



LiAir X3C-H

UAV LiDAR System

User Guide

Contents

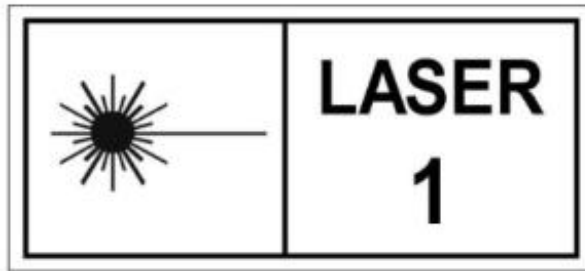
1 User Instructions	1
2 Product Introduction	4
2.1 Technical Specifications	5
2.2 Product Structure	7
2.3 System Components	9
2.3.1 Laser Scanner	9
2.3.2 Integrated Navigation System	11
2.3.3 Storage and Control Unit	12
2.3.4 Camera	12
2.3.5 GNSS ground station	13
3 Package List	14
4 Data Acquisition	15
4.1 Base Station Setup	15
4.2 Installation	16
4.3 Parameters Settings	17
4.4 Data Acquisition	20
5 Data Download	21
5.1 X3C-H data download	21
5.2 Base station data download	21
6 Data Georeferencing	22

6.1 Project Folder Structure	22
6.2 Open Project	24
6.3 Select and Configure Parameters	25
6.3.1 POS Processing Settings	25
6.3.2 Laser Scanner Settings	29
6.3.3 Camera Settings	29
6.4 Georeferencing Point Cloud Data	30
7 System Transportation and Maintenance	40
7.1 Operation Notice	40
7.2 Equipment Maintenance	41

1 User Instructions

ⓘ Safety Precautions

1. LiAir X3C-H system use Class 1 (IEC60825-1:2014) eye-safe laser sensors. If you have any concerns, please contact GVI for details.



2. Please read this manual carefully before operating the system, and the system operator must be at least 18 years old.
3. Please stop using the system if you hear noticeable noises, warnings, or while the device is damaged. Contact the manufacturer's technicians for maintenance in time. Forcible use may cause permanent damage to the system.
4. Strictly follow the tutorials, advises, warnings, and other cautions included in this user guide as well as other documents provided by GVI.
5. Do NOT use any power supply outside the specified voltage range (12~24V, 1A@24VDC). Incorrect voltage supply may cause permanent damages to the integrated instruments and other hazards. Damage caused by the use of an unauthorized power supply are not covered by the Product Warranty.
6. Keep the power, USB, network and other connector ports clean and dry, and

do not insert other objects other than the connector.

7. Tampering with the product is strictly prohibited and will void the Product Warranty. Any repair, modification, or upgrade must be performed by GVI technician or authorized service provider.
8. This product is a high-precision mapping and surveying instrument that must be handled with care. This product should be stored and transported in the protective case provided with the LiAir X3C-H at the time of purchase or in a protective case authorized for use by GVI.
9. When not in use, store LiAir X3C-H system and accessories in a cool and dry environment. Make sure the device is powered off when performing maintenance and cleaning.
10. The working temperature of this equipment is $-20^{\circ}\text{C} \sim 50^{\circ}\text{C}$. Below/exceed this temperature range, it may cause wrong measurement results, data loss or equipment damage.
11. Before using the equipment, please ensure that the operating environment is far away from the source of electromagnetic interference.
12. There are corresponding specifications for battery use and storage. Please refer to the lithium battery use/storage specifications for details.
13. After the equipment is scrapped, please do not throw it directly into the trash can. It can be sent back to the manufacturer, and the manufacturer will

handle it on your behalf.

GreenValley International Inc. reserve the right to explain the above terms.

GreenValley International Inc. March 5, 2023

2 Product Introduction

LiAir X3C-H is a new light and compact UAV LiDAR system developed by GreenValley through integrating the 360° scanning LiDAR, self-developed inertial navigation system, and 26MP HD mapping camera with a high computing power edge computing platform. With a highly integrated design, it can be used for topographic mapping, forestry measurement and power line inspection. Equipped with LiGeoreference/LIDAR360 software independently developed by GreenValley, it can provide one-stop mapping solutions for customers.



The LiAir X3C-H (shown above) mainly consists of three components: a LiDAR scanning system, an inertial navigation system, and a storage & control system.

The main components include:

1. The dynamic differential GNSS receiver for measuring the spatial position of the reference point for emitting the LiDAR signals;
2. Attitude measurement equipment for measuring the attitude parameters, namely inertial measurement unit (IMU);
3. Laser ranging equipment used to measure the distance between the laser

signal emission reference point and the ground point, that is, the core part of the entire integrated system, the laser scanner;

4. The storage control system, which is used for data storage and device control, receiving the signals transmitted from the ground to the airborne, and controlling the parameters adjustment, data acquisition and downloading.
5. Power supply and management unit.

Operating principle:

1. The system controls the device to collect data by receiving and executing commands sent by the hardware switch.
2. Then the raw data collected are stored in the TF card and copied to the local computer for processing after the collection is completed.
3. Finally, the LiGeoreference software is used to combine and georeference the position and angle information under the coordinate system of the LiDAR system with the POS data to obtain accurate geographic coordinates.

2.1 Technical Specifications

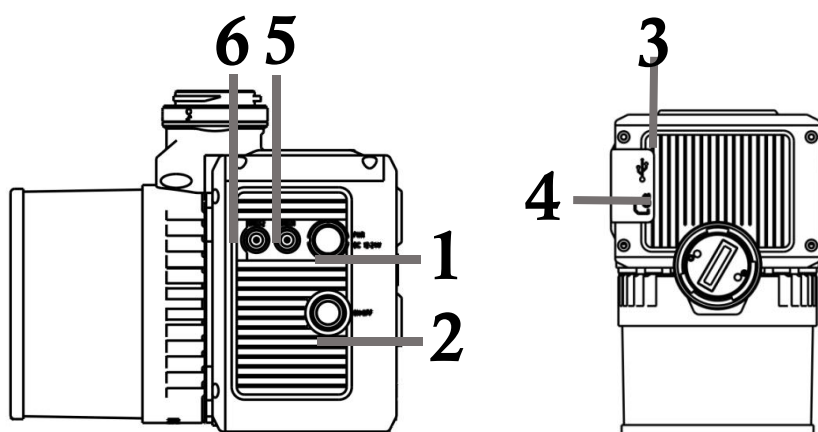
X3C-H System Specifications

Weight	1.12kg
Scan Range (Sunny, Outdoor @100 klx)	80 m @ 10% reflectivity; 200 m @ 54% reflectivity;

	300 m @ 90% reflectivity
Field of view	360° (Horizontal) ×40.3° (Vertical)
Number of Returns	3
Scan Rate	first return : 640,000 points/s dual return: 1,280,000 points/s triple return: 1,920,000 points/s
Camera Pixels	26MP
POS Attitude Accuracy (post-processing)	0.008°
POS Azimuth Accuracy (post-processing)	0.038°
System Accuracy (Vertical)	5 cm@70m
Size	153*100*133mm
Communication	WIFI
Voltage	12~24V, 1A@24VDC
Power Consumption	24W
Operating Temperature	-20~50°C
Storage Temperature	-30~60°C

UAV Model	DJI M300 RTK
Data Georeferencing Software	LiGeoreference point cloud data georeferencing software

2.2 Product Structure



- 1— Power Port (PWR): Connect the power cable to power up the system.
- 2— Switch button (ON/OFF) and indicator: The button shared for power-on and project creation and display the working status of the device.
- 3— USB-C port: For the communication between the computer and the device for firmware upgrade and data download.
- 4— Memory card slot: with a built-in 256G TF card for data storage.
- 5— GNSS1: First(Main) antenna port.
- 6— GNSS2: Second antenna port.

Meaning of status indicator status:

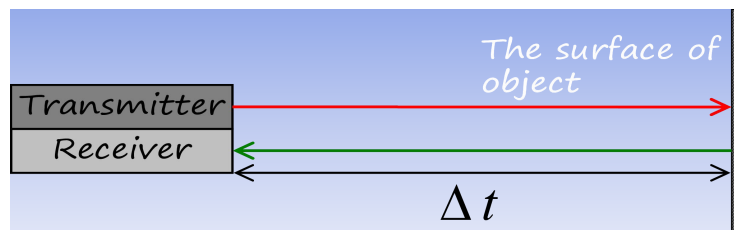
LED	Color/Status	Description
ON/OFF	Flashing Red (Four Times a Second)	System is powered on and initializing
	Solid Green	System initialization completed
	Flashing Green (Once per second)	The project has been created, the inertial navigation data is being recorded, and the system is working normally
	Flashing Red (Once per Second)	The project has been created, the inertial navigation data is being recorded, and the system is working abnormally
	Solid Red	The system status is abnormal, the reasons include: <ul style="list-style-type: none"> 1. TF card space is less than 15G 2. M300 RTK PSDK module is not activated 3. IMU misalignment 4. Camera self-test failed 5. The laser scanner is not synchronized

2.3 System Components

2.3.1 Laser Scanner

The laser scanner is the core of the system. The LiDAR uses the laser as the emitting light source and the photoelectric detection sensor as the receiving element. According to the principle of laser ranging, the distance and angle are measured and recorded, so as to determine the azimuth information of the measured object.

The transmitter in the LiDAR emits a beam of ultra-short light pulses on the object and diffusely reflects back to the receiver. The speed of light is known, and the distance from the target object to the sensor is calculated by the flight time of the laser beam in the air.



LiDAR ranging equation:

$$S = \frac{1}{2} \times c \times \Delta t$$

Where: S is the distance from the sensor to the target; c is the light speed; and Δt is the round-trip time of the laser beam.

