



# LiDAR Mapping Systems

## Trajectory Processing with Inertial Explorer

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All the features, functionality, and other product specifications are subject to change without prior notice or obligation. Information contained herein is subject to change without notice.

Please read carefully and visit our [website](#) and [documentation](#) for further information and support.

**NOTE:** This manual provides a description and function of the base post-processing workflow for trajectory and LiDAR mapping calibration. The product you purchased may not support certain functions dedicated to specific models, upgrades or customizations.

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# 1. Inertial Explorer Trajectory Processing

Refining the position and orientation of the system through differential corrections and coupling of GNSS and IMU data will increase the accuracy of the data from LiDAR and other sensors.

## 1.1 Prepare Reference Station Data

- Some GNSS receivers, such as Leica and Stonex, produce raw files that can be opened natively in InertialExplorer. Raw data from other receivers, such as Trimble receivers, will need to be converted to a RINEX file format prior to processing in InertialExplorer.

### 1.1.2 Refining Reference Station Coordinates

- There are 3 viable options for refining reference station coordinates. These options are ranked from 1-Best to 3-Worst:

Option 1: Setup reference station over a previously surveyed or known coordinate

- Using an established project monument is the easiest way to tie into your project datum

Option 2: Use OPUS or similar gnss post-processing service, to post process your reference station coordinate. The most accurate OPUS solutions have an overall RMS less than 3 cm.

- Here is a list of some free GNSS online post-processing services:

[OPUS: U.S. National Geodetic Survey](#)

[AUSPOS: Geoscience Australia](#)

[Centerpoint RTX Post Processing: Trimble Navigation Limited](#)

[GAPS: University of New Brunswick](#)

[APPS: Jet Propulsion Laboratory](#)

[CSRS-PPP: Natural Resources Canada](#)

A comparison report of these processing services and detailed description of each service can be found [here](#).

Option 3: Utilize Precise Point Positioning (PPP) in IE to derive reference station coordinate

- PPP is a positioning technique that removes or models GNSS system errors to provide a high level of position accuracy from a single receiver. A PPP solution depends on GNSS satellite clock and orbit corrections, generated from a network of global reference stations. Once the corrections are

calculated, they are delivered to the end user via satellite or over the Internet. These corrections are used by the receiver, resulting in decimeter-level or better (up to 3cm) positioning with no base station required.

## 1.2 Project Wizard

Start Inertial Explorer and use the [project wizard](#) to input your data into the software

### 1.2.1 Rover Data

- [Input the ".nav" file as Remote \(Rover\) Data "GNSS Data File"](#)
  - The IMU data file path will automatically populate since the ".nav" file contains GNSS and IMU information.
- [Specify your Rover antennae\(s\) model and height](#)
  - For Phoenix LiDAR Systems' custom GNSS antenna select a "Generic" profile with a measured height of 0.00m, measured to L1 Phase Centre.

Project Wizard

**Remote (Rover) Antenna Height**  
Please enter remote GNSS antenna details. Click "Next" to continue

Remote file name:  
C:\Users\User\Documents\TRAINING\10172018-IE training\rover\2018082

Antenna Height

From station file: N/A View STA File

Antenna profile: Generic Info

Measured height: 0.000 m

ARP to L1 offset: 0.000 m

Applied height: 0.000 m

Measured to

ARP

L1 Phase Centre

Compute From Slant

Figure 3.2 PLS custom rover antenna settings

To accurately process the rover trajectory we need all baselines from the Base reference station measured to the rover GNSS Phase Center. Note that Antenna Reference Point (ARP) to phase center measurements vary by antenna model, and selecting an antenna profile applies a Phase Center Offset (PCO) for the selected antenna model.

The ARP to Phase Center offset for Phoenix LiDAR Systems custom GNSS antenna is **0.043m**, and has already been accounted for by the GNSS lever arms in SpatialExplorer during acquisition. See section [7](#) for more information on the difference between GNSS ARPs and phase centers.

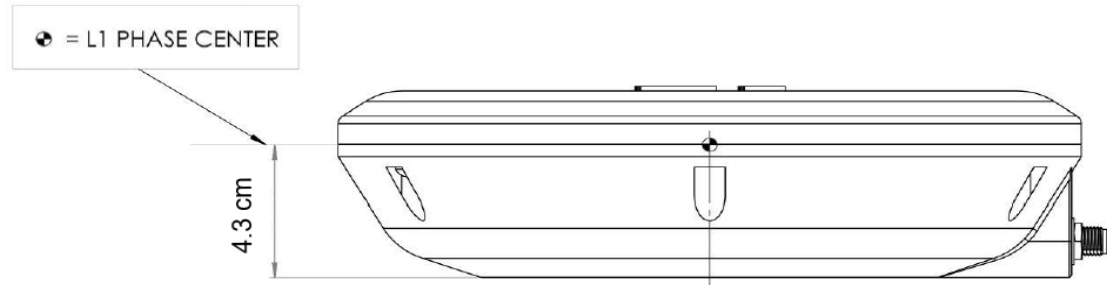


Figure 3.3 Phase center offset (PCO) for Phoenix LiDAR Antenna from ARP to L1 phase center

## 1.2.2 Base Station Data

- [Add the raw base station file\(s\)](#)
  - Edit the base station details (Very important!)
    - Specify the Antenna model, measured height, and if that height is referencing ARP or L1 Phase Center.
    - Input latitude, longitude, ellipsoidal height, datum and epoch based on the refined coordinates that were determined in section [3.2.1](#)

**NOTE:** Inertial Explorer will perform a 7 parameter coordinate transformation from your input datum to your processing datum, but will not account for a time dependent transformation between varying epochs. Therefore, you must input your initial reference station coordinate using the appropriate time-dependent coordinate that corresponds to the desired processing epoch.

