What Happens in X-PAD when you setup an Autonomous Base? How do you adjust points collected with an OPUS solution?

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Version used for testing: 4.5.060

Definitions

Ground Mark GM

The point on the ground that the tip of the rod is touching

L1 Phase Center PC

The position of the L1 phase center of the antenna. Usually above the mechanical top of the antenna.

L1 Offset L1

The distance from ARP to the electrical L1 Phase Center of the antenna.

Instrument Height HI

The distance from the point of the rod to the top of the rod that mechanically mates to the ARP.

LS

The distance from the L1 PC down to the Ground Mark (GM). This is the rod height plus the L1 offset:

LS = HI + L1

Antenna Reference Point ARP

The center of the bottom of the receiver mounting hole

Geoid Height GH

In this document GH is the Geoid18 difference

Ellipsoid Height

The ellipsoid height.

Ortho Height

The orthometric height is computed as:

Orthometric Height = Ellipsoid Height – GH

Setting up a Base Example

When the base is configured, in this case by clicking ‘Measure Here’, X-Pad reads the DGPS or Autonomous position from the receiver:

Note that the Latitude/Longitude/Height is an Ellipsoid Height for the Ground Mark.

The Z value at the bottom of this screen is the Orthometric Height of the Ground Mark. The Ellipsoid and Orthometric heights will differ by the Geoid Height (GH) difference.

For this configuration:

HI:	6.562 ft = 2.000 m	Rod height = distance from ARP down to GM
L1:	6.906 ft = 0.1053 m	distance from ARP up to L1 Phase Center
LS:	**6.907** ft **= 2.1053** m	Rod height + L1 offset
GH:	-54.838 ft = -16.714 m	Geoid Height (negative for ConUSA)

Starting with the **Base position** shown in X-PAD shown above:

Ground Mark:

Ellipsoid:	4319.415 ft = 1316.558 m	
Ortho:	4374.253 ft = 1333.272 m	(Ellipsoid – GH)

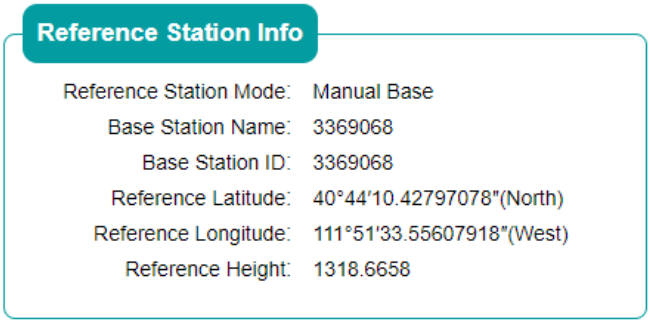
Compute the L1 Phase Center by adding LS to the GM:

Ellipsoid: 4326.322 ft = **1318.663 m**

The L1 Phase Center programmed into the receiver needs to be this Ellipsoid Height. X-PAD sends this height to the receiver. The receiver then broadcasts the L1 Phase Center location to the Rover along with correction data for each tracked GNSS signal.

We can look at the Reference Height that the receiver is using by logging into the Base via Wi-Fi. (Hint: Set the antenna height on the 'Receiver Configuration: Antenna Configuration' to 0.000 meters to display the true broadcast height.)

For the Base configuration above:

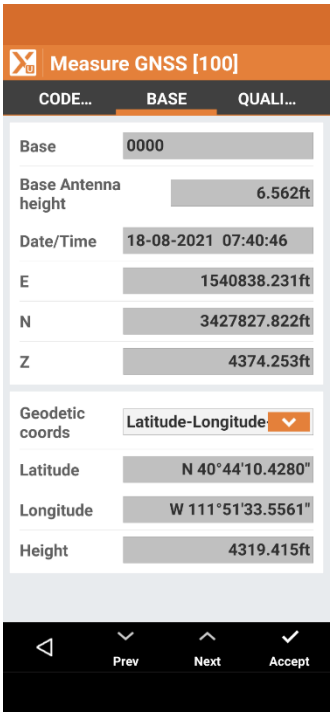


PC Ellipsoid: 4326.331 ft = 1318.6658

So, the configuration of the Base resulted in the desired / correct ellipsoid height for the L1 Phase Center position. (It worked properly ☺!)

Storing a GPS Point in X-PAD

If we connect to a Rover using the Base and store a point in X-PAD and then look at the 'File: Points/Measurements/Code: MEASURE: (edit): BASE (tab)' screen, the reported Base position is displayed:

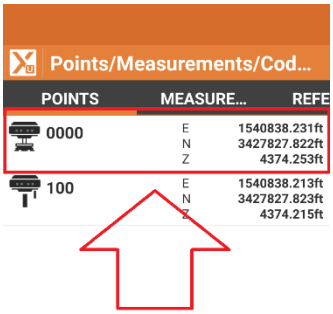


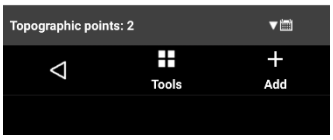
This position should be the Ground Mark at the Base.