LiAir X3C-H is integrated with the HESAI 32-channel 360° scanning laser with the following parameters:



Laser Scanner Parameters

Scanning Principle	Rotating Motor
Number of Channels	32
Scan Range	80 m (@ 10% reflectivity)
Measurement Frequency	1920 kHz (@ 3 returns)
Scanning Frequency	5Hz~20Hz
Horizontal field of view	360°
Vertical Field of View	-20.8°~ +19.5°
Vertical Angle Resolution	1.3°
Laser Class	Class 1 Eye-safe
Number of Echoes	3
Measurement Accuracy	1 cm

Note: The laser sensor cannot be directly irradiated with strong laser light (including two sensors facing the light), so as to avoid high-intensity laser damage to the receiving sensor.

2.3.2 Integrated Navigation System

The airborne Position Orientation System (POS) is an inertial measurement unit (IMU) and Global Navigation Satellite System (GNSS). POS systems are used to accurately determine system velocity, position, and attitude values at specific moments in time.

1. Global Navigation Satellite System (GNSS)

Global navigation satellite system, or (GNSS) on LiAir X3C-H supports, mainly includes GPS, GPS (the U.S.), Galileo satellite navigation system (Europe), BeiDou Navigation Satellite System (China), and GLONASS (Russia). The GNSS of LiAir X3C-H includes the aviation GNSS antenna and the base station antenna.

2. Inertial Measurement Unit (IMU)

Inertia measurement unit, or IMU, consists of a high-accuracy three-axis gyroscope and a high-accuracy three-axis accelerometer. It is the benchmark center of the LiDAR system. Its role is to get the position and orientation information without external reference data.

The LiAir X3C-H integrates a 3-axis MEMS (Micro-Electro-Mechanical System) gyroscope, 3-axis MEMS accelerometer and dual GNSS/BD receivers into one system, the POS system. Together the POS system components gather multi-reference parameters that provide accurate, effective and reliable by optimization algorithm of integrated navigation system.

3. Inertial Navigation Accuracy

System Accuracy (post-processing)	Azimuth	0.038° (1 σ)
	Attitude	0.008° (1 σ)
Data frequency	200Hz	

2.3.3 Storage and Control Unit

Main functions:

1. To receive control information from ground station and accurately send the commands to the corresponding sensors.
2. To control and coordinate the normal operation of all sensors.
3. LiDAR data, inertial navigation data, photos and Log information are stored in the system's memory card.

2.3.4 Camera

The main parameters of the built-in camera are listed below:

Sensor	APS-C
Lens	16mm fixed focal length lens
Effective pixels	26 MP
Pixel size	3.76 μ m
Image size	6252*4168

DFOV	83°
------	-----

2.3.5 GNSS ground station

The GNSS ground (base) station is mainly used to observe the same point for a long time to reach a high single-point accuracy as a differential reference for the UAV mobile station. A GPS ground station is composed of a GPS antenna, a GPS receiver and a power supply.

3 Package List



- ① LiAir X3C-H LiDAR System×1 ② USB cable×1 ③ GNSS antenna assembly×1 ④ GNSS antenna×2 ⑤ 256G TF card × 1 ⑥ Card reader × 1
⑦ USB flash drive × 1 ⑧ Tool × 1 ⑨ Document × 1

Note: The actual package list may vary depending on delivery

4 Data Acquisition

4.1 Base Station Setup

1. Select an open area for positioning

Place the GNSS antenna at an open area in order to ensure the antenna can get access to the GNSS satellites as many as possible. Apart from this, the placement spot of the GNSS antenna should be stable and far away from the electromagnetic interference.

- Open areas refer to those places which are not covered by high objects. The maximum elevation mask angle of surrounding objects should be less than 15°.
- The source of strong electromagnetic interference might be cellular base station, high voltage transmission lines, or objects with high reflectance (e.g., mirror, large water body) which may cause the multipath propagation.

2. Set up base station

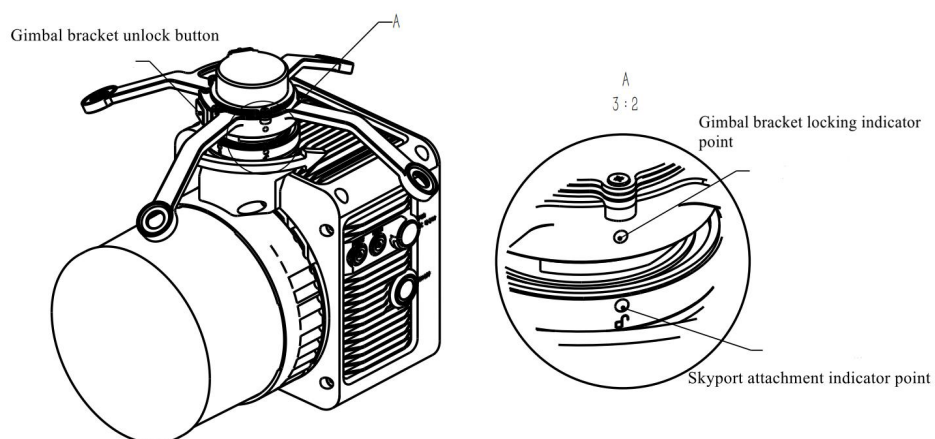
Set up the base station on the selected base station point. For surveying and mapping projects or other projects with high precision requirements, a tripod should be erected in accordance with specifications, and the base station should be erected on the tripod.

Please refer to the LiBase user manual for more specific operation process.

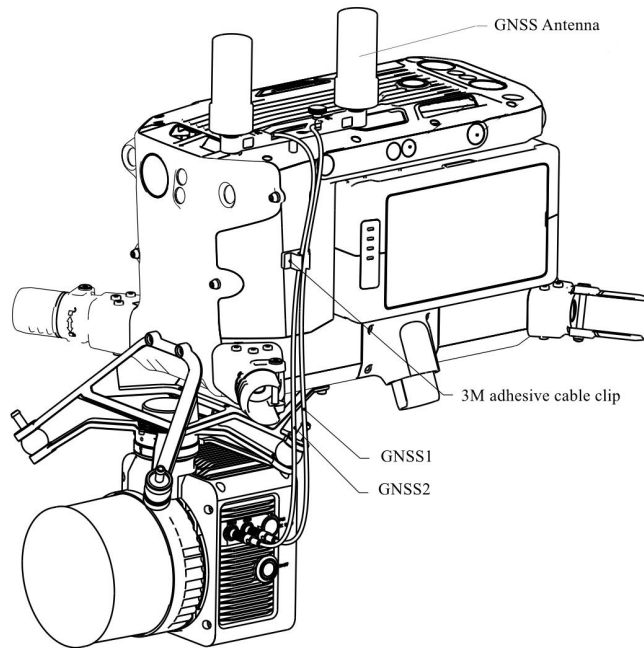
Note: The base station needs to start collecting data 15 minutes before the flight operation, and stop collecting data 15 minutes after the operation ends.

4.2 Installation

1. Mount the device to the M300 UAV after checking that the shock absorbing ball is not broken.



2. Install the GNSS antenna assembly with GNSS1 connected to the rear antenna and GNSS2 to the front antenna. (The flight direction is specified as Forward)



3. Confirm that the TF card has sufficient free space, insert it into the device, and remove the laser and camera protection covers.
4. Turn on the remote controller and power on the UAV.
5. Press and hold the ON/OFF button of the device for more than 3 seconds to turn it on.

Check the indicator status: flashing red quickly indicates the system powered on and initializing; and solid green indicates the system initialization has been completed and the device works normally. Please refer to [Descriptions of System Indicators](#) for more specific descriptions of indicators.

4.3 Parameters Settings

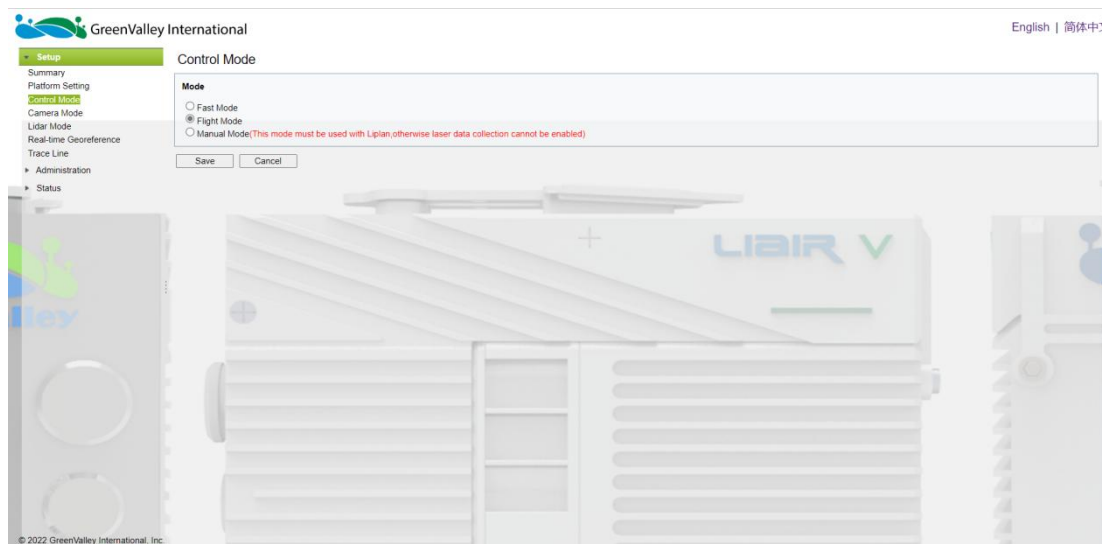
LiAir X3C-H will remember the parameters last set and you can skip this step if no modification is required. LiAir X3C-H mainly contains laser parameters, camera parameters and etc. The parameters can be modified by either logging into the Web client of the device.

1. Login Web page

- a) Establish the communication between the device and a computer or smart phone via WiFi network. After the device is powered on, search for the wireless network with the name LiAir_XXXXXX, click “Connect” and enter the password 66666666.



