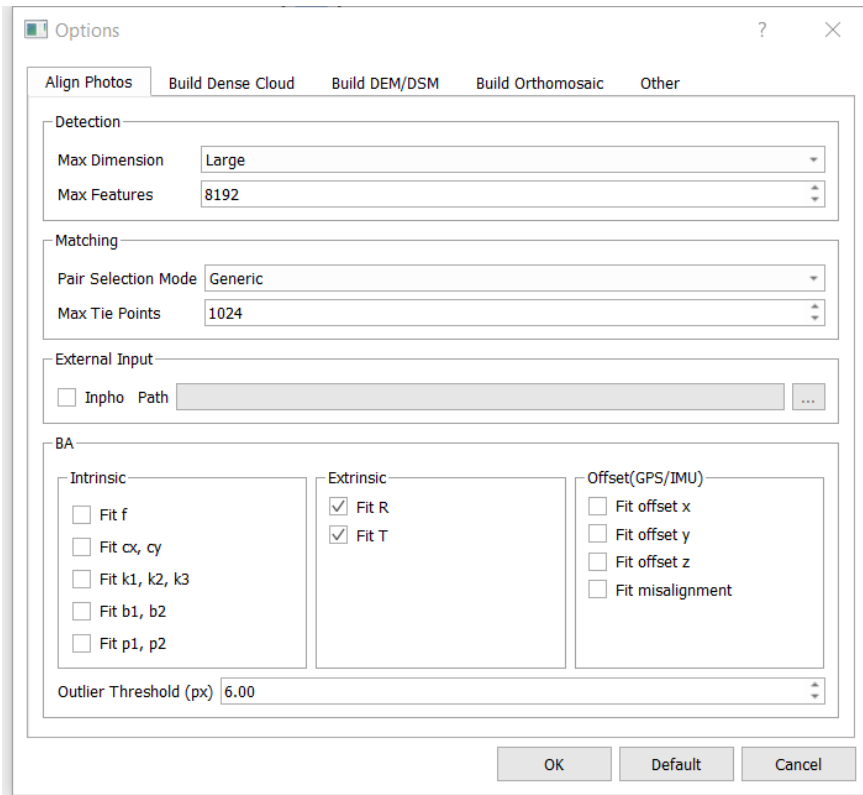
1. Launch LiMapper.



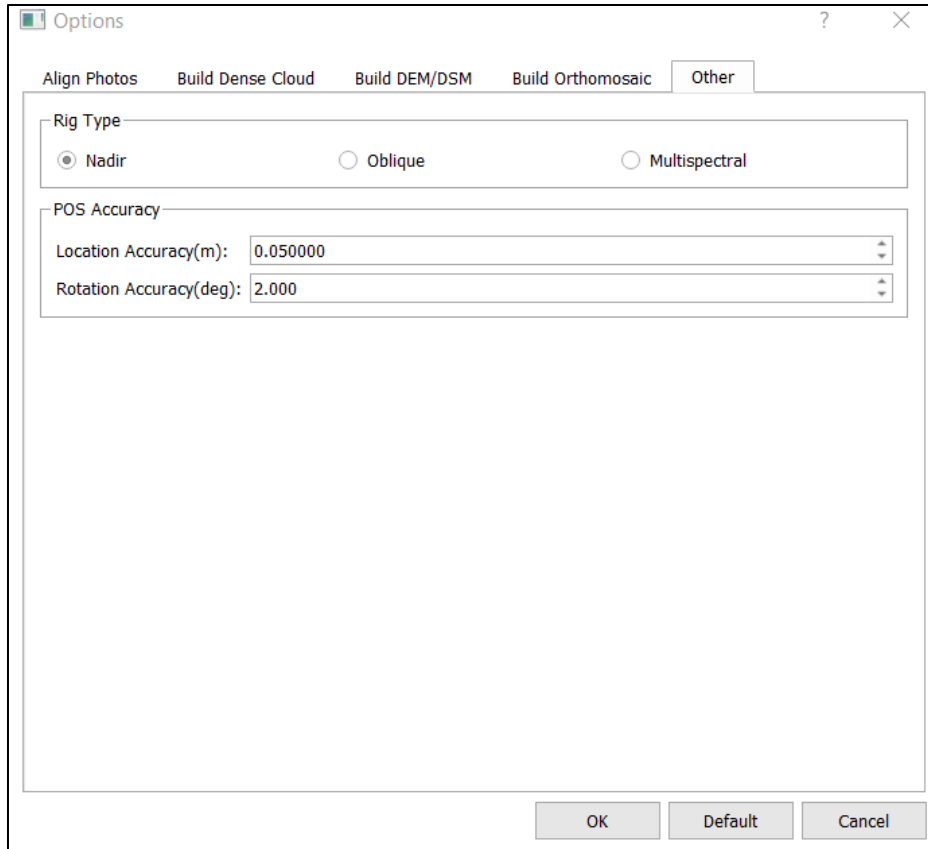
2. Click **New Template** New Template.
3. Fill in **Title** and **Description**. For example:

A screenshot of a dialog box titled "Edit Template - P4R". It contains a "Title" field with the text "P4R" and a "Description" field with the text "Processing template for Phantom 4 RTK". Below these fields is a "Steps" section with four checkboxes, all of which are checked: "Align Photos", "Build Dense Cloud", "Build DEM/DSM", and "Build Orthomosaic". At the bottom of the dialog are four buttons: "Options...", "OK", "Default", and "Cancel".

