ENGINEERING AND CONSTRUCTION BULLETIN

US Army Corps of Engineers

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SUBJECT: Use of National Geodetic Survey (NGS) Coordinate Conversion and Transformation Tool (NCAT) and VDatum instead of CORPSCON.

CATEGORY: Directive and Information.

1. **References:**

a. Engineer Manual (EM) 1110-2-6056, Standards and Procedures for Referencing Project Elevation Grades to Nationwide Vertical Datums, 31 December 2010

b. Engineer Regulation (ER) 1110-2-8160, Policies for Referencing Project Elevation Grades to Nationwide Vertical Datums, 1 March 2009

c. EM 1110-1-1005, Control and Topographic Surveying, 1 January 2007

d. NGS Coordinate Conversion and Transformation Tool (NCAT), https://geodesy.noaa.gov/NCAT/

e. NOAA/NOS Vertical Datum Transformation Tool (VDatum), https://vdatum.noaa.gov/welcome.html

f. Federal Emergency Management Agency (FEMA), Vertical Datum Conversion Guidance, May 2014

2. **Purpose.** This ECB establishes U.S. Army Corps of Engineers (USACE) policies for the transformation and conversion of geospatial coordinates from one datum and/or coordinate system to another. It specifically addresses the valid datum transformation and coordinate conversion tools that should be used in these processes. Its purpose is to ensure that datum transformations and coordinate conversions are done utilizing the most up to date methods developed by the National Oceanic and Atmospheric Administration (NOAA), National Geodetic Survey (NGS) and/or NOAA National Ocean Service (NOS). This ECB does not address transformations that involve the World Geodetic System 1984 (WGS 84) or any of the International Terrestrial Reference Frames (ITRFs).

3. **Applicability.** This ECB applies to every CONUS/OCONUS USACE Command and is effective upon issuance.

4. **Background.** The NOAA NGS has the sole responsibility to define the geodetic datums (e.g. NAD 27, all NAD 83 realizations, NGVD 29, NAVD 88; sometimes also called reference frames, or datum realizations, but the word “datum” will encompass all of these terms in this bulletin) and projected coordinate systems (e.g. State Plane Coordinate System of 1927, State

Plane Coordinate System of 1983), known collectively as the National Spatial Reference System (NSRS), for use by federal civilian agencies within the United States and its territories. As part of this responsibility, the NGS has updated the NSRS to better reflect the data collected and used in their definitions and development. When new datums are defined, NGS develops algorithms and methods to provide the nation with consistent transformations between older and newer horizontal and vertical datums. Originally these transformation algorithms were stand-alone programs with a minimal user interface (e.g. NADCON, VERTCON). USACE developed a user-friendly interface to combine the datum transformations and coordinate conversions into one program, called CORPSCON. CORPSCON was updated several times over the years with the last version being released in 2009. Since then, NGS has released new tools, datums and geoid models that have not been incorporated into CORPSCON. In addition, NGS has developed online tools called NCAT and VDatum which, like CORPSCON, integrate numerous previously stand-alone programs in a user-friendly interface. Unlike CORPSCON, these online tools are up to date as of the date of this bulletin. The NGS NCAT and NOAA/NOS VDatum tools use the same core engines (such as the latest version of NADCON), so that identical input data will yield identical results through either tool. It is USACE policy that those requiring horizontal and/or vertical datum transformations and coordinate conversions use the current NCAT or VDatum tools instead of CORPSCON. In addition, this ECB supersedes the use of CORPSCON described in the documents listed in the references until they can be updated to reflect this new policy.

5. **Geospatial Data Transformations.**

a. Datum Transformations: The methodology used to shift historical or legacy survey data referenced to an older datum to a current datum (e.g., vertical data in NGVD 29 to NAVD 88 or horizontal data in NAD 27 to NAD 83 (2011) epoch 2010.00) varies depending upon many factors such as time constraints, funding restrictions, accuracy requirements, etc. The most accurate method is to re-observe each project control mark used for the original survey of interest and use these calculated differences to transform the data as described in method 1 below. Even with the establishment of new coordinates on the project control, the changes between the original survey and now on other features that are not part of the project control are only estimates. The relationship between the surveyed features and the control marks may have changed due to subsidence, settlement, or NSRS readjustments. There are four methods to develop transformations from one datum to another for projects that are referenced to older datums.