- b) Enter `http://192.168.1.88` in browser to open the LiAir X3C-H Web Configuration page (username: root; password: 888888). Click “System Settings” to set the device parameters.



Note: we recommend to use Google Chrome or IE11.

2. Parameter Settings

a) Control modes

This section can be used to configure laser and camera data acquisition modes.

LiAir X3C-H has the following control modes available for data acquisition.

Flight Mode: This mode is the ex-factory default setting. In this mode, when the device is stationary on the ground, the device does not collect LiDAR and camera data, and automatically starts LiDAR and camera data collection after the drone takes off into the air, and automatically stops LiDAR and camera data collection when the drone is landed.

Fast Mode: Click the power (ON/OFF) button, create new project, and synchronize the collection of both IMU data and LIDAR data simultaneously.

Manual mode: In this mode, the device automatically starts lidar and camera data collection when it reaches the first waypoint, and automatically stops data collection when it reaches the last waypoint.

Note: the Manual mode must be used with GreenValley APP, otherwise it will be impossible to activate the laser and camera data acquisition.

b) Camera modes

Camera On/Off: To enable or disable the camera

Trigger mode: Periodic mode, used to trigger the photo shooting at the preset fixed time interval (rang: 1-50s, 2s by default). Distance mode, used to trigger the photo shooting at the preset fixed interval of distance (10m by default).

Configuration: To set the interval of time or distance.

4.4 Data Acquisition

1. Power on the drone, press and hold the ON/OFF button of the system for at least 3 seconds to turn it on, and wait for the indicator light to be solid green, which means the system is in a normal state.
2. Short press the ON/OFF button for 0-2 seconds after the system indicator light is normal, the indicator light flashing in green (1 time/s), which means the project is created and the IMU data recording starts.
3. After take-off, the laser scanner and camera will start collecting data automatically.
4. After completing the flight routes and landing, the data collection of the laser and camera will automatically stop.
5. Short press the ON/OFF button for 0~2 seconds to stop the IMU data recording and finish the project, then the indicator light will be solid green again.
6. Press and hold the ON/OFF button for at least 3 seconds, the indicator light will turn off and the system will be powered off.
7. Power off the drone.

Note: In order to improve the accuracy of inertial navigation data, it is recommended to fly a figure-8 after takeoff and before landing.

5 Data Download

5.1 X3C-H data download

All data of LiAir X3C-H will be stored in the TF card, including project files, camera images, LiDAR data, IMU data and log files. Insert the TF card into the computer and copy the project files to the computer (folders that are not suffixed with _NAV).

5.2 Base station data download

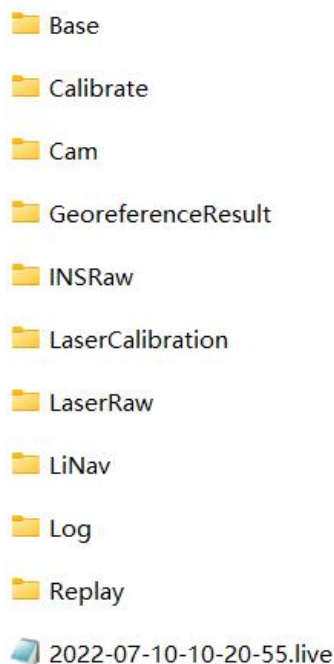
Please refer to the LiBase user manual to download base station data.

6 Data Georeferencing

LiGeoreference is a LiDAR point cloud georeferencing software developed by GreenValley which allows users to merge range measurements collected by mobile, UAV or airborne laser scanning systems with position and orientation information recorded by integrated IMU and GNSS sensors. Point clouds can also be attributed with RGB imagery using LiGeoreference's data fusion capabilities to produce a true-color 3D model of an object or area surveyed. LiGeoreference is now available as a stand-alone application with a helpful graphical user interface as well as a command-line interface for scripting and easy integration with third party software. In this article, the main purpose to produce this chapter is to show the data post-processing procedure resolved by LiGeoreference.

Note: For more information, introduction of assembling LIDAR system together with Drones is detailed in LiGeoreference User Handbook section.

6.1 Project Folder Structure



Project folder is named with UTC Time, including:

- **Base folder** is used to store the ground GPS base station data.
- **Calibrate folder** is used to store calibrated files (*.cal). Please notice that: do not remove or delete this folder, otherwise, the performance of georeferencing will fail.
- **Cam folder** is used to store camera images and the information of exposure time, location, and attitude angles of each image (.cam).
- **GeoreferenceResult folder** is used to store the post-processed point cloud data calculated by the LiGeoreference software.
- **INSRaw folder** is used to store the raw IMU data (*.rgps,*.rimu,*.rnav).
- **LaserCalibration folder** is used to store the calibrated file of LiDAR (*.csv) but only available to partial series like LiAir 200 and LiAir 220.
- **LaserRaw folder** is used to store the raw data of laser scanner's point cloud (*.vpts).

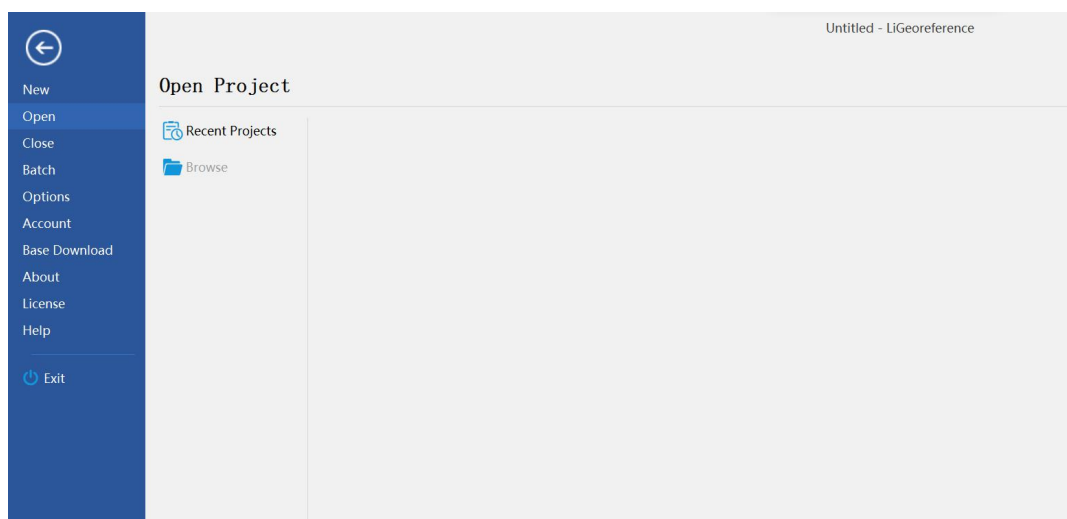
Note: **.vpts is the default format developed by GVI.*

- **LiNav folder** is used to store the intermediate file when processing the data of integrated navigation system. What's more, the final-georeferencing results of POS data is suitable to be stored as well.
- **Log folder** is used to store the log information of the project showing detailed operation process.
- **Replay folder** is used to store the replay file of recorded trajectory and point cloud data, but only available to the specified device which supports real time display.
- ***.Live (project file)** is used to record the information of project organization,

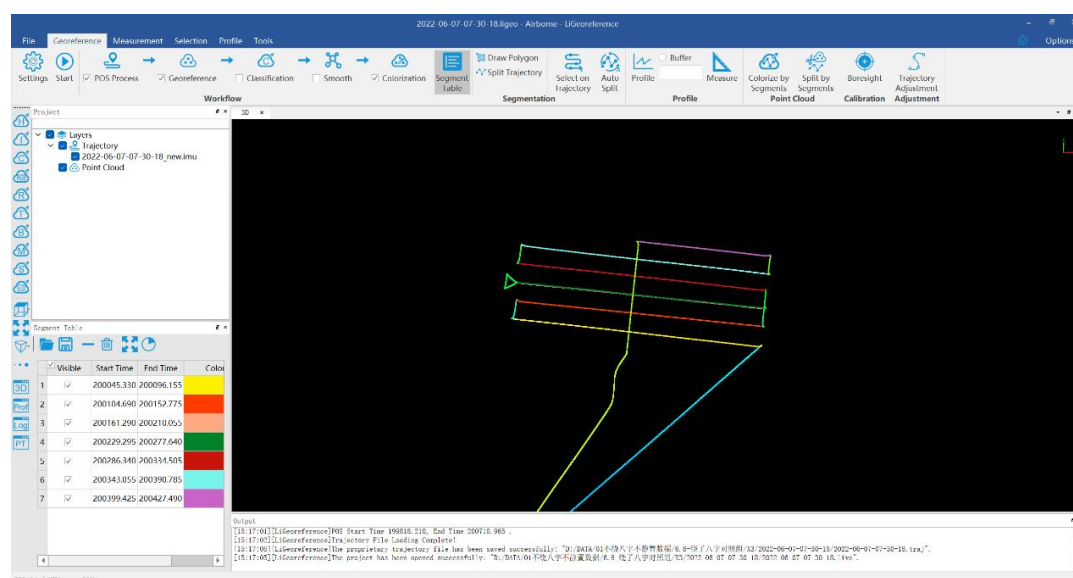
configuration values, etc.

6.2 Open Project

1. Open LiGeoreference software, Click “File” icon on the toolbar to open LiGeoreference project file (.live) through “Browse” icon.

