Pennsylvania State Geospatial Coordinating Board
Geodetic Working Group
Special Report on State Plane Coordinate System (SPCS) of 2022
Accepted by unanimous vote of the GeoBoard 11/16/2023*

Executive Summary

The Pennsylvania Coordinate System Law (1992, P.L. 1224, No. 161, Cl. 76.) defines "a system of coordinates for designating the positions of points on the surface of the earth within the Commonwealth of Pennsylvania." The Law needs to be updated for two reasons: a) to provide the Commonwealth with a much-improved digital framework for Pennsylvania State Plane Coordinates that is aligned with the new National Spatial Reference System (NSRS); and b) to finally redress the confusing "dual foot" problem.

The National Geodetic Survey (NGS) is modernizing our NSRS, which is the official definition of Earthly positional parameters including longitude, latitude, height, scale, gravity, and orientation throughout the United States. In short, these parameters will change in 2025. The Law from 1992 explicitly ties the Pennsylvania Coordinate System to the outgoing NSRS. The differences are meaningful.

Meanwhile, the National Institute of Standards and Technology (NIST) finally ended the era of the "U.S. Survey Foot", which is a legacy unit of length measurement used only by surveyors and inconsistent with the other definition of the foot that is standard in every other industry sector. The Law explicitly requires the "U.S. Survey Foot"; all other industry sectors use the "International Foot."

If left unchanged, the Law from 1992 will, in effect, compel mapping professionals working on Pennsylvania projects to continue developing and maintaining maps and geographic datasets that are tied to outdated geodetic concepts, outdated positioning technologies, and a legacy unit of measure. The trickledown effect of a "do nothing" approach will lead to degraded accuracy of statewide geospatial data, growing inconsistencies along boundaries and borders, and potentially require maintenance of two sets of maps and geographic data at significant expense.

The GeoBoard's Analysis

The Commonwealth should update the Pennsylvania Coordinate System Law during the 2023-24 legislative session in anticipation of the adoption of the North American Terrestrial Reference Frame of 2022 (NATRF22). Any legislation on this matter should reference the model law recommendations published by the National Geodetic Survey and the zone boundaries recommended by our Geodetic Working Group in March 2020. Individual GeoBoard members are prepared to assist the legislature in technical aspects of any such legislation if requested. There are plans to update similar laws in all 50 states, and as of this time, several have already passed legislation.[1]

About the GeoBoard

The Pennsylvania State Geospatial Coordinating Board (a.k.a., GeoBoard) was established within the Office of Administration (Act 178 of 2014) to: "Provide advice and recommendations to the Governor and the citizens of this commonwealth on geospatial issues and provide uniform data standards,

[1] Example legislations (as of summer 2023) https://geodesy.noaa.gov/pub/SPCS/ExampleLegislation/

coordination and efficiency in geospatial policy and technology issues among Federal, State and local government agencies, academic institutions and the private sector."

More information

The GeoBoard's Geodetic Working Group (GWG) is a subset of working professional surveyors, geodesists, geographers, and GIS professionals. The GWG includes representatives from the Pennsylvania Society of Land Surveyors (PSLS), PennDOT, PA Turnpike Commission (PTC), and the Office of Administration (OA). The representatives have worked together with our Regional Geodetic Advisor from the NGS to understand the new NSRS, the "dual foot" problem, and the benefits to be realized by replacing the old Pennsylvania State Plane Coordinate system with a modern one.

Background: A new national geodetic control system is coming

A geodetic control system is a standard framework for establishing and referencing coordinates for maps and geographic datasets. A national geodetic control system allows users across the country to determine longitude, latitude, height, scale, gravity, and orientation locally while staying consistent with other users using the same system. To ensure consistency and reliability, however, the geodetic control system must be more accurate than any map or geographic dataset built upon it.

Classic geodetic control consists of a network of metal marks or rods affixed to Earth's surface with documented horizontal coordinates (i.e., longitude, latitude) and/or vertical coordinates (i.e., heights). The marks or rods serve as "starting points" for users of the system to begin their own surveys and to create their own maps and geographic datasets. In theory, all the maps and datasets produced by any myriad of users should be consistent with each other so long as everyone follows the correct protocols and references the same geodetic control system.[2]

One key assumption underlying classic geodetic control systems is stability. Generally, the coordinates of the metal marks and rods are assumed to be "fixed" and reliable for decades, except in areas where earthquakes and crustal movement are known issues, such as southern California.

Technology has a way of changing things. Technological advances have improved our ability to precisely measure accurate coordinates while simultaneously outpacing the accuracy and assumed stability of our classic geodetic control systems. The advent of space geodesy and satellite navigation technologies revealed issues like ongoing rotation of the entire North American tectonic plate, ongoing glacial isostatic adjustment centered around Hudson Bay, and other motions.[2] Observed differential movement among all the metal marks and rods undercuts the fixed stability assumption and it helps to explain why offsets, overlaps, and misalignments can and do occur between mapping projects.

The NGS is responding by modernizing our NSRS, which includes our official geodetic control system that defines Earthly position parameters including longitude, latitude, height, scale, gravity, and orientation throughout the United States. The basis for longitude, latitude, and height in the new NSRS is called the "North American Terrestrial Reference Frame of 2022" (NATRF2022) and, although delayed, final definition and acceptance is expected in 2025.