### RESOURCES:

1) NOAA's tool for transforming positional coordinates across time and between spatial reference frames: <https://www.ngs.noaa.gov/cgi-bin/HTDP/htdp.prl>

2) NOAA's Horizontal Time-Dependent Positioning Toolbox:  
<https://www.ngs.noaa.gov/TOOLS/Htdp/Htdp.shtml>

- **OPTION:** Calculate the reference station coordinates using PPP at this stage only if there is not a better alternative (Coord. Options > compute from PPP) .
- **OPTION:** Add base stations from download
  - Publically available reference station can be utilized for projects without static data from a dedicated base

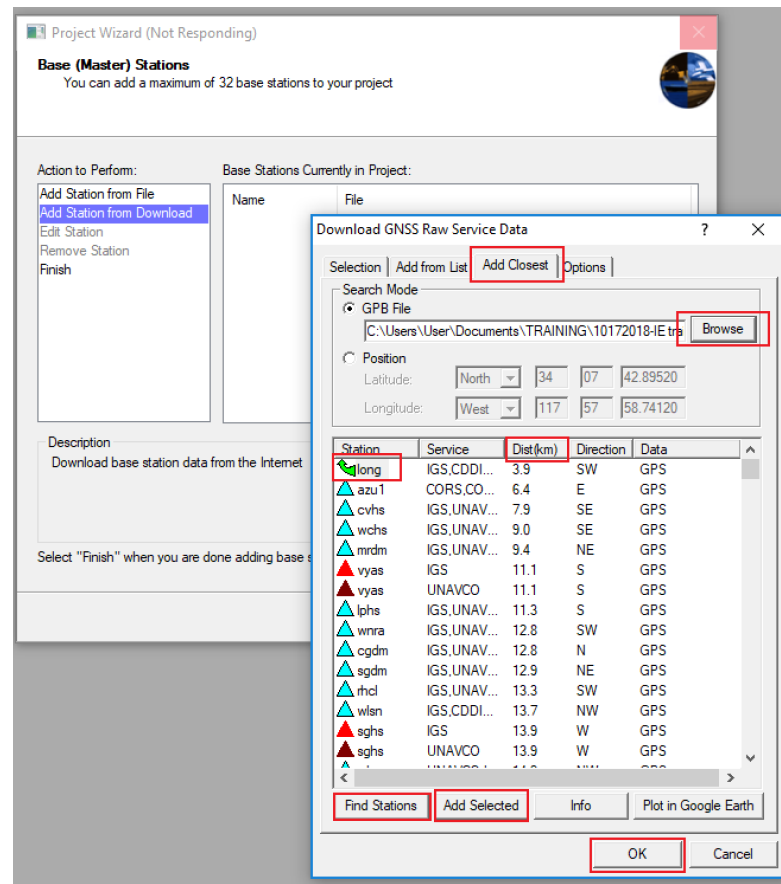


Figure 3.4 Download publicly available reference station data from within IE

If you are using CORS data, keep in mind that all coordinates from CORS sites are in NAD83 (2011) epoch 2010.000. If you are processing data using a CORS station, and your desired processing epoch is anything other than epoch 2010.000, you will need to transform the initial positional coordinate for the input reference station

**NOTE:** As your baseline increases, accuracy decreases. Due to the nature of RTK/PPK, accuracy degrades linearly at a rate of 1 mm for each km between the base and rover. For this reason, the best trajectory results are produced when using a base station located on site.

## 1.3 Process GNSS

- Once finished with the Project Wizard, 'Process GNSS'
  - Configure Processing Method
  - Configure Processing Direction
  - Configure Processing Profile
  - Configure Elevation Mask (optional for mobile applications)

## 1.4 Process Coupled Trajectory

- [Process Loosely \(LC\) and/or Tightly \(TC\) Coupled](#) to refine the trajectory solution to  $\pm 0-2$  cm in Combined

[Position separation, and +/- 0-2 arcmin Attitude separation graphs](#) for the time period of data acquisition. Tight coupling produces a CTS file, while loose coupling produces a CLS file. Both CLS and CTS files can be opened in SpatialExplorer and used for point cloud production.

- Configure Processing Direction (check Multi-pass option during TC processing)
  - Configure Processing Profile
  - Configure Processing Datum
  - Verify GNSS/IMU lever arm offset
  - Verify Body to IMU Rotation
  - [Configure IMU alignment settings \(Static/Kinematic/Automatic\)](#)
- **Optional:** If your solution is < +/- 4 arcmin Attitude separation, you can use the '[solve lever arm](#)' function in LC to refine\estimate the IMU to GNSS antenna lever arms. Calculate iteratively to refine these values. Once they have coalesced, process your LC/TC again to include the new lever arm values during trajectory processing.  
**Note:** Use with caution, this option is best suited for verification and is not a replacement for precise measurement of the integrated hardware.
  - **Optional:** [Output SBET and SMRMSG files](#) with names specifying the exact mission, processing datum, and GPS week. SpatialExplorer can use CTS and CLS files for point cloud fusing, so there's no need to create an SBET if you are only using the trajectory in SpatialExplorer.
    - SBET will be based on either LC or TC, whichever results are active in IE during output
      - \*When outputting an SBET/SMRMSG, the default input file will always be the TC solution (if you processed both LC and TC), therefore if you want to output an LC solution, be sure to verify your input file is correct (".cls" = LC and ".cts" = TC).
  - [Output final graphs by outputting an HTML report](#)  
\*Note: Everytime you output an HTML report it writes to an "HTML" folder. If you want to output a separate report for your LC and TC solution be sure to change the name of the "HTML" folder before outputting the second solution.
  - Optional: Output a KMZ of your trajectory to reference with Google Earth or to send to your client



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