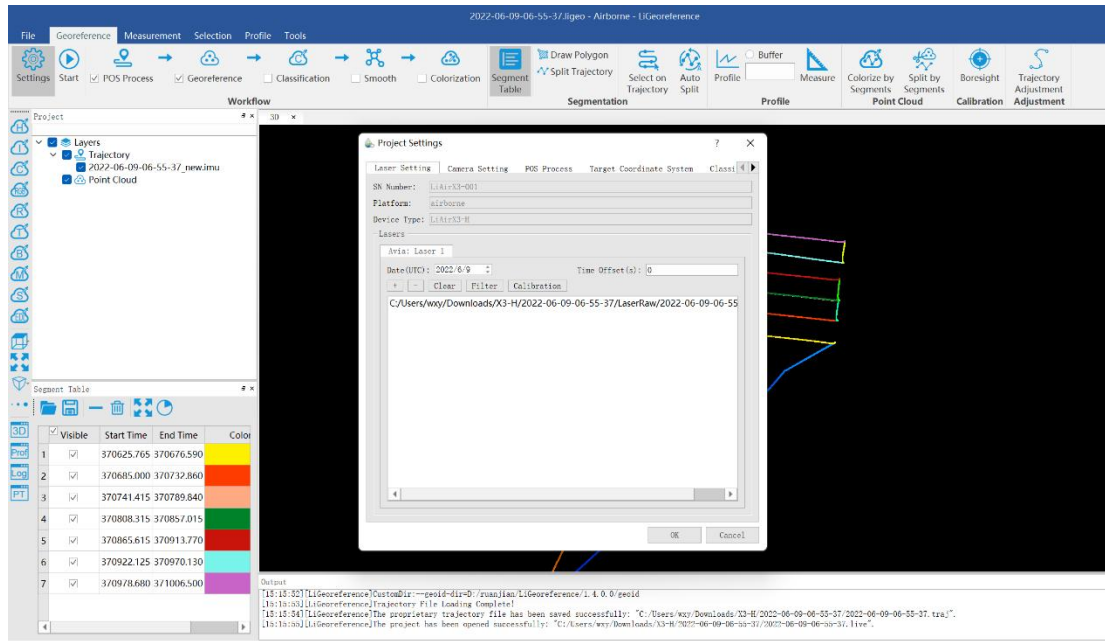


2. Users can also open the project file via “Recent Projects” icon which refers to history project opened before.
3. After opening the project, the georeferencing tool will automatic import the IMU file.



6.3 Select and Configure Parameters

Before undertaking post-processing procedure, users can use the "Settings" function to set the calculation parameters, including laser settings, camera settings, pos process, target coordinate system, classification, and smooth settings. Normally, users only need to set pos process settings.



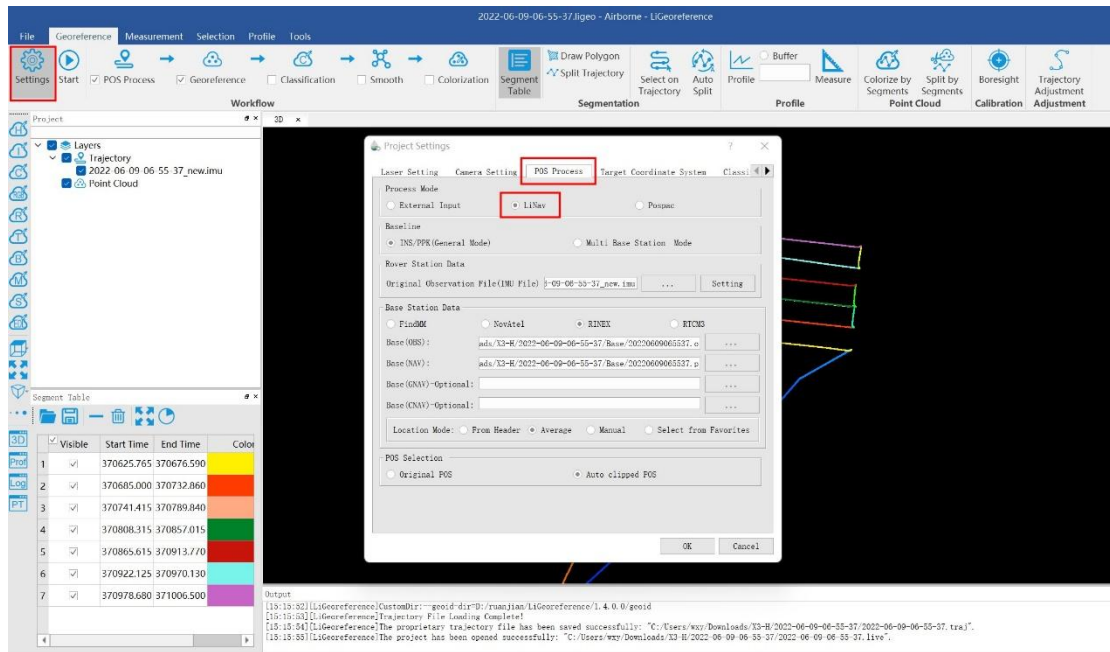
6.3.1 POS Processing Settings

LiGeoreference software has pos calculation and point cloud calculation functions. Users could directly use LiGeoreference software to calculate LiAir X3C-H's trajectory, or choose to use other third-party software to perform pos processing procedure.

1. Using LiGeoreference to Perform POS Processing

Click the "POS Process" button in the setting interface.

- (1) Select LiNav processing mode



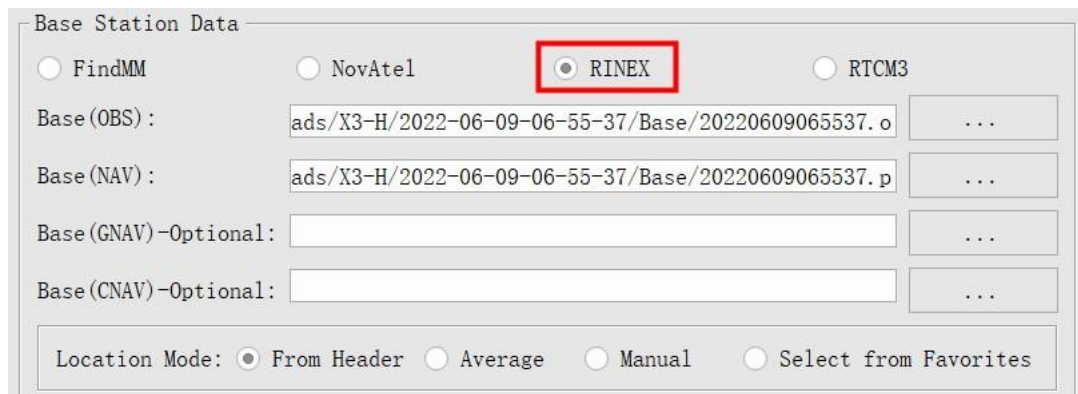
(2) Select the processing mode according to the length of the trajectory. It is recommended to use the general mode. When the length of the trajectory is more than 10 km, the long baseline mode can be selected.

(3) Load rover station data, under normal circumstances, the software will automatically read the rover station data under the project folder.

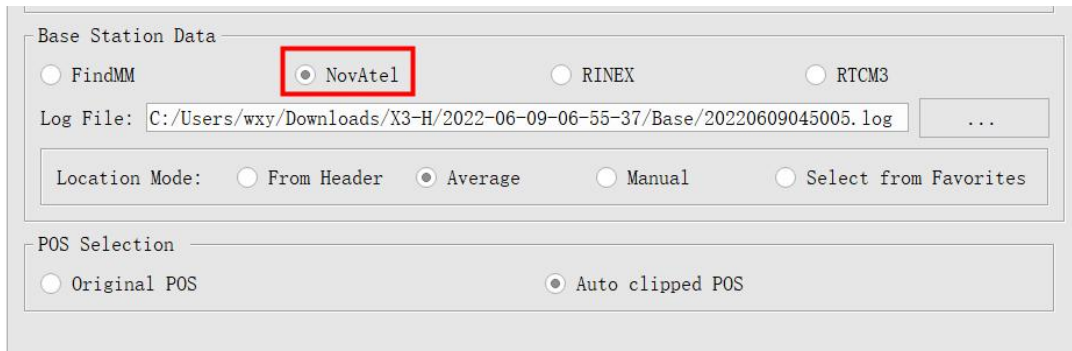
(4) Select base station data

Under normal circumstances, the software will automatically read the base station data in the project folder, or manually load the base station data.

If the format of the local base station is the Rinex format, select the Rinex option to load the base station data.



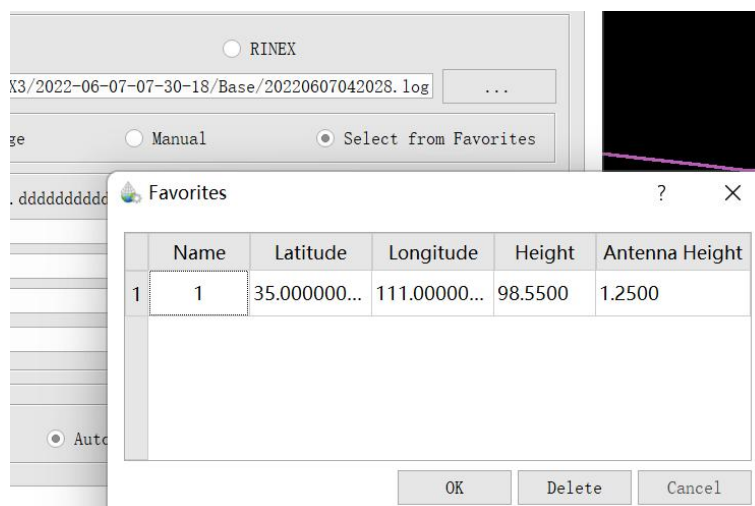
If the local base station format is Log format, select the NovAtel option.



The screenshot shows a dialog box titled "Base Station Data". It contains three radio buttons: "FindMM", "NovAtel" (which is selected and highlighted with a red box), and "RINEX". To the right of "RINEX" is another radio button labeled "RTCM3". Below these is a "Log File" field with the text "C:/Users/wxy/Downloads/X3-H/2022-06-09-06-55-37/Base/20220609045005.log" and a browse button "...". Underneath is a "Location Mode:" section with four radio buttons: "From Header", "Average" (selected), "Manual", and "Select from Favorites". At the bottom is a "POS Selection" section with two radio buttons: "Original POS" and "Auto clipped POS" (selected).

