

# GPS Localization

## Basic Principles

The GPS receiver on the machine is capable of very precise positioning. But the positions that it computes are relative to a global reference system defined in terms of a geographic latitude, longitude and height above (a representation of) the earth's surface. To be useful for local site work these global coordinates need to be converted into local site coordinates, defined in terms of a distance north and east of some origin point and some distance above some elevation datum. These north, east, elevation coordinates (often abbreviated to NEZ coordinates) may be those of some regional coordinate system, or may just be arbitrarily defined for the specific site by the project's survey crew. In either case a mathematical conversion is necessary to turn global GPS coordinates into NEZ coordinates that are relative to the locally defined coordinate system.

The basic approach to calculating this mathematical conversion is to provide "pairs" of point coordinates for each control point in the project. A point pair consists of (a) local NEZ coordinates for the point and (b) global latitude, longitude and height coordinates for the point. For local NEZ coordinates it is usually just a matter of obtaining these from the project's survey crew. For global GPS coordinates there are several ways to obtain these that will be discussed here. It is these pairs of points that are used to calculate a precise mathematical conversion formula for converting all GPS coordinates that are generated in the receiver to local NEZ for the particular project.

It is important to understand the significance of this “GPS Localization” process and what steps to take to ensure a high-quality localization suitable for centimeter-level grading. First, it is critical that the surveyor’s local control points are precisely measured. The quality of these measurements directly affect the quality of grade. Second, it is important that these control points are spread more-or-less evenly around the site. Generally the more control points the better but if these are all clustered together or are all at one end of the site then the results will be less than ideal. A good rule of thumb is to chose control points evenly distributed around the perimeter of the site or grading area. For overall system performance, it is also preferable to chose control points that are elevated, easily accessible, and are not obstructed by trees, buildings etc.

# Obtaining GPS Coordinates for Localization

There are two ways to obtain GPS coordinates for your project's control points.

1. Measure points with a Topcon GPS RTK Survey System.

**OR**

2. Move the machine to each control point and take a measurement using the machine-mounted GPS system. This method requires that all control points be machine-accessible.

The first method involves editing the project file using Project Builder. Double-click on the Project Builder icon, select the appropriate project file for editing and use the "Next" button to move to the GPS Localization screen. Select the control point from the list and then press the "Localize point" button. Note, if the point is not already in the list you will first need to go back to the "Control Points" screen and add the new control point together with its local NEZ coordinates.

**Localize point**

Point

Name

Use for horizontal localization

Use for vertical localization

Measure GPS point

Machine

Slope distance from edge of antenna to ground mark

Key in GPS point

WGS84 Latitude

WGS84 Longitude

WGS84 Height

Fig 4.00

Enter the latitude, longitude and height information manually. This involves pressing the edit box for each value and using the pop-up keypad to enter each value. Note that to enter a latitude value of N37°56'25.34567" you must enter the number as 37.562534567 on the keypad. And if you are working in the southern hemisphere a value of S41°21'34.23456" must be entered as -41.213423456 (negative). Similarly for longitude values in the western hemisphere (e.g. the United States), a value of W121°49'34.34567" must be entered as -121.493434567.

If you have northing, easting and elevation coordinates, select both the “Use for horizontal localization” and “Use for vertical localization” should be selected. However, you can use Control points without elevation values by checking only the "Use for horizontal localization" and likewise for vertical.

The second method for obtaining GPS coordinates is to measure them using the GPS on the machine. On the Localize Point screen select the “Measure GPS point” option.

The screenshot shows a dialog box titled "Localize point" with a close button (X) in the top right corner. The dialog is divided into several sections. The "Point" section at the top has a "Name" field containing "Maggie". Below this are two checked checkboxes: "Use for horizontal localization" and "Use for vertical localization". The "Measure GPS point" radio button is selected, and a "Measure" button is positioned to its right. Below this is a "Machine" dropdown menu showing "D8R". The "Slope distance from edge of antenna to ground mark" is set to "2.000m". The "Key in GPS point" radio button is unselected, and there are three empty input fields for "WGS84 Latitude", "WGS84 Longitude", and "WGS84 Height". On the right side of the dialog, there are "OK" and "Cancel" buttons.

Fig 4.01

The process of measuring is straightforward but does involve setting up all machine components and moving the machine to close proximity of the control point. The machine must first be setup and a machine configuration file created as per the previous section. The base station must also be up and running on one of the control points in the list. Select the correct machine configuration.

Remove the GPS antenna from the machine's blade mount so that it can be used for measurement of the control point. Disconnect the strain-relief cable from the GPS antenna and the GPS cable. Use the site calibration cable to connect the GPS antenna to the GPS cable.