The position is transmitted from the Base to the Rover with the correction data so that if a variable VRS server is the source or two bases are used intermittently on a job; each point will have a valid 'measure from' point. In addition to the possibly unique Base position, the correlation, and covariance matrices for measurements are also stored.

Again Z is the orthometric height and Height is the Ellipsoid height.

Every base that is used when storing points will generate an incrementally numbered base point in the job:





For a typical UHF Base / Rover application there will only be one base listed.

For a Network VRS Server, as the Rover moves appreciable distances a new virtual base will be generated.

Adjusting a Base position to match an OPUS Solution

It is common to setup a Base at an autonomous/unknown position and then immediately collect RTK shots on features. These features will be correct relative to each other, however they will have some offset from the desired reference frame; in the USA: NAD83 2011 (2010.0).

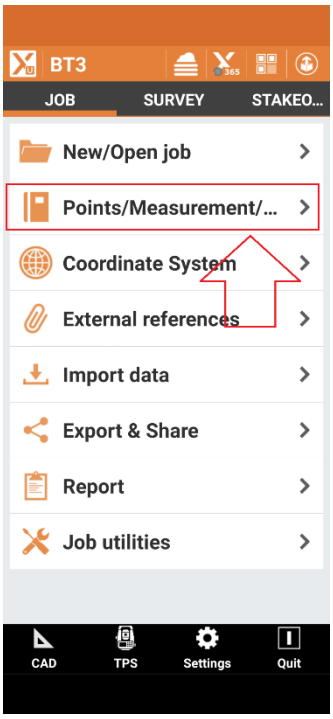
X-PAD automates the adjustment of the Rover shots.

First, you might want to make a copy of your job data in a separate file for safety. From the JOB menu, click on 'Job utilities', then 'Save a copy of the job >'. Enter a reasonable name for the adjusted file like: 'JOB3_OPUSAdj.gfd4', click on 'Accept', then 'Accept' the default site location.

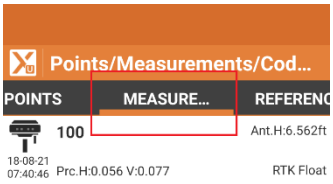
X-PAD will ask if you want to open the new saved job, click on Yes.

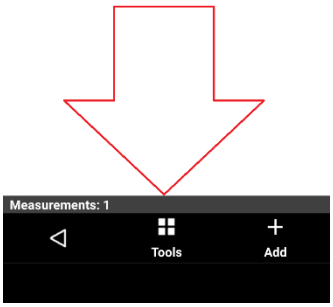
Your original file will be preserved and the adjusted points will end up in a new, separate job.

From the JOB menu, click on 'JOB: Points/Measurements/CODES':

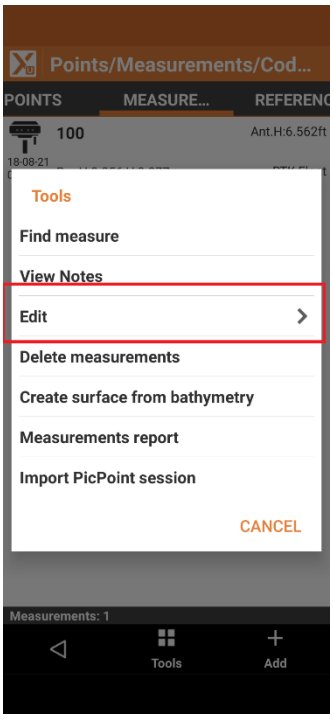


On the 'MEASURE' tab, click on the 'Tools' button at the bottom:

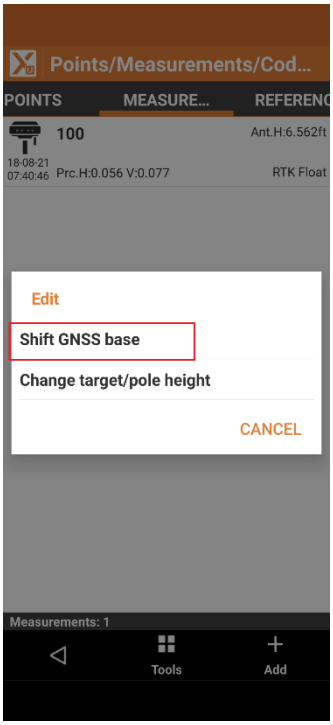




On the 'Tools' menu, click on 'Edit >':