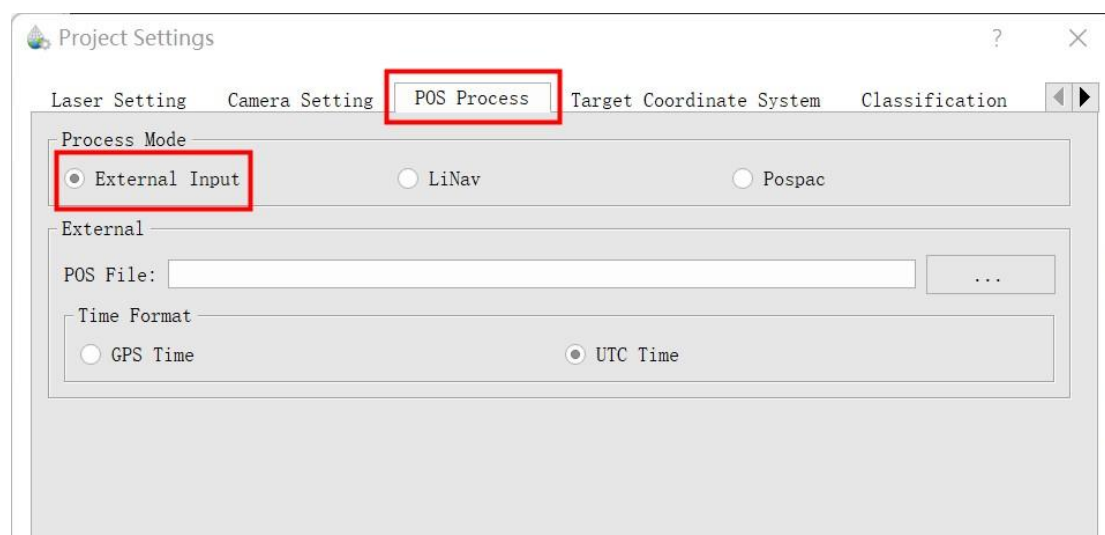
(5) Enter the Base Station Coordinates

- When there is no precise base station coordinate, users could select "Average" mode. And the positioning principle is single point positioning, which leads to meter-level errors between the point cloud coordinates calculated by this method and the true coordinates.
- When there are accurate base station coordinates, users could manually input the base station coordinates. Additionally, users could use "Save to Favorites" function to save the entered base station coordinates, and later can directly use the saved base station coordinates through "Select from Favorites".
- Analyze from the data header: some base station files and base station coordinates are stored in the header file. "From Header" option needs to be clicked when users want to use this function. For example, Cloud Trajectory base station is normally stored in this mode.
- Select from favorites: Users could select the base station coordinates stored in the software.

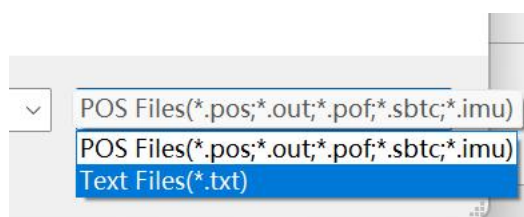


2. Import External IMU or Existing POS Data

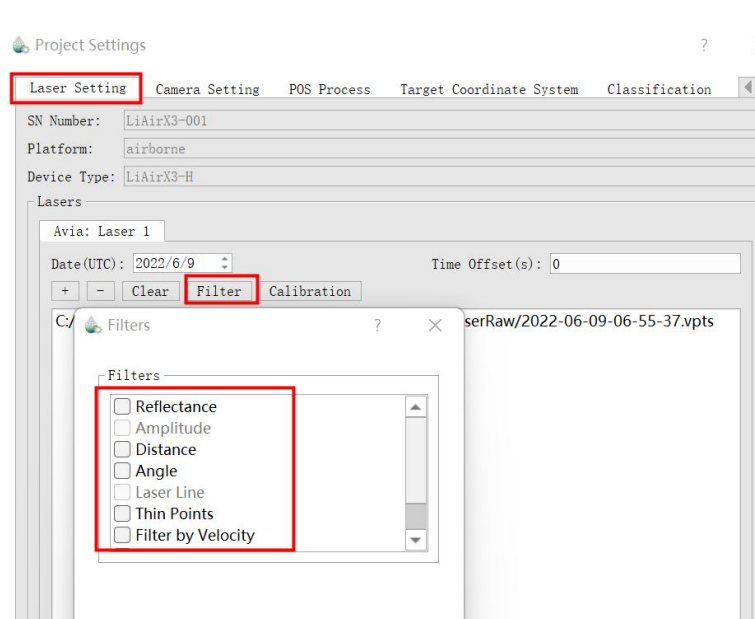
Select "External Input" under Process Mode to import pos data.



The external input function supports importing the original IMU data and the processed POS data, and the specific format includes *.pos, *.out, *.pof, *.sbtc, *.imu.



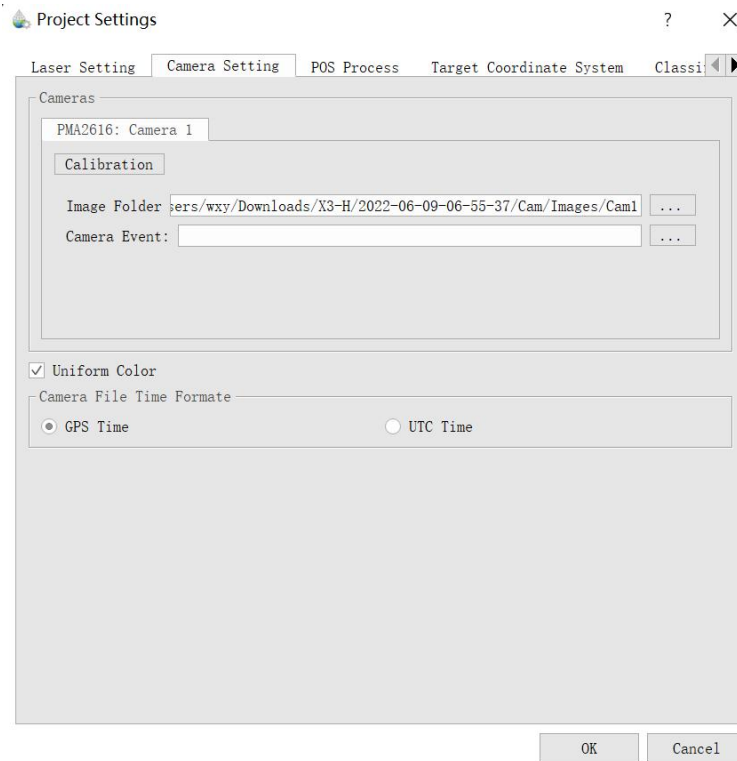
6.3.2 Laser Scanner Settings



Normally, the user does not need to change the parameters of the laser setting interface. If users want to limit the output power range by reflectivity, distance and scanning angle, users could change the range via clicking "Filter" to set the parameters. For more details, please visit [LiGeoreference users guide](#).

6.3.3 Camera Settings

Normally, users do not need to change the parameters of the camera setting interface.



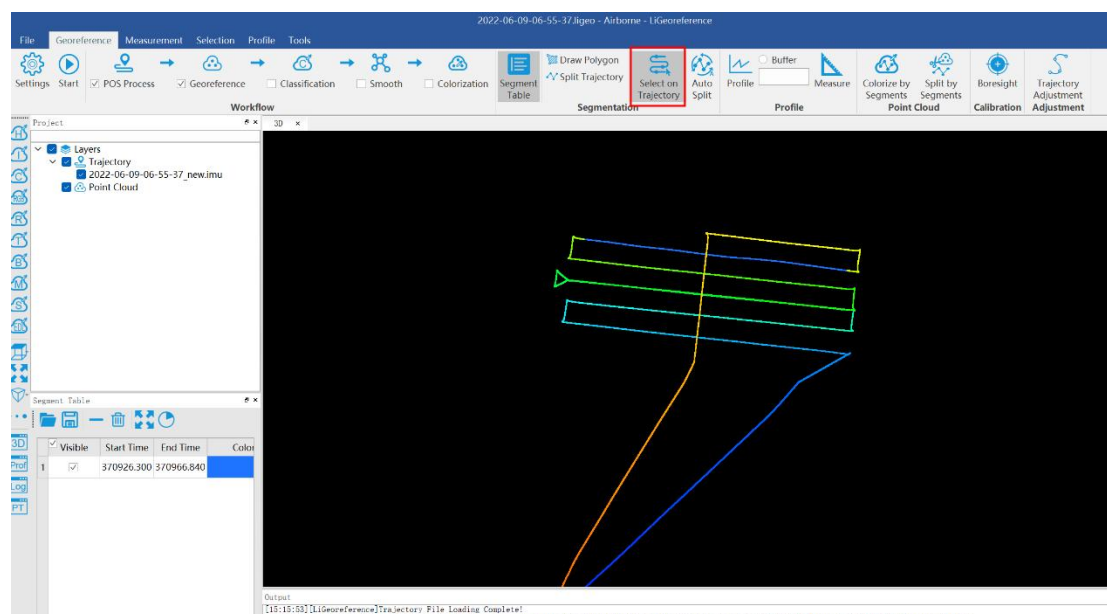
Uniform Color Function: sometimes the shooting is affected by the light and the uniform color function will make the light and dark more uniform, but will blur the color slightly.