Then, either set up a tripod over the control point and mount the antenna as you would setup a base station, or mount the antenna to a standard surveyor's range-pole with 5/8" threaded end and tapered tip. You will need to carefully measure the slanted distance between rim of antenna and control point (or tip of range-pole) and enter this value into the "Antenna Height" entry below the "Machine" entry. It is a good idea to use a BiPod when localizing with a range pole to insure the antenna does not move. Now you are almost ready to measure.

Make sure that the GPS receiver is turned on and receiving satellite and radio data. If using a range-pole set up with a BiPod or have someone hold this vertical and away from the machine so as not to block satellite visibility. If the machine is too close to the control point and in any way obstructing the antenna's view of the sky then measurement may take considerable time or may not succeed at all.

With the range-pole steady press the "Measure" button. It is essential to keep the pole vertical and steady for the duration of this measurement. You will see a new dialog indicating status of the measurement. When the status dialog disappears you now have an accurate GPS coordinate for this control point! If there is a problem, you will

receive a problem report. Refer to the troubleshooting guide at the rear of this manual if you have difficulty making these localization measurements.

When you have successfully measured the GPS coordinates of this point you can press the “OK” button to take you back to the point list. Now in the list you will see horizontal and vertical errors reported for each point that has been calibrated.

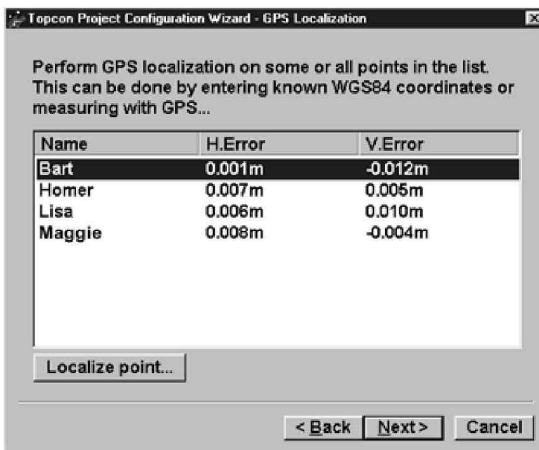


Fig 4.02

If you do not see these errors displayed then you may not have checked the “Use for horizontal localization” and/or “Use for vertical localization” check-boxes in the “Localize Point” dialog. Press the “Localize Point” button for the selected point and rectify this (you will not need to re-measure). For your first and second control point you should see errors that are exactly zero. For subsequent points the error values should be very small, i.e. less than the expected grading precision. If you start to see errors in excess of this precision then there are several possibilities why this is the case.

If the error values for the first few points are reasonable but increase significantly when a new point is measured, then the point just measured either has local NEZ values that are incorrect or inaccurate or the GPS measurement was in error. Check that the local NEZ values that were provided are true and accurate. Also, try to re-measure the point again to see if there is any improvement in these error values. If necessary, use another point.

After each successful measurement is completed and before the machine is moved to the next control point it is a good idea to save the project file by pressing “Next” and then “Finish” to close the Project Builder program. If the power were to inadvertently fail on the computer then this point information would be lost. Repeat this localization process for all points on the site that are accessible.

When you are done localizing and all error values are within an acceptable tolerance, the project file will contain the precise mathematical conversion formula necessary for your grading machinery. This localization process need only be done once at the start of the project. You may have many different grading tasks for your machines on this site and they can all make use of this same project file to ensure precise and compatible positioning on all design surfaces on the site. You should make a backup copy of this project file onto PC card or floppy disk by pressing the “Copy” button on the very first screen of the Project Builder program.

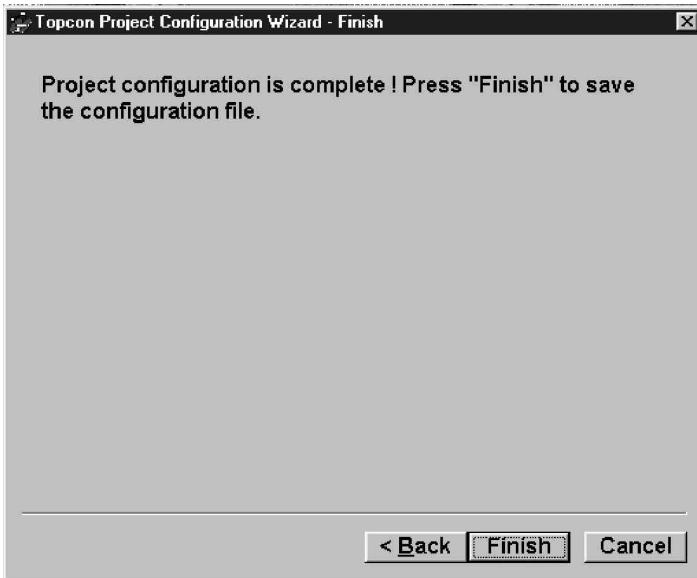


Fig 4.03