On the Edit menu click on 'Shift GNSS base':

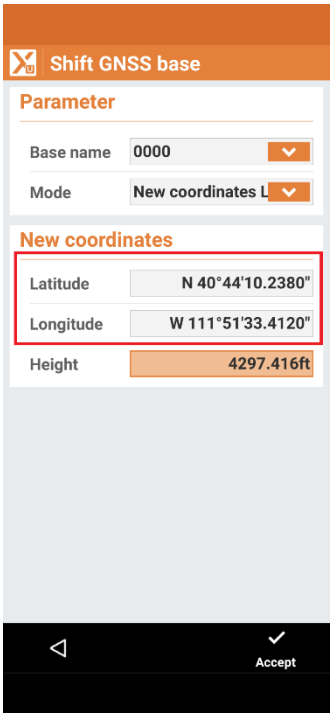


Enter the Latitude and Longitude from the OPUS positioning report:

```
REF FRAME: NAD_83(2011)(EPOCH:2010.0000)              ITRF2014 (EPOCH:2021.6261)

        X:      -1802350.582(m)    0.001(m)          -1802351.540(m)    0.001(m)
        Y:      -4492711.326(m)    0.002(m)          -4492710.040(m)    0.002(m)
        Z:       4141119.248(m)    0.005(m)           4141119.129(m)    0.005(m)

     LAT:    40 44 10.10238        0.004(m)        40 44 10.11718       0.004(m)
   E LON:   248  8 26.58804        0.000(m)       248  8 26.52976       0.000(m)
   W LON:   111 51 33.41196        0.000(m)       111 51 33.47024       0.000(m)
      EL HGT:          1309.855(m) 0.004(m)             1309.143(m)    0.004(m)
ORTHO HGT:             1326.571(m) 0.041(m) [NAVD88 (Computed using GEOID18)]
```



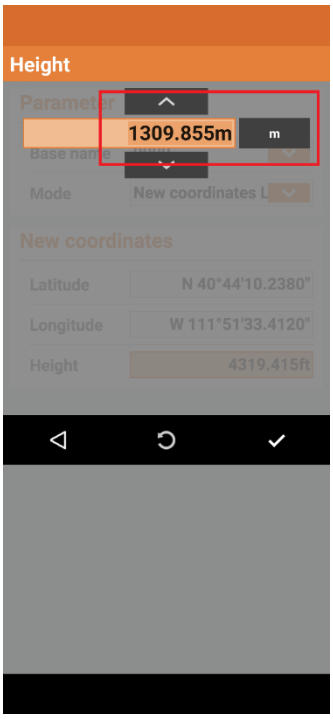
Even though the displayed elevation is in feet, and the OPUS return is in meters:

```
REF FRAME: NAD_83(2011)(EPOCH:2010.0000)              ITRF2014 (EPOCH:2021.6261)

        X:      -1802350.582(m)    0.001(m)          -1802351.540(m)    0.001(m)
        Y:      -4492711.326(m)    0.002(m)          -4492710.040(m)    0.002(m)
        Z:       4141119.248(m)    0.005(m)           4141119.129(m)    0.005(m)

     LAT:    40 44 10.10238        0.004(m)        40 44 10.11718       0.004(m)
   E LON:   248  8 26.58804        0.000(m)       248  8 26.52976       0.000(m)
   W LON:   111 51 33.41196        0.000(m)       111 51 33.47024       0.000(m)
      EL HGT:          1309.855(m) 0.004(m)             1309.143(m)    0.004(m)
ORTHO HGT:             1326.571(m) 0.041(m) [NAVD88 (Computed using GEOID18)]
```

you can enter the metric ellipsoid height directly by selecting meters on the entry box:



Finally click on the 'Accept' button to translate the Rover points.

You can now use these adjusted points as if they were collected from a known base position.

This base translation feature is also available in X-PAD Fusion desktop software.

It is also possible to use the 'COGO: Move, Rotate & Scale' function to adjust the Rover points.

Advanced: .RAW file format

When you 'START BASE', records similar to these are written into the .raw file (which is in the same location as the JOB file):

```
NTE,DT2021-08-18,HM13:38:08,CD,NTModel: CHC - Smart GNSS S/N: 3369068 RTK Device: Internal RadioChannel: 0
NTE,DT2021-08-18,HM13:38:48,CD,NTStart base 0 Latitude N 40°44'10.4280" Longitude W 111°51'33.5561" Height 4319.415ft BH:6.562ft
```

The first line includes the receiver model, serial number and correction source.

The second line includes the position of the Ground Mark and the Instrument Height.