6.4 Georeferencing Point Cloud Data

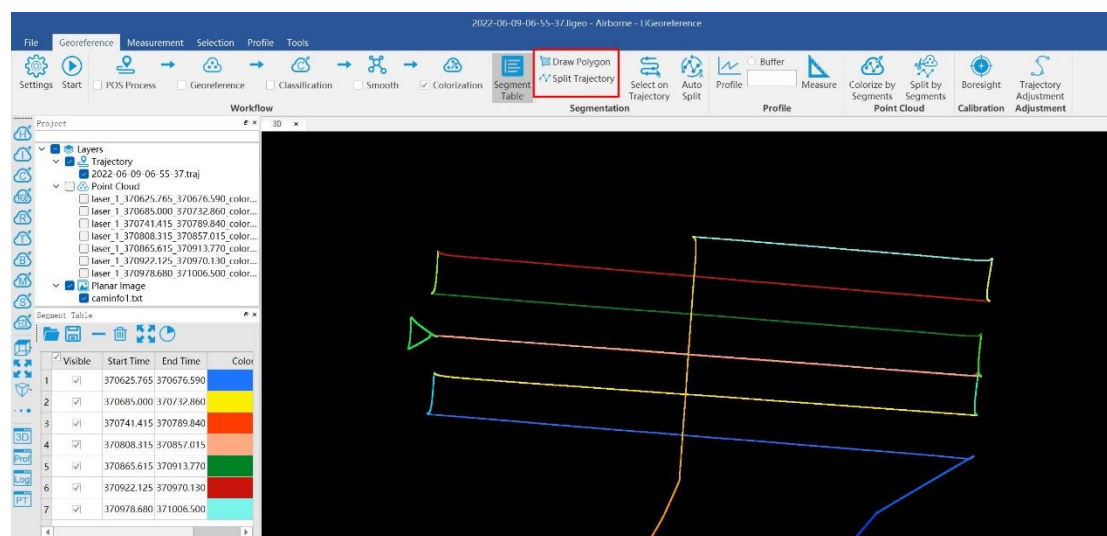
1. Select Georeference Range

Users could select the range to be georeferenced as needed. And there are two modes to be selected, including "trajectory selection" or "draw polygon". And this document only introduces the operation process of using the "trajectory selection" tool. The way of "drawing polygon" could be found in the user manual of LiGeoreference software.

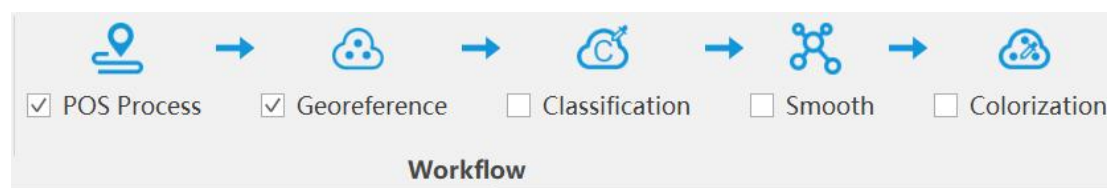
(1) Click the "Select On Trajectory" button on the main interface of the software, and a table will automatically pop up at the same time, select the trajectory which needs to be georeferenced, and click OK.



(2) If needed to select multiple trajectories, then repeat the above operation, and the selected trajectory segments will be displayed in the cutting table at the lower left corner.



2. Select Processing Module

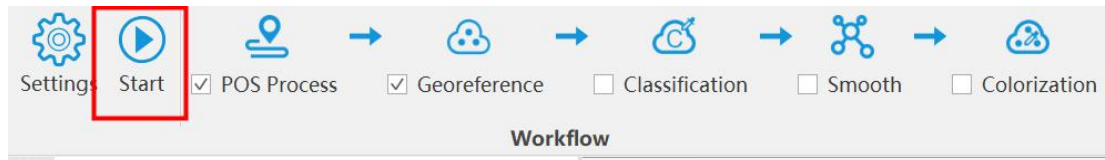


After opening the project, LiGeoreference will select “POS Process” and “Georeference” module by default. Users could check and re-choose the function modules as needed.

Note: If there is no image data, please do not choose "Colorization" module, otherwise the program will prompt an error.

3. Data Georeferencing

Click "Start" button to start data calculation. After the calculation is completed, the point cloud is automatically displayed in the main window.

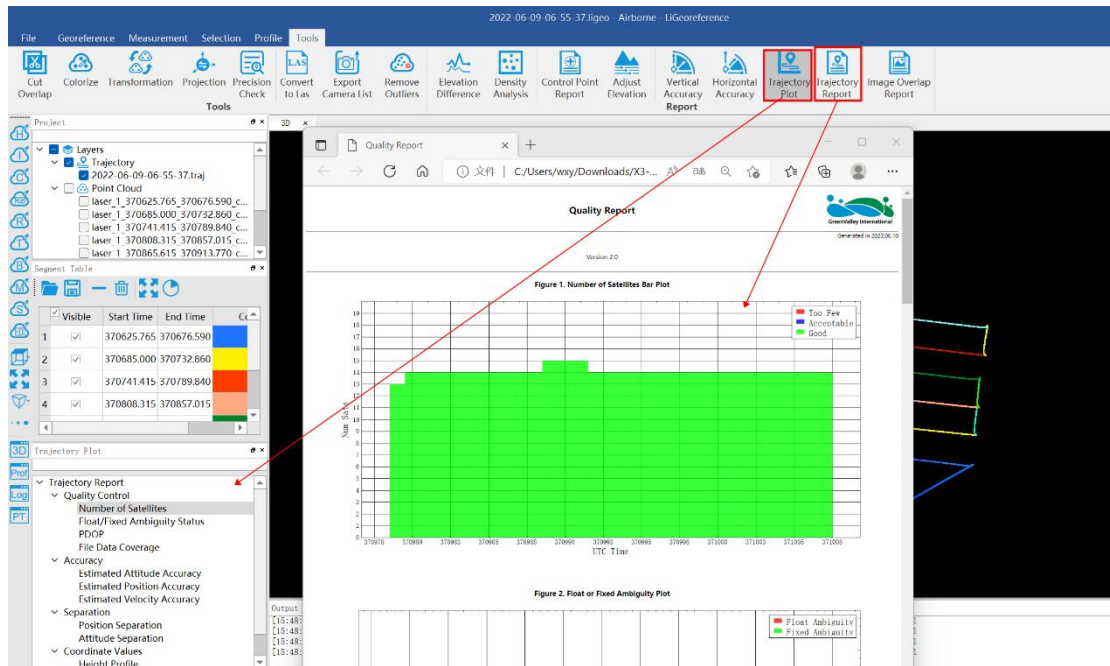


4. Data Quality Assessment Reports

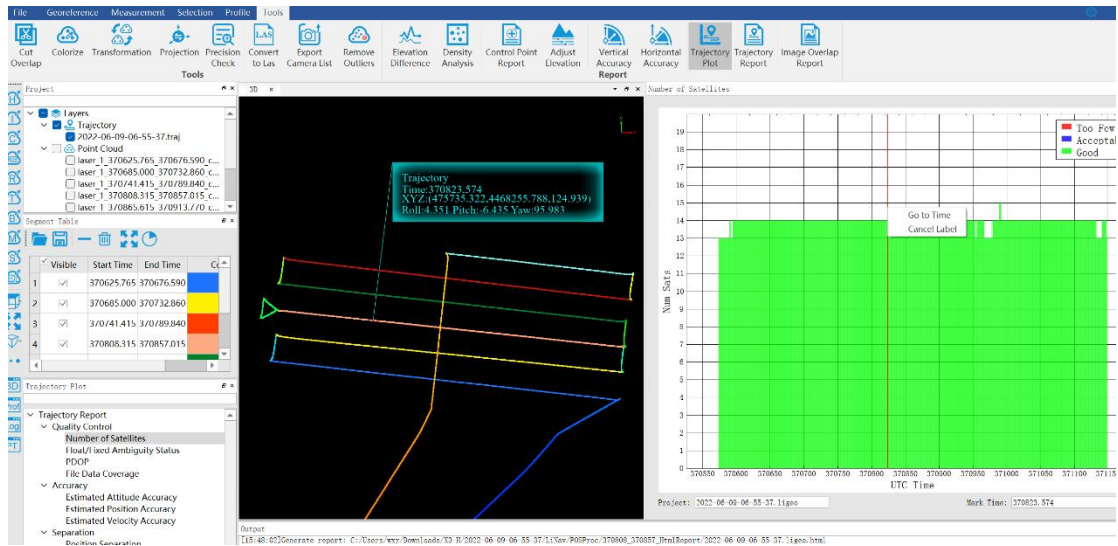
If the user needs to view the "Trajectory Report" and the "Image Overlap Report", click the "Trajectory Plot" (or "Trajectory Report") or "Image Overlap Report" (only suitable for devices with cameras) under the "Tools" bar.

a) POS Trajectory Report

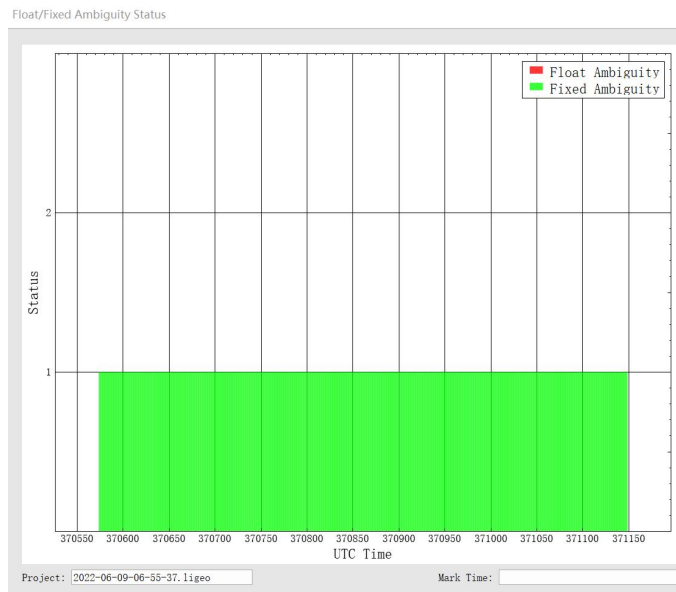
There are 11 POS accuracy evaluation criteria included in the software. Usually, the number of satellites, data coverage, estimated attitude accuracy, estimated position accuracy and PDOP value are mainly checked during data quality inspection. Users can click the evaluation index of a certain plot, or directly click "Trajectory Report" to generate a complete track accuracy report.