(1) Field measurements with known historical coordinates/elevations: This method will yield the most accurate values based on the historical reference control marks. The reference control marks must be recovered and occupied/surveyed using GNSS, leveling or other methods, depending upon required project accuracy. The difference between the historical coordinates and/or elevations and the newly established coordinates and/or elevations is then used to shift the historical data to the new datum/epoch. This will not account for any differential subsidence or settlement between the project control and the surveyed features that may have occurred after the legacy reference datum was established. If critical project elements require datum transformation, the elements should be resurveyed using the new datums if time/funding allows.

(2) Field measurements without known historical coordinates/elevations: When the reference legacy datum and/or the historical project control is not recorded and unknown, some assumptions will be required, such as what control marks were used and their actual coordinates and/or elevations. Again, GNSS or other survey methods depending upon required accuracy may be used to establish new coordinates and/or elevations on the existing project control. Then historical project control coordinates and/or elevations will have to be calculated based on resurveying features that have coordinates in the available historical drawings/data. The difference between the calculated historical coordinates and/or elevations and the newly established coordinates and/or elevations is then used to shift the historical data to the new datum/epoch.

(3) Common published marks in the survey area: The closest marks with published coordinates and/or elevations in both datum/epochs can be used to determine an average shift for the area. This method contains many assumptions and therefore is less accurate but may be of some use on some projects.

(4) Transformation Routines (NCAT, VDatum): Through the use of standard and official datum transformation routines (i.e. NGS NCAT, NOAA/NOS VDatum), existing coordinates can be transformed between various datums using a consistent method. These routines are good for transforming coordinates and elevations between established datums, including "realizations", or epochs, of those datums (e.g. NGVD 29 and NAVD 88, NAD 27 and NAD 83(1986), or NAD 83(1986) and NAD 83(2011) epoch 2010.00). Since these transformations are approximations modeled using published surveyed values, they contain some errors that need to be checked to make sure they fall within the desired project accuracy requirements.

b. Coordinate Conversions: It is important to point out that NCAT can perform coordinate conversions from geodetic (latitude, longitude, ellipsoid height) to global Cartesian (X,Y,Z), to projected Cartesian (northing, easting in State Plane), UTM or U.S. National Grid referenced to the same datum, in addition to datum transformations. As these conversions are definable mathematical constructs with no uncertainty, the output coordinates retain the accuracy of the input coordinates. When converting from one coordinate system to another referenced to the same datum, make sure that units are specified and labeled correctly.

6. **Use of International Foot and U.S. Survey Foot.** The National Institute of Standards and Technology (NIST) and the National Geodetic Survey (NGS), National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA), took collaborative action to provide national uniformity in the measurement of length. As part of this effort, it was decided to deprecate the use of the U.S. survey foot on December 31, 2022. As a result, the U.S. survey foot will be phased out as part of the modernization of the National Spatial Reference System (NSRS). It is expected that the NSRS modernization will be implemented in 2025. Until this time, USACE should continue to designate current State Plane or UTM coordinates with the same linear unit used by the jurisdiction where a project is located or as required within the project documents (international foot, U.S. survey foot, or meter). Legacy coordinates in U.S. survey feet should continue to be expressed in U.S. survey feet. Additional guidance on this will be provided prior to the implementation of the NOAA NGS modernization of the NSRS.

7. **Metadata.** It is important to make sure that all geospatial data is well documented with quality metadata. This includes identifying the datum (both horizontal and vertical), coordinate system, and the unit of measure for each set of data.

8. **Update.** All new requirements will be included in the next appropriate policy document update prior the expiration of this ECB.

9. **Points of Contact.** HQUSACE point of contact for this ECB is Mr. Jacob Watts, Geospatial Community of Practice Lead, jacob.a.watts@usace.army.mil. The technical point of contact for this ECB is Mr. James Garster, CEAGC-GSS, james.k.garster@usace.army.mil.

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