NGS Toolkit, Part 8: The National Geodetic Survey NADCON Tool

Donald M. Mulcare

The most frequently used item in the NGS Geodetic Toolkit is the North American Datum Conversion (NADCON) tool. NADCON transforms geographic coordinates between the NAD 27, Old Hawaiian, Puerto Rico, or Alaska Island datums and the NAD 83 system. NADCON also transforms between the original implementation of NAD 83, labeled NAD83 (1986), and the statewide High Precision Geodetic Network (HPGN). The acronym HPGN has been replaced by High Accuracy Reference Network (HARN) but still appears in the documentation and prompts for NADCON.
NADCON is intended for use in applications like mapping, low accuracy surveying, and navigation. The accuracy of transformations between NAD 27 and NAD 83 (1986) are typically 12-18 cm and 5-6 cm between NAD 83 (1986) and HPGN. These accuracy statements are for the conterminous U.S. (lower 48 states) and are at the one-sigma level of significance.

Why Use NADCON?
Because the adoption of the North American Datum of 1983 (NAD 83) involved not only a change in reference ellipsoid but also the removal of distortions in the North American Datum of 1927 (NAD 27), we cannot accurately relate the datums by either a single set of transformation parameters or a polynomial.
NADCON accounts for the distortions and provides accurate results. It can be used with large data holdings, does not require an expert to use, and does not require any user interaction or decisions during its use.
The Federal Geodetic Control Committee (FGCC) has recognized the accuracy of the methods by recommending it as the standard method of mathematical transformation between datums. The official notice is at:
http://www.ngs.noaa.gov/PUBS_LIB/FedRegister/FRdoc90-18809.pdf

Where Can It Be Used?

The NAD 27 to NAD 83 transformation can be performed in the conterminous U.S. (lower 48 states); Alaska, including the Aleutian Islands, the St. Lawrence Island, St. George Island and St. Paul Island; Puerto Rico; the U.S. Virgin Islands;, and the Hawaiian Islands.
Transformations between NAD 83 and the state HPGN coordinates can be performed wherever a grid file exists. There are no grid files for the following states: Alaska, North Carolina, and South Carolina. There are grid files for Puerto Rico and the Virgin Islands as well as two sets of grid files for the islands making up American Samoa.
Due to the structure of the NADCON grids (described below), it is possible to obtain results beyond the area covered by the model. Transformations performed in ocean regions, or more than a short distance beyond the U.S. boundaries with Mexico and Canada are not valid and will not provide results within the stated accuracy of the program. In near offshore regions, results will be less accurate but will seldom be in excess of five meters. Further offshore NAD 27 was undefined. Therefore, the NADCON computed transformations are extrapolated and no accuracy can be stated.

How Does It Work?
A search was made of the NGS data base that identified points that were adjusted in both systems. The differences in the coordinates at these points were used to create grid files of latitude and longitude shifts. NADCON determines coordinates for points based on an interpolation of these grid files. The creation of the grids is illustrated in Figures 1, 2, and 3.
The grids are created using a technique known as minimum curvature. This technique can be used for similar problems. The implementation in NADCON is described in NOAA Technical Memorandum NGS-50 available at:
http: //www.ngs.noaa.gov/PUBS_LIB/pub_index.html

The program works best where the data are dense. As NGS develops similar products to support transformations to new datums, we will only use data from the NGS data base. So, it is important that users interested in improving the quality of transformations in their area consider submitting projects to NGS.
In order to illustrate the operation of NADCON, transformations will be performed using NGS-published coordinates for A-Order station DAN (JW1512).
The section labeled *CURRENT SURVEY CONTROL in Figure 4 indicates that the coordinates are NAD 83(1991). The date refers to the year the Maryland HARN was adjusted.
The coordinates are also indicated to be "ADJUSTED." While these coordinates are derived from an adjustment, some points in the NGS data base are scaled.
The section SUPERCEDED CONTROL DATA in Figure 5 shows the coordinates for DAN in both NAD 83 (1986) and NAD 27. Not all points in the NGS data base have coordinates in all systems.

NADCON requires geographic coordinates as input. Coordinates can be entered as either degrees, minute and seconds; degrees, minutes and decimal minutes; or decimal degrees.
NADCON uses the location of the decimal to determine the format of the input. If no decimal is present, an error message will be displayed.
In our first example, we transform from NAD 27 to NAD 83.

Program Output
Program output includes not only the new coordinates but also the magnitude and direction of the latitude and longitude shifts. The shift values are reported in both seconds and meters.
As this transformation is between NAD 27 and NAD 83, we see the large shift we expect. For these transformations, positions of points can change between 10-100 meters in the conterminous United States (see Figure 9); more than 200 meters in Alaska, Puerto Rico, and the Virgin Islands; and in excess of 400 meters in Hawaii. At our station the total shift is 24.011 meters (78.78 feet).
When converting between NAD 83 and HPGN we have an additional step. We must specify the state in which the point is located. This directs the program to load the appropriate file of gridded coordinate shifts.
As with the other transformation, our output includes the direction of the transformation. Since our transformation involved an NAD 83 to HPGN conversion, the magnitude is much less. Here the total shift was 0.196 meters (0.64 feet).
The expected range of values for shifts between NAD 83 (1986) and a HPGN is 0.2 to 1.0 meters relative to the original NAD 83 (1986) adjustment.

Transforming a File of Points
Users can also transform a file of points. This feature is accessed through a link on the transformation page (see Figure 12). Selecting this link will cause a new input form to be displayed.

The Input File Formats
NADCON supports three file formats as shown in Figures 13 through 15 (on page 33). Users interested in the consistency of transformations in an area should use the file option. The output from this option includes a statistical summary of the transformations.

How Good Are the Transformations?
Tabulated below are the differences between the transformed coordinates and the published values for DAN (JW1512). These differences should not be expected to be typical as the accuracy of transformations is dependent on the distribution and quality of data from which the grids of shift values are derived.

Are These Results Good Enough?

The user must decide whether the accuracy supported by NADCON is acceptable for their work. Those interested in more accurate results should reacquire data or readjust original observations.

Users should also remember that while the output is shown to five decimal places, this does not imply that the results are accurate at the millimeter level.

Donald Mulcare is a Geodesist with the Geodetic Services Division of the National Geodetic Survey. He currently serves as Geodetic Advisor to the State of Maryland.

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