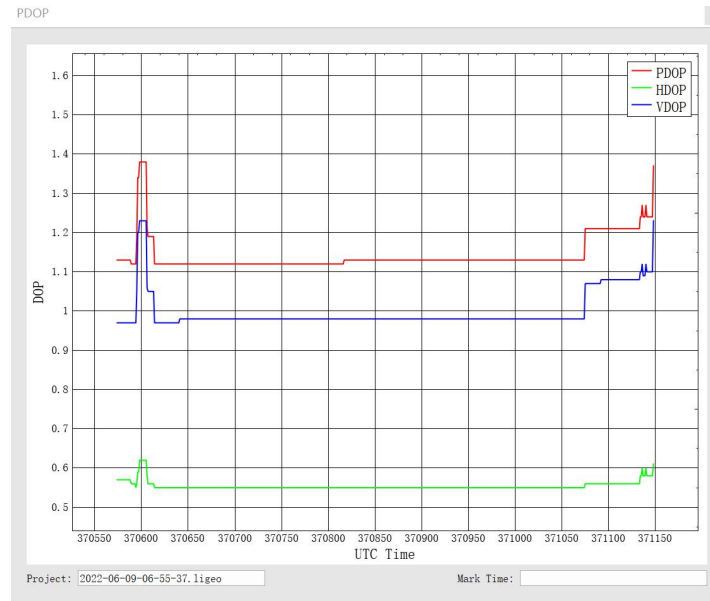
Satellites Number: Click to open the plot to show the relation between number of satellites, which can be reached, and the GPS time. This tool is used to show the number of satellites can be reached by the device each time during the data acquisition. Satellites number is shown on the Y-axis. The green part on the plot means the number of satellites is good at that time. The blue part on the plot means the number of satellites is just acceptable at that time. While the red part means the satellite number is too few to meet the requirement. The insufficient GNSS signal will result in poor data quality. If the number of satellites can be reached by the device is too few during a period of data acquisition, user can select the time period and right-click on that. Then click “Go to Time” button to find out the corresponding period on the trajectory.



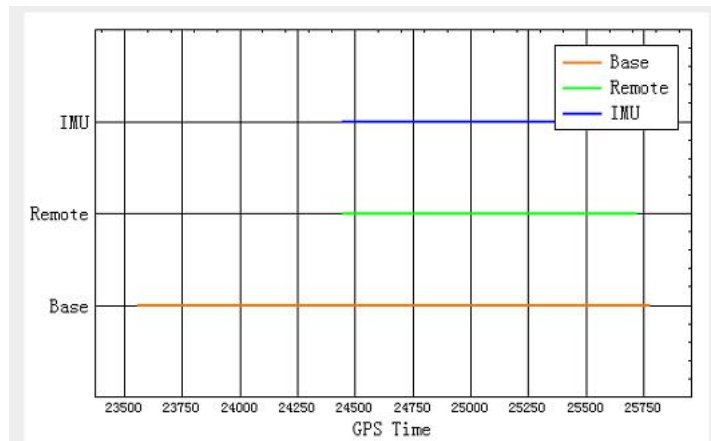
Floating/Fixed ambiguity status: Click to show the plot of ambiguity resolution status. This is used to show the situation of cycle ambiguity resolution. If the status is shown as green on the plot, it means the cycle ambiguity resolution is fixed. If it is red on the plot, it means the cycle ambiguity resolution is floating.



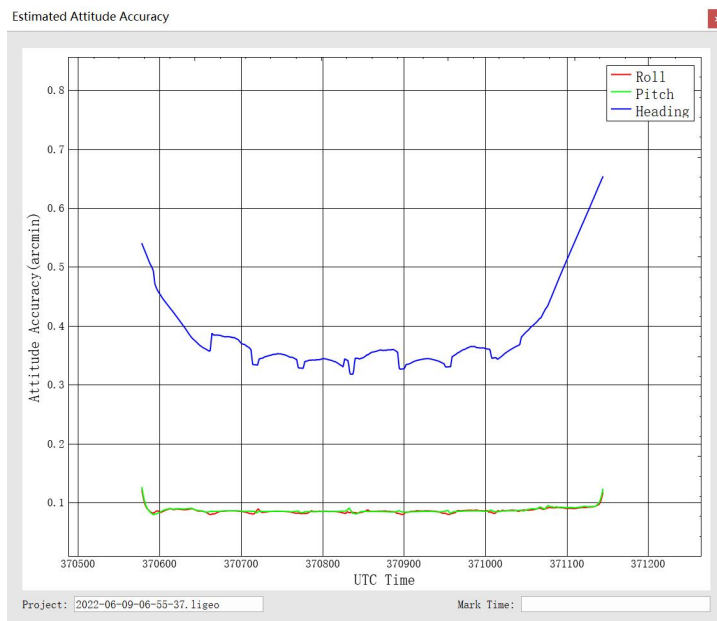
PDOP: Position dilution of precision, or PDOP, shows the distribution of the GNSS satellites. Click to show the plot of PDOP. The smaller PDOP is, the better the distribution is.



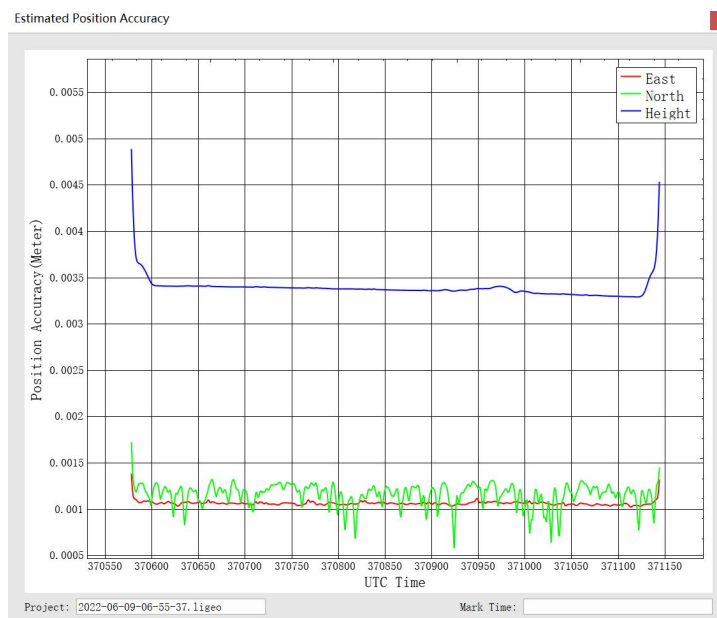
File Data Coverage: Click to show the plot of data coverage situation. This is used to show the data coverage relation among base station data, IMU data, and GNSS data of the moving device.



Estimated Attitude Accuracy: Click to show the plot of attitude accuracy. This plot is used to show that if the accuracy exceeds the limitation of the IMU accuracy. The X-axis shows the GPS time. The Y-axis shows the attitude accuracy. Red line is for changes in Roll direction. Green line shows the changes in Pitch direction. While the blue line shows the changes in the heading direction.

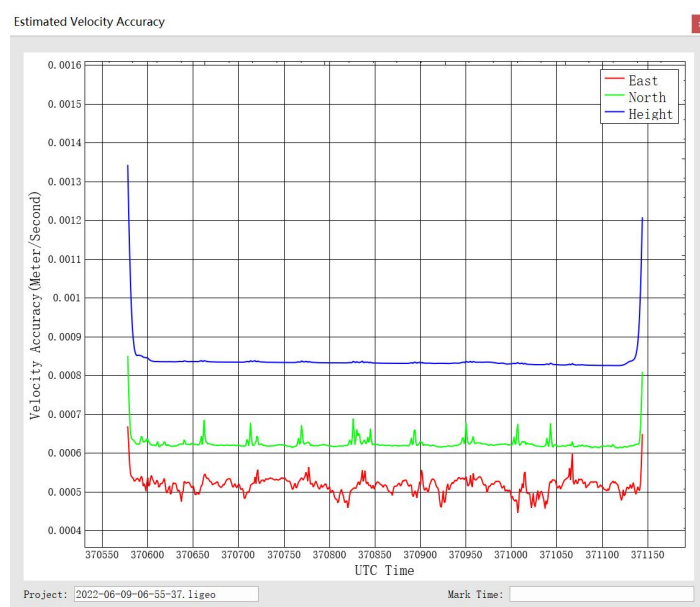


Estimated Position Accuracy: Click to plot the position accuracy. The X-axis shows the GPS time. The Y-axis shows the position accuracy. Red line is for position accuracy in East direction. Green line shows the position accuracy in North direction. While the blue line shows the position accuracy in height direction.

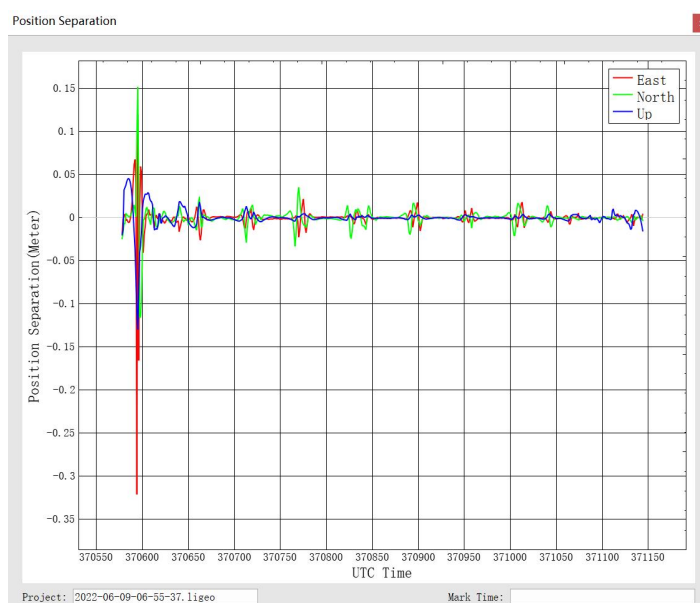


Estimated Velocity Accuracy: Click to plot the velocity accuracy. The X-axis shows the GPS time. The Y-axis shows the velocity accuracy. Red line is for velocity

accuracy in East direction. Green line shows the velocity accuracy in North direction. While the blue line shows the position velocity in height direction.

