The Importance of a GNSS Site Calibration when Using a Real-Time Network

At CSDS, we continually strive to ensure our network provides you with the utmost in RTK precision and repeatability. However, real-world accuracy and assurance can only be achieved by checking into control and, if necessary, a GNSS site calibration (aka "localization," or transforming our network reference frame and corrections onto your own network of control points).

There are four important questions you should ask when using an RTN:

1. What is the datum or reference frame that is required for your surveying project?
2. Does your job require only relative RTK precision or precision and accuracy to a predefined coordinate system?
3. How well am I checking into control on my current project?
4. How will I be able to transform onto control on an older project if the RTN I'm using has undergone an adjustment?

The CSDS RTN was established using a very precise adjustment over a large area using the NAD83 (2011) reference frame (NAD meaning "North American Datum"). Although this degree of precision and the reference frame may be acceptable for some applications, the only way to ensure the highest degree of accuracy from any RTN is by means of a GNSS site calibration on to known survey control. Furthermore – as minor adjustments will be performed on our network in the future, locating or establishing your own project site control will be vital to ensure that you have a method of checking your precision and accuracy after future adjustments and, if necessary, performing a new GNSS site calibration to compensate for any significant differences.

GNSS, Precision, Accuracy & Grid Coordinates

In the most generic terms: GNSS receivers speak natively in "WGS 84 Latitude and Longitude" coordinates. There are other refined, or "local" datums built for specific regions, such as the NAD27 & NAD83. NAD27 is based on the Clarke 1866 ellipsoid or, the more modern and regularly readjusted, NAD83 datum (based on the GRS 80 ellipsoid). One fundamental difference between WGS-84 and NAD83 is that NAD83 is defined to remain essentially constant over time for points on the North American Plate, whereas WGS84 is defined with respect to the average of reference locations all over the world. But still, the raw coordinate frame/format for WGS 84 and NADXX are expressed in latitude, longitude and ellipsoidal height (not mean sea-level, or "geoid" elevations). For us on a project site that is to be surveyed, engineered and constructed upon, a grid system Northing, Easting and Elevations (YXZ) – coordinates allow us to calculate ground distances and elevations a bit more easily than trying to calculate the differences between raw observed latitude, longitudes and ellipsoid heights… so published coordinate systems such as US State Plane or UTM grids have been created in order for us to transform these latitude and longitude values from WGS 84 or NAD83 ellipsoids into relative grid systems and positions expressed as northings, eastings and elevations. After all, who wants to try to calculate distances or angles on a construction site using degrees, minutes, and seconds rather than grid coordinates?

RTK GNSS systems typically yield +/- 1-2cm relative precision. Traditional base/reference receivers can be set up on top of tripods over known points within published coordinate systems, thus allowing the rover receivers to yield both relative RTK precision and accuracy in relationship to other points within these published grid coordinate systems. But a few questions to ask yourself:

What if I'm unable to physically setup a base receiver over a known, published coordinate due to obstruction or risk of the base receiver being left alone in an unsafe location?

Now that I'm leveraging the value of an RTN and don't need an additional base receiver on site anymore – how can I transform my GNSS project onto a coordinate system other than that of the CSDS RTN?

What about arbitrary or assumed coordinate systems (i.e. 5000/5000/100) that were derived by a total station or autonomous GNSS survey?

How can I correlate the GNSS systems native latitude/longitude/height with these unpublished coordinate systems?

What if I create a network of control points based on a known coordinate system, perform a least-squares adjustment, therefore slightly changing the geometry of my control points from their known, published origins?

How can I tie my GNSS system into them as precisely and accurately as possible?

How do I tie into property or section corners calculated from assumed coordinates and record distances/bearings?

All of these are good questions, and the answer to all of them is a GNSS site calibration.

Here in California, we are fortunate to live and/or work in a region with beautifully amazing, diverse topography. Unfortunately, we are sitting above (and within reach) of a few tectonic plates that are moving in different directions – and rapidly in terms of tectonic velocities:

The Pacific Plate is moving to the northwest at a speed of between 7 and 11 centimeters or ~3-4 inches a year.
The North American plate is moving to the west-southwest at about 2.3 cm.

The CSDS RTN reference frame will remain the same (based on NAD83 (2011), but to compensate for subsidence and subtle movement upon each plate, we will continue to perform adjustments within each subnet a few times a year, hence the highly recommended practice of locating or establishing your own site control and performing a site calibration after each adjustment.

Understanding GNSS Site Calibrations (What Exactly Happens Under the Hood?):
The mathematical transformations that are applied to convert WGS 84 positions to grid coordinates are:

1. A datum transformation to convert the WGS-84 latitude, longitude, and ellipsoidal height coordinates to latitude, longitude, and ellipsoidal height coordinates relative to the ellipsoid of the local map grid.
2. A map projection to convert the local ellipsoid latitude and longitude coordinates into local map grid northing and easting coordinates (the height value is not altered in this process).
3. A geoid model to WGS-84 height to get approximate elevation above sea level. A horizontal adjustment of the transformed grid coordinates to best fit local control data. This adjustment allows for any local variations in the projection system that cannot be accommodated in the overall datum transformation.
4. A height adjustment to convert the heights above the local ellipsoid or elevations derived from the geoid to local control elevations above sea level.
5. The horizontal and vertical adjustment are stored as part of the coordinate system definition for the project. All GNSS points in the database are updated using the calibration parameters, resulting in more accurate local grid coordinate values.

For more information on GNSS site calibrations using Trimble hardware and software, please visit our support page at: www.csdsinc.com/support/

If you have any additional questions about the CSDS RTN or GNSS site calibrations, please contact Tech Support at support@csdsinc.com