Creating "modified" state-plane projections

This Technical Tip provides instructions for creating "modified" state-plane projection zones that match the shifted-and-scaled state-plane coordinates used by some organizations. Such coordinates are often referred to as "local" or "surface" coordinates.

When you have the results of a good control survey and are told or can otherwise determine how the coordinates were modified, this approach is faster, easier, and more accurate than trying to perform an in-field calibration.

This document concentrates on the horizontal component, but if you are provided good ellipsoid heights and elevations for an appropriate set of the control points you can perform a vertical-only calibration before you even leave the office. That will refine and improve the vertical accuracy of your GPS measurements. If you do a vertical-only calibration, make sure that the ellipsoid heights and elevations used in the calibration are truly independent values – not simply a result of applying the separation obtained from the geoid model.

You should definitely check the control in the field by measuring to the control points as they are available, but if the control network was properly done to begin with there will be little or nothing gained by making additional field measurements for calibration.

Many organizations scale state-plane coordinates so inversed grid distances will be reasonably close to the distances measured on the ground. Less frequently, the coordinates are also shifted by subtracting offset values from the northings and/or eastings (either before or after scaling) so the modified coordinates will not be confused with true state-plane coordinates.

State-plane coordinates that are only scaled are handled very easily in Trimble Geomatics Office (TGO). That procedure is described in another Technical Tip document from Inland GPS. This document discusses how to handle both shifting and scaling.

It is important to realize that the grid coordinates of grid points in a TGO project can change if the coordinate-system definition of the project is changed after the grid points are imported into the project. Therefore, this procedure establishes the necessary coordinate-system-definition details before the grid points are imported into the project.

An example –

The control-points listing sheet from the Federal Highway Administration for a project in Wyoming includes NAD83 (1993) geographic (latitude and longitude) coordinates, state-plane coordinates in the Wyoming West Central (WY 4903) zone, and local coordinates for each of the control points.

The conversion from state-plane to local coordinates is explained in a note appearing at the bottom of the control-points listing sheet, as follows:

> **Note: Local coordinates were determined by first subtracting 192,986.0512 from the state-plane northing value and 388,713.6083 from the easting. Then multiplying the result by a factor of 1.000445847. Station 3088 has a value of North = 50,000, East = 200,000.**

The NAD83 (1993) geographic coordinates provided for Point 3088 are 42º 41' 15.453951" North latitude and 108º 53' 19.731872" West longitude.

Three methods are presented below -

Brute-force method -

We will let TGO do the work, as follows:

1. Create a new project in TGO using the correct linear units. In the Project Properties dialog, click on the Coordinate System tab. In the "Coordinate system settings" area in the upper part of the window, click the Change button and the Select Coordinate System dialog will appear. Select the New System radio button, then the Next button.

   You will be at the Select Coordinate System window. Click Coordinate System and Zone option, then Next. In the Select Coordinate System Zone window, select the correct Coordinate System Group (US State Plane 1983 in our example) in the left side and the correct Zone (Wyoming West Central 4903 in our example) in the right side, then click Next.

   In the Select Geoid Model window you can select the correct geoid model, in most cases in the United States and in our example this will be Geoid99 (Conus). Click Finish.

   The "Coordinate system settings" area of the Coordinate System tab should now show the correct System, Zone, Datum, and Geoid model. The "Local site settings" area of this tab will show question marks except for the coordinate display setting, which will read "Grid coordinates." If all is correct, click OK.

2. Go to Plan View in TGO, and key in the geographic coordinates (called WGS84) for one of the points, Point 3088 in our example. Confirm the true state-plane coordinates for this point by changing the coordinate view to grid.

3. Open Project Properties and click on the Coordinate System tab. Click the Change button in the "Local site settings" area of the window and you will be at the "Local site settings" dialog. Check the box by "Use ground coordinates" and enter the scaling factor, 1.000445847 in our example. Click OK to close the "Local site settings" window; then click OK to close the Project Properties window.

4. Check the current grid coordinates for your point. Now Point 3088 in our example is at 243,072.0936 m north and 588,619.4068 m east. Our example stated the local coordinates for Point 3088 are to be 50,000 m north and 200,000 m east.

5. Open Project Properties and click on the Coordinate System tab. Click the Change button in the "Local site settings" area of the window and you will be at the "Local site settings" dialog. The "Northing offset" will be the current northing less the desired northing (243,072.0936 – 50,000.0000 = 193,072.0936) and the "Easting offset" will be the current easting less the desired easting (588,619.4068 – 200,000.0000 = 388,619.4068). Enter the offset values, click OK to close the "Local site settings" window; then click OK to close the Project Properties window.

6. Check to make sure the grid coordinates for the first point are correct. Add more points to the TGO project, either as grid or geographic coordinates, and make certain everything matches up.

   One of the best tests to determine if you have achieved "surface coordinates" is to examine the combined scale factors of points in the project. To do this in TGO, simply label all points with the "Combined Scale Factor" from the View | Point Labels command. The combined factors should be very close to unity. Ideally, some will be slightly greater than one (points at elevations less than the elevation of the projection surface) and others will be slightly less than one (points at elevations greater than the elevation of the projection surface). Remember that every ppm difference from unity in the combined scale factor represents approximately 21 feet vertical separation from the projection surface.

   Another good check is to inverse between pairs of far-apart points and compare the grid and ground distances. Remember that ultimately it is impossible to perfectly flatten a round and lumpy world onto a flat projection surface. Recognize and live with the inherent limitations.

You can do exactly the same thing in Survey Controller Ver 10.00 and higher. The Survey Controller versions running on the TSC1 require a different approach in which the user modifies the projection parameters.