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[2] NOAA Technical Report NOS NGS 64 (2017, revised 2021)
https://geodesy.noaa.gov/library/pdfs/NOAA_TR_NOS_NGS_0064.pdf

NATRF2022 is the culmination of a decades-long effort to improve our geodetic control system and it marks a significant transition away from classic control networks consisting of static marks and rods to a new digital network of active satellite positioning sensors. Users will be able to access NATRF2022 in real-time via internet or mobile connections (some provided by state governments, some via paid commercial services) and achieve accurate survey-grade coordinates in the field with smaller crews and more efficient field operations. Cost savings are expected to accrue daily across survey, engineering, and GIS operations that move forward and adopt. The outgoing classic system for horizontal coordinates is called "North American Datum of 1983" (NAD83) and the outgoing classic system for vertical heights is called "North American Vertical Datum of 1988" (NAVD88).[3]

Surveyors, engineers, and GIS professionals commonly use mathematical *projections* to convert geographic coordinates, which are expressed in degrees, into planar coordinates, which are expressed in easier-to-use meters or feet. The Pennsylvania State Plane Coordinate System is an example of a projected coordinate system. According to the Law from 1992, Pennsylvania coordinates must be projections of NAD83 coordinates and expressed in meters or U.S. Survey Feet.

The GWG believes a clear need exists to update the Law by removing the explicit reference to the outgoing "North American Datum of 1983" requirement and replacing it with new future-proof language that simply references "the current NSRS." The GWG has been working with our Regional Geodetic Advisor from NGS to develop a new Pennsylvania State Plane Coordinate System of 2022, which will be standard projections of the new NATRF2022 coordinates.

Background: The dual foot problem

The legal definition of the foot in the United States is based on the meter. In 1866, the US Congress defined 1 foot = 1200/3937 meter *exactly* (or 1 foot = 0.3048006 *approximately*).

For several reasons, Congress officially revised the definition as 1 foot = 0.3048 meter, *exactly,* in 1959. The new definition was legally binding and intended for the entire United States, but a temporary exception was allowed for geodetic surveying only. To distinguish between the dual versions of the foot, the old one was named the "U.S. Survey Foot" (for mapping and geodetic surveying only) and the new one was named the "International Foot" (to be used by everyone else in every other industry sector). It was furthermore mandated that the U.S. Survey Foot be replaced by the International Foot upon readjustment of the geodetic control networks of the United States. Although such a readjustment was completed in 1986 – 37 years ago - use of the U.S. Survey Foot has persisted. The ongoing dual foot problem has long created confusion, especially among students and the public, and it creates expensive measurement errors even among professionals.

The National Institute of Standards and Technology (NIST) and the National Geodetic Survey (NGS), each a part of the Department of Commerce (DoC), have taken collaborative action to redress the dual foot problem and provide national uniformity in the measurement of length (85 FR 62698).[4] After December 31, 2022, any data derived from or published as a result of surveying, mapping, or any other activity

[3] New Datums (NOAA NGS, 2023) https://www.ngs.noaa.gov/datums/newdatums/index.shtml

[4] Deprecation of the U.S. Survey Foot (Federal Register) https://www.federalregister.gov/documents/2020/10/05/2020-21902/deprecation-of-the-united-states-us-survey-foot

within the U.S. that is expressed in terms of feet should only be based on the definition of one foot being equal to 0.3048 meter, *exactly*.

The GWG recognizes the opportunity to finally redress the legacy foot problem that is being perpetuated by the Law. The legacy "U.S. Survey Foot" requirement should finally be replaced by the standard "International Foot" requirement used in all other industry sectors.

Adverse consequences of the "do nothing" approach

The GWG expects mapping professionals to eagerly access NATRF2022 via the internet and mobile connections so they can achieve accurate survey-grade coordinates in the field and so their maps and geographic data will be consistent with others' maps and geographic data. The GWG believes redressing the "dual foot" problem will mitigate a common source of confusion and measurement error by ensuring every foot – the foot - is finally defined the exact same way across all industry sectors.

If the Commonwealth chooses not to embrace the upgrades to the NSRS and chooses not to deprecate the legacy U.S. Survey Foot, then the Pennsylvania Coordinate System Law from 1992 will, in effect, compel mapping professionals working on Pennsylvania projects to continue developing and maintaining maps and geographic datasets that are tied to outdated geodetic concepts, passive technologies, and a legacy unit of measure. Meanwhile, colleagues and competitors in other states will be developing and maintaining maps and geographic datasets that are tied to modern geodetic concepts and digital technologies while realizing the efficiencies associated with using the standard International Foot. The trickledown effect of a "do nothing" approach will lead to degraded accuracy of statewide geospatial data products, growing inconsistencies along boundaries and borders, and creeping production costs whenever maps or data need to be transformed from one coordinate system, or from one definition of a foot to another.

Financial impact of adopting the changes

The financial impact of adopting the proposed changes should be minimal to the public but a little more for the geospatial community. Geospatial agencies and companies are not required to maintain their data in the NSRS, nor are they required to transform their legacy data after a new geodetic control system is released. However, the GWG expects many in the geospatial community will want to take quick advantage of NSRS Modernization, so they will promptly put forth moderate efforts to transform their map data and update their best practices and workflows. Software is typically used to perform bulk coordinate transformations; much of which can be automated. The NGS is committed to providing free and authoritative tools via the internet to facilitate such transformations, so it provides alternatives to commercially licensed software. The NGS tools are just as robust as any commercial application, but like all software, each requires effort to learn and use properly.

Summary

The purpose of the Pennsylvania GeoBoard is to: "Provide advice and recommendations … on geospatial issues and provide uniform data standards, coordination and efficiency in geospatial policy and technology issues among Federal, State and local government agencies, academic institutions and the private sector." Accordingly, the GeoBoard suggests that the Pennsylvania Coordinate System Law (1992, P.L. 1224, No. 161, Cl. 76.) be updated to provide the Commonwealth with a much-improved digital framework of Pennsylvania State Plane Coordinates that is aligned with the new NSRS and finally redresses the confusing "dual foot" problem.