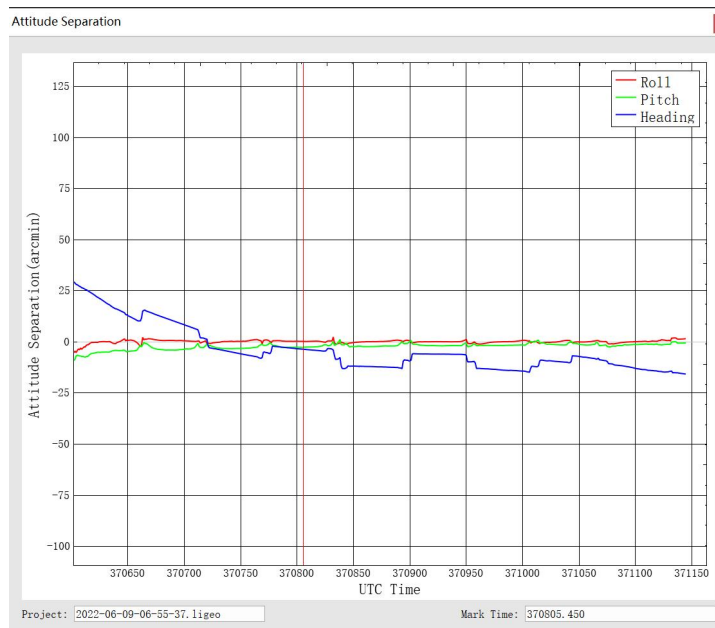


Position Separation: Click to plot the position separation. This plot shows the differences of position in East, North, and Up directions during the forward-backward processing.

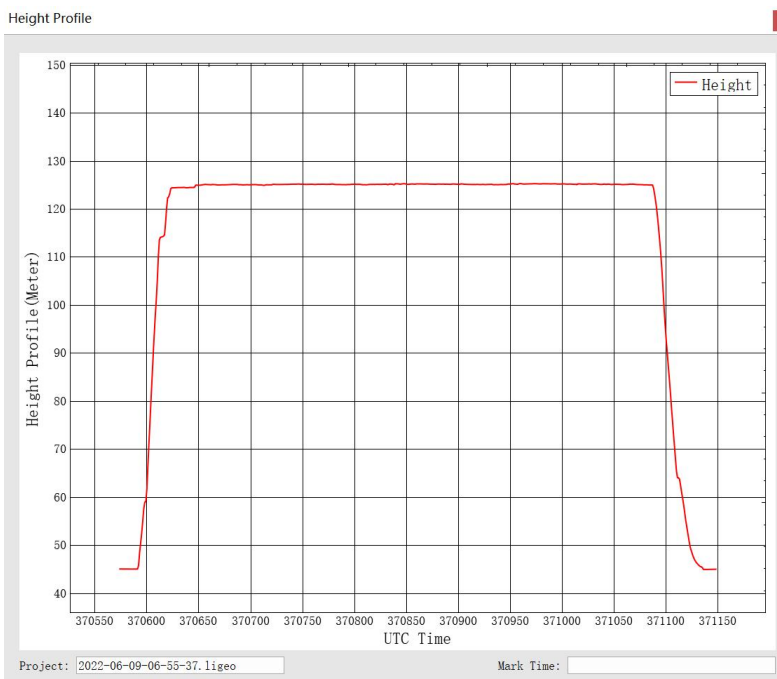


Attitude Separation: Click to show the plot of attitude separation. This plot is used to show the difference among the angles in Roll, Heading, and Pitch directions during the forward-backward processing. The smaller the value is, the

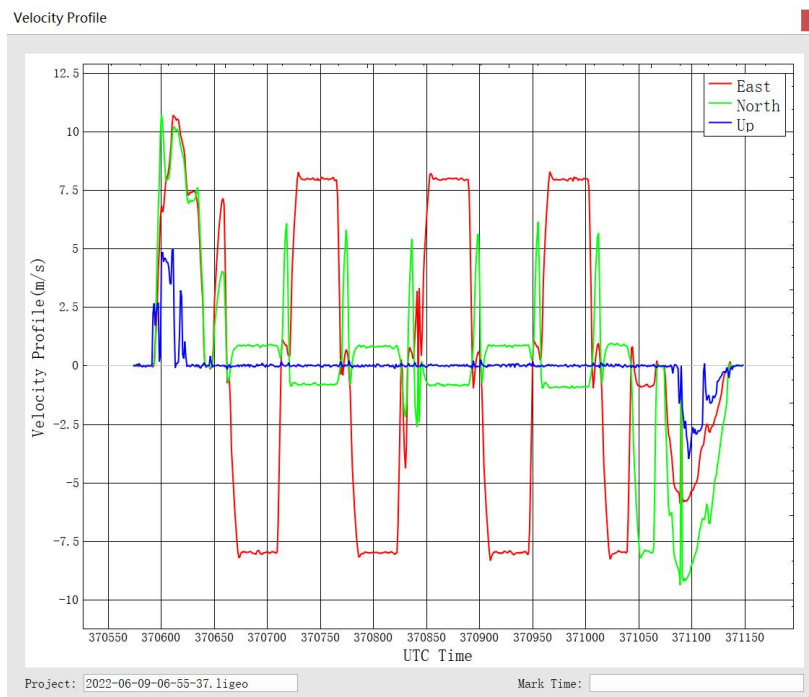
better the matching degree of the forward-backward processing is.



Height Profile: This plot shows the changes in height during the data acquisition.



Velocity Profile: This plot shows the changes in velocity during the data acquisition. Red line is for the changes in East direction. Green shows the changes in North direction. While the blue line shows the changes in up direction to the ground.



b) Image Overlap Report

The image overlap report lists the image overlap. The report could check whether the photos are lost.

The image shows a "CamReport" dialog box. It has a "PointCloud" checkbox which is unchecked. Below it is a table with a "Select" column and a "File Name" column. All items in the "Select" column are checked. Below the table is a "Height" checkbox which is checked, followed by a text input field containing "80" and the unit "Meter". At the bottom right are "OK" and "Cancel" buttons.

Select	File Name
<input checked="" type="checkbox"/>	laser_1_370625.765_370676.590_color.LiData
<input checked="" type="checkbox"/>	laser_1_370685.000_370732.860_color.LiData
<input checked="" type="checkbox"/>	laser_1_370741.415_370789.840_color.LiData
<input checked="" type="checkbox"/>	laser_1_370808.315_370857.015_color.LiData
<input checked="" type="checkbox"/>	laser_1_370865.615_370913.770_color.LiData
<input checked="" type="checkbox"/>	laser_1_370922.125_370970.130_color.LiData
<input checked="" type="checkbox"/>	laser_1_370978.680_371006.500_color.LiData

7 System Transportation and Maintenance

7.1 Operation Notice

To ensure the reliable use of the system and the safety of the operation personnel, please observe the following notices during installation, use and maintenance.

1. Pay attention to the protection of the scanning lens to prevent scratches.
2. Handle with care during installation to prevent the system from falling or being impacted.
3. Before scanning, please make sure the scanning lens is clean and dust-free.
4. Avoid sudden changes in temperature to prevent damage to the system.
5. During the operation, it is forbidden to directly contact the laser scanning lens with any part of the body.
6. If the system needs to be transported, it must be stored within appropriate packages.
7. The operating temperature of the system is $-20^{\circ}\text{C}\sim 50^{\circ}\text{C}$. In case of rain, snow, fog, sand and other bad weather, the operation should be stopped. It can prevent equipment damage and on the other hand, it can ensure the measurement accuracy. In case of sudden bad weather during work, please move the device to a safe place in time.

8. Please pinch both ends of the connector when pulling out the communication cable, and prohibit violent insertion and removal.
9. Non-professionals, without permission, please do not try to disassemble the equipment, do not repair it without permission, so as to avoid accidents or aggravate the damage of the equipment. If the equipment is modified or disassembled not authorized by GreenValley International Inc., the warranty will be void.

7.2 Equipment Maintenance

1. Before turning on the device, check whether the scanner lens is clean, if there are any stains, it should be cleaned immediately.
2. After the equipment is used, check whether the scanning window of the scanner is dirty. If it is dirty, it should be cleaned up immediately.
3. Regular cleaning: Use special lens paper to gently wipe the laser scanning lens, and wipe from the inside to the outside in a circular manner.
4. The storage temperature range of LiAir system is $-30^{\circ}\text{C} \sim +60^{\circ}\text{C}$, and the storage environment requires ventilation and dryness.
5. Make sure that all power is turned off before storage, and the equipment is stored in an appropriate box.
6. If the storage time is more than one month, the power-on test should be carried out.

7. During the transportation of LiAir equipment, the packing box equipped at the factory should be used.
8. If it needs to be packed separately due to special circumstances, please ensure that the packing box has a certain pressure resistance, and label the outside of the box with signs such as "Precision Instrument", "Handle with Care", "Fragile", etc. to avoid equipment damage.
9. The instrument is a precision instrument, avoid violent impact during transportation and handling, and avoid damage to the optical components in the instrument or cause direction deviation.
10. During the warranty period, customers can enjoy free firmware update services. After the warranty period is expired, customers can purchase firmware update services.