4. Click **Options**.
5. In **Align Photos** tab, under **BA** (Bundle Block Adjustment) section, uncheck all options for **Intrinsic**. The intrinsic written in photos can be read and used in post-processing automatically for P4R photos. Leave all other parameters in **Align Photos** tab as default.





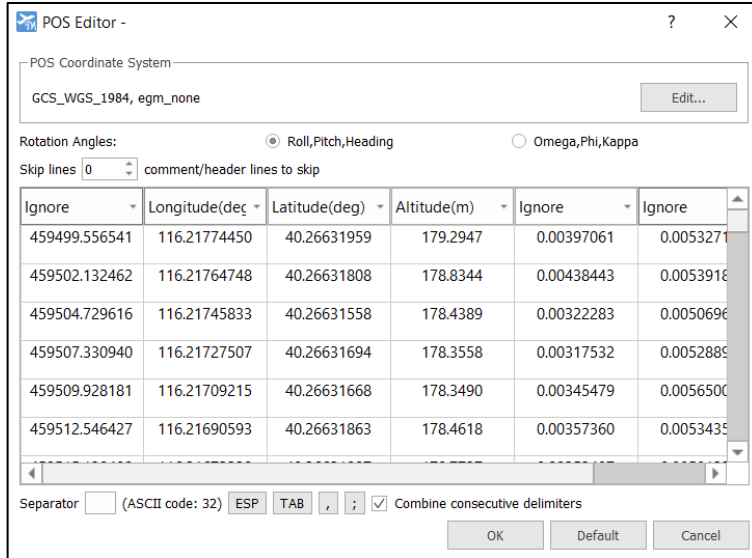
6. Under **Build DEM/DSM** tab, check **Build DSM** and **Build DEM** (if needed), and adjust **Resolution**.
7. Under **Build Orthomosaic** tab, the default **Pixel-level mosaic based on surface** model is selected, which in most cases generates the best results and has the fastest processing speed. Adjust **Resolution** as needed.
8. In **Other** tab, under **POS Accuracy** section, change **Location Accuracy** (m) to 0.05.



9. Click **OK** when finished to save the template.

Create New Project

1. Create on the new template saved.
2. Type in a **Project name** and select **Project location**. Click **Next** to navigate through the **New Project Wizard**.
3. In **Load Photos** window:
 - 3.1. Click  to load the project photos.
 - 3.2. Click  to **Import POS**. In the **Import POS** browsing window, navigate to and select the LiNav_GNSS_Extraction.txt file.
 - 3.3. Change **POS Coordinate System** to **GCS_WGS_1984**. Set **Vertical Coordinate System** to **Default**, meaning WGS 1984 ellipsoid height.
 - 3.4. Adjust the column headers as below:



3.5. Click **OK** to save POS editing, and click **Next**.

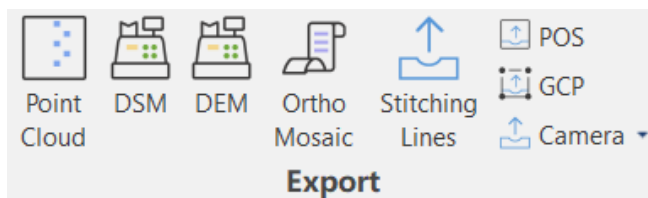
4. In **Select Output Coordinate System** window, a default **Horizontal Coordinate System** and default **Vertical Coordinate System** are selected based on geolocation. Change if necessary.
5. Click **Finish** to finish creating **New Project**.

One-step Processing

1. If **GCPs** and/or **Check Points** will be used, in the **Process** section on the ribbon, uncheck **Dense Cloud**, **Terrain**, and **Mosaic**. The processing will only complete the photo **Alignment** step, after which you will need to import the GCPs/MTPs/Check Points, pair 2D observations on photos, and update alignment and generate a quality report. Please refer to [Using GCP/MTP](#) in LiMapper manual for further instructions. If no GCPs/MTPs/Check Points will be used in the project, skip this step and move to next step.
2. If specific changes need to be made to this project in addition to template configuration, click **Configure** and modify options.
3. Click **Start Process** . When finished, the results will be added to the content panel.

Export

In **Export** section on the ribbon, select a product to export and navigate through the export window.



