**static or known point base occupation.**

This is a suggested guide based on several fixed-wing UAS PPK missions. This is what works for me to achieve cm accuracy with 3 or more checkpoints and no control points. -tmckinney

Project setup:

* Set up base over known point when possible.  We Like NAD83(2011). It is tied to the North American tectonic plate and avoids issues with transformation related to time (WGS84/IRTF2014). Ellipsoidal height simplifies processing, is native to GNSS, and provides better vertical accuracy from RINEX. Larger orthometric error is a function of the uncertainty associated with the GEOID. \*In this workflow, the current geoid is applied for orthometric heights after data processing during model export.
* Use second static observation to ‘tie in’ to NGS published Benchmarks when possible – In OPUS Projects, multiple occupations are tied to the National Spatial Reference System. Vector data are a mathematical representation of the processing and differencing of raw GNSS data collected by two receivers. Vectors provide a least squares adjustment from user base and NGS base. ‘Share’ data with OPUS to help maintain the National Spatial Reference System (NSRS). Solutions will be used in the next modernization.

Base setup:

TM11-D1 likes fixed-height tripods. fixed-height platforms provide assurance for antenna centering, prevent height measurement error, and reduce setup time. Traditional tripods are not as vertically stable as fixed-height center pole tripods and are not recommended for long GNSS observations. Traditional tripods with dual clamps may be used. (TM11-D1). Regardless, incorrect antenna height is the number one source of error.

* Take care in setting up GNSS base.
* Use sandbags if necessary to secure tripod.
* Record exact height from mark to receiver ARP.
* Document with Photos
* Turn on receiver 5 min before flight for ‘known point’. Be careful not to bump or move the tripod.
* Turn on receiver 1-2 hours before flight for new point. Collect static data for at least 2 hours for unknown point, 4 is better, particularly for long baselines.
* Turn receiver off before takedown and 5 min after flights (known point); 1-2 hours (unknown point).

Quality Assurance:

* Validation at cm requires careful attention to detail.
* RTK a minimum of 3 checkpoints (CPs).  Consider placing 3 CPs at a reference location rather than one. If you blow a checkpoint, you have two more. Same cost; more statistics.

[[Webinar Wingtra + Agisoft] Aerial data collection and processing in terms of accuracy |Wingtra](https://wingtra.com/mapping-drone-wingtraone/drone-survey-accuracy/webinar-on-accuracy-with-agisoft/dca4oo4xx/?utm_campaign=Marketing%20funnel%20%2F%2F%20Accuracy&utm_medium=email&_hsenc=p2ANqtz--U-1HXu0TlVQi8VueeNyqfUWTLGn31oHFRHD3fWnXlo72I0_UyttSWM4840jYnj9zNy7zz5osLhqd05NHWfO4YrmWr1Q&_hsmi=84374536&utm_content=84374536&utm_source=hs_automation)

* Use blunder shots - 180 epochs (multipath, height, reinitialization) on a ‘known and trusted’ benchmark.
* Loop CPs two or more hours later when the GPS constellation changes - GPS when retrieving CPs. Redundant observations provide error assessment. ‘Close out’ survey with blunder shots on BM.
* Evaluating uncertainty. Accuracy can be quantified by computing RMSE for published vs observed vertical coordinates. If a ‘known and trusted’ BM (vertical order 2 or better – level II survey) is not available (≤ 9km), an OPUS-S solution of a quality reference mark (brass cap, feno spike, etc) occupied two or three times at 4 hrs or greater could be substituted. Assuming normally distributed errors, vertical accuracy (95% confidence) is computed from RMSE (Wilson and Richards, 2006). NSSDA vertical accuracy (FGDC, 1998) is computed using the following equation:



The square root of the average of the squared differences between published and observed values. Vertical order 2 within 0.05 m.

[Vertical Accuracy Calculation Spreadsheet](https://www.fgdc.gov/standards/projects/accuracy/part3/VERTICAL.XLS/view), FGDC.GOV

[U.S. Geological Survey Techniques and Methods 11-D1 (usgs.gov)](https://pubs.usgs.gov/tm/11d1/tm11-D1.pdf)

Quality Assure the GNSS Survey; Quality Assure the UAS Survey; And Quality Assure the Analysis.

Go Fly.

Process raw GNSS data:

* Process RINEX data in OPUS after 24 hrs. Or...
* Process RINEX in [CSRS-PPP.](https://webapp.csrs-scrs.nrcan-rncan.gc.ca/geod/tools-outils/ppp.php?locale=en&_gl=1*mxs6zc*_ga*MjI4NzI4MjU5LjE3NDE5NjY0NzQ.*_ga_C2N57Y7DX5*MTc0MTk2NjQ3NC4xLjEuMTc0MTk2NjQ4Ni4wLjAuMA..) Cm accuracy within one hour. Rather than using nearby base stations, CSRS-PPP uses precise orbit, clock and bias corrections derived from a global network of receivers to estimate cm accuracy. Output include ITRF position, trajectory, quality assurance estimates and a quality control report.
* Download CORS data if using EMLID Studio static processing [National Geodetic Survey - User Friendly CORS v4.0 (noaa.gov).](https://geodesy.noaa.gov/UFCORS/) Examine NGS CORs sites with [NCN Residual Time Series Comparison Tool](https://geodesy.noaa.gov/OPUS-Tools/ncn-plots/) for mean, standard deviation, and root-mean-square (RMS) error of the residuals.
* EMLID Studio Static output results are dependent on base coordinate input. Reach base coordinates are natively WGS84(latest realization), currently G2296, GPS weeks: 2296. If base coordinates are NAD83(2011) epoch 2010.0, static processing results are NAD83(2011) epoch 2010.0. Emlid Studio Static Processing reads RINEX Header Position ECEF X, Y, Z coordinates in meters and converts to LLH. CORs base coordinates are NAD83(2011) 2010.0 (as of March 2025). Convert WGS84(G2296) or ITRF2020 base coordinates to NAD83(2011) epoch 2010.0 using [NGS Horizontal Time-Dependent Positioning](https://geodesy.noaa.gov/TOOLS/Htdp/Htdp.shtml) > Transform positions between reference frames and/or dates.
* Update PPK rover data and adjust RTK rover shots without fix.

PPK in Wingtra:

* Select WingtraPilotProjects Folder
* Import base files.
* Edit base location > add NAD83(2011) base location from processed solution.  Choose Geodetic LLH
* Select Coordinate system, NAD83(2011)
* Specify Base station antenna offset > set Antenna offset up – distance from mark to ARP (pole/tripod height).
* Set APC offset if receiver is not known to Wingtra. (0.134 for EMLID RS3)
* ‘Apply to all’ if batching multiple flights.
* Geotag. Select csv output. Consider leaving untagged photos on photogrammetry workstation and outputting geotag info to .csv.

Metashape: add photos, align, optimize, add CPs, and validate sparse cloud.

* Add photos.
* Import reference > add geotag csv for LLH, accuracy, and rotation (select all; check box in reference panel).
* Verify Reference Settings > NAD83(2011), adjust accuracy settings as necessary.
* Align
* Optimize
* Add Check Points and 3-5 projections
* Validate CPs in Reference panel. Observe error(m) (Uncheck CPs before error reduction)
* Gradual Section/optimization
* Build Models and export with geoid. Specify projection and NAVD88 for ortho heights. Current Geoid in Geoids folder.