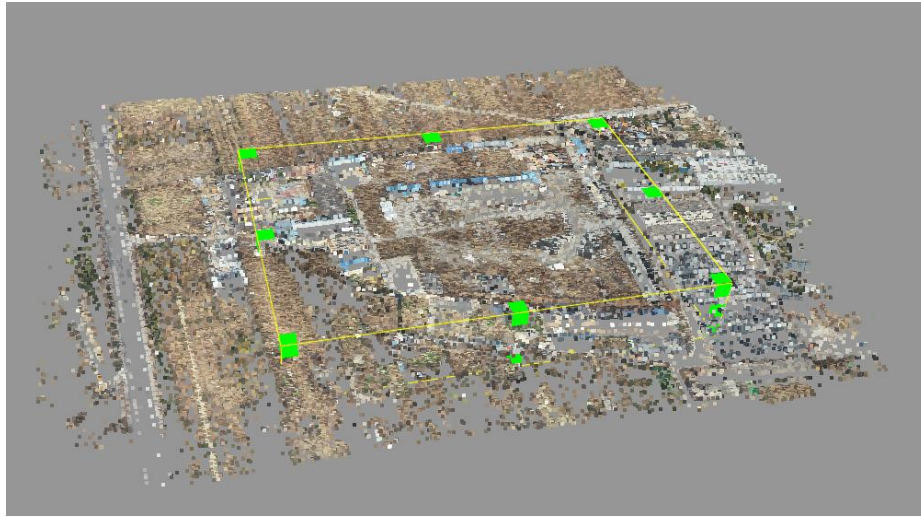
Advanced Editing

LiMapper provides advanced editing tools to improve product quality.

- **Adjust ROI**

After Photo Alignment, 3D Viewer should display the tie points and a yellow Region of Interest (ROI) box. The default ROI covers all of the scene. If you only need to reconstruct some region, you can adjust the

ROI to reduce computation for future steps. Building Dense Cloud, Building DEM / DSM and Building Orthomosaic will only process and produce products in ROI.



- **Stitching Line Editing**

After building orthomosaic, user can manually define an area and reassign photo(s) to the area, in these situations: obvious offsets are observed along stitching lines; important landmarks on the ground are covered by ground objects, clouds, or shadows in the automatically assigned photo(s); moving objects such as cars and pedestrians should be removed from the orthomosaic, etc. Please refer to [Adjust Stitching Lines](#) section of LiMapper manual for further instructions.



Using the Adjust Stitching Line tool to reduce distortion



Using the Adjust Stitching Line tool to eliminate moving objects on the street

FAQ

Why is PPK still needed given that P4R has RTK capability?

The method of RTK provides real-time correction of position data. However, PPK is still the recommended method to achieve stable accuracy results. PPK does not require signal link between the drone and the base station. The data recorded by the drone and data recorded by the base station during the flight will be joint together after the flight to process position data. This eliminates the accuracy loss that is often seen in RTK method due to connection loss between the drone and the base station in complex environments such as built-up areas where buildings would block the signal link.

What base station data is supported?

Currently we support two data formats for base station data: NovAtel and Rinex. Base station collected in field, or free or commercial CORS data are supported if they are converted to Rinex format.

What files/data are needed for PPK processing?

Four inputs are needed:

1. PPKRAW.bin: an RTCM3.2 MSM5 format file that stores satellite observation data and ephemeris data, generated automatically by P4R and stored in the camera's SD card.
2. Timestamp.mrk: an ASCII format that stores exposure and time stamp, generated automatically by P4R and stored in its SD card.
3. Base station data: NovAtel or Rinex base station data.
4. Base station location: the measured coordinates of base station location and antenna height.

Does LiPPK and LiCloud correct for the offset between antenna center and CMOS center?

Yes, the position data output from LiPPK and LiCloud is adjusted to the CMOS center, optimizing the absolute accuracy result in the following photogrammetry processing.

Should I use the 'Distortion Correction' option on P4R?

No, the 'Distortion Correction' option should be disabled. According to DJI manual, 'if distortion correction is enabled, the image quality may be lower due to processing. It is recommended to disable this option when original images are needed for post processing'. LiMapper can automatically correct distortions of the photos using calibrated distortion parameters.

Why do I need to adjust POS accuracy when doing photogrammetry processing in LiMapper?

POS accuracy of photos plays as a Weight Factor in Bundle Adjustment, to improve processing speed and improve absolute geolocation accuracy. Given that using LiPPK or LiCloud solution to correct photo positions will result in centimeter-grade accuracy, adjusting POS accuracy in LiMapper can make the best use of this high accuracy to optimize the accuracy of photogrammetry results. Therefore, please adjust the POS accuracy to 0.05 meter when creating template in LiMapper for P4R projects.

Can I purchase LiPPK, LiCloud, and/or LiMapper separately?

The components function seamlessly with each other as an integrated solution, but they can also be purchased and used separately as complementary tools for your current workflow because they are compatible with output/input files generated by most popular hardware/software in the market.