



National Spatial Data Infrastructure

Geospatial Positioning Accuracy Standards Part 1: Reporting Methodology

Federal Geodetic Control Subcommittee
Federal Geographic Data Committee

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Department of Agriculture • Department of Commerce • Department of Defense • Department of Energy
Department of Housing and Urban Development • Department of the Interior • Department of State
Department of Transportation • Environmental Protection Agency
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Federal Geographic Data Committee

Established by Office of Management and Budget Circular A-16, the Federal Geographic Data Committee (FGDC) promotes the coordinated development, use, sharing, and dissemination of geographic data.

The FGDC is composed of representatives from the Departments of Agriculture, Commerce, Defense, Energy, Housing and Urban Development, the Interior, State, and Transportation; the Environmental Protection Agency; the Federal Emergency Management Agency; the Library of Congress; the National Aeronautics and Space Administration; the National Archives and Records Administration; and the Tennessee Valley Authority. Additional Federal agencies participate on FGDC subcommittees and working groups. The Department of the Interior chairs the committee.

FGDC subcommittees work on issues related to data categories coordinated under the circular. Subcommittees establish and implement standards for data content, quality, and transfer; encourage the exchange of information and the transfer of data; and organize the collection of geographic data to reduce duplication of effort. Working groups are established for issues that transcend data categories.

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1.1 Introduction

1.1.1 Objective

This document provides a common methodology for reporting the accuracy of horizontal coordinate values and vertical coordinate values for clearly defined features where the location is represented by a single point coordinate: examples are survey monuments, such as brass disks and rod marks; prominent landmarks, such as church spires, standpipes, radio towers, tall chimneys, and mountain peaks; and targeted photogrammetric control points. It provides a means to directly compare the accuracy of coordinate values obtained by one method (e.g., a cartographically-derived value) with that obtained by another method (e.g., a Global Positioning System (GPS) geodetic network survey) for the same point. It is increasingly important for users to not only know the coordinate values, but also the accuracy of those coordinate values, so users can decide which coordinate values represent the best estimate of the true value for their applications.

1.1.2 Scope

Activities which collect or produce data coordinates include geodetic network and crustal motion surveys; national, regional, state, and county topographic mapping; bathymetric mapping and nautical charting; engineering, construction, and facilities management mapping and drawing; cadastral and boundary surveying; etc. These activities support geospatial data applications in areas such as transportation, community development, agriculture, emergency response, environmental management, and information technology.

This document is being developed in parts to address various activities. Each data activity will apply the same general accuracy standard to develop a reporting classification scheme for its particular data. The following parts have been submitted to date:

Part 2, STANDARDS FOR GEODETIC NETWORKS. Geodetic control surveys are usually performed to establish a basic control network (framework) from which supplemental surveying and mapping work, covered in other parts of this document, are performed. Geodetic network surveys are distinguished by use of redundant, interconnected, permanently monumented control points that comprise the framework for the National Spatial Reference System (NSRS) or are often incorporated into the NSRS. These surveys must be performed to far more rigorous accuracy and quality assurance standards than control surveys for general engineering, construction, or topographic mapping. Geodetic network surveys included in the NSRS must be performed to meet automated data recording, submission, project review, and least squares adjustment requirements established by the National Geodetic Survey (NGS). The lead agency is the Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, NGS; the responsible FGDC unit is the Federal Geodetic Control Subcommittee (FGCS).

Part 3, NATIONAL STANDARD FOR SPATIAL DATA ACCURACY. The National Standard for Spatial Data Accuracy (NSSDA) implements a testing and statistical methodology for positional accuracy of fully georeferenced maps and digital geospatial data, in either raster, point,

or vector format, derived from sources such as aerial photographs, satellite imagery, and ground surveys. The NSRS is the framework that references positions to the national datums. Positional accuracy of geodetically surveyed points in the National Spatial Reference System is reported according to Part 2, Standards for Geodetic Control Networks, Geospatial Positioning Accuracy Standards. NSRS points may also be selected as an independent source of higher accuracy to test positional accuracy of maps and geospatial data according to the NSSDA. The lead agency is the Department of the Interior, U.S. Geological Survey, National Mapping Division. The responsible FGDC unit is the Subcommittee on Base Cartographic Data.

In addition, two other parts have been identified for inclusion in this document and are under development:

Part 4, ENGINEERING, CONSTRUCTION, AND FACILITIES MANAGEMENT. This part will provide accuracy standards for engineering surveys and maps used to support planning, design, construction, operation, maintenance, and management of facilities, installations, structures, transportation systems, and related projects. It uses the NSSDA for accuracy testing and verification of fully georeferenced maps for A/E/C and Facility Management applications such as preliminary site planning and reconnaissance mapping. It will also provide guidance in developing positional accuracy specifications for geospatial data products, such as architectural and engineering drawings, construction site plans, regional master planning maps, and related Geographical Information Systems (GIS), Computer-Aided Drafting and Design (CADD), and Automated Mapping/Facility Management (AM/FM) products, that may not be referenced to a national datum and where accuracy is based on survey closure ratios or elevation differences. The lead agency is the Department of Defense, U.S. Army Corps of Engineers. The responsible FGDC unit is the Facilities Working Group.

Part 5, NAVIGATION CHARTS AND HYDROGRAPHIC SURVEYS. This part will specify minimum standards for hydrographic surveys so that hydrographic (sounding) data are sufficiently accurate and spatial uncertainty is adequately quantified for safe use by mariners. The accuracy of hydrographic surveying is highly dependent upon knowledge of tidal datum planes and the special accuracy requirements to support safe navigation. This part will provide a standardized methodology for evaluating survey data and reporting resultant data quality through a standard statistical approach. It will be based on the recently revised International Hydrographic Organization (IHO) Standard for Hydrographic Surveys, which is in the final stages of review by the international community. The lead agency is Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of the Coast Survey. The responsible FGDC subcommittee is the Bathymetric and Nautical Chart Subcommittee.

1.1.3 Applicability

Use Geospatial Positioning Accuracy Standards to evaluate and report the positional accuracy of spatial data produced, revised, or disseminated by or for the Federal Government. According to Executive Order 12906, Coordinating Geographic Data Acquisition and Access: the National Spatial Data Infrastructure (Clinton, 1994, Sec. 4. Data Standards Activities, item d), "Federal agencies collecting or producing geospatial data, either directly or indirectly (e.g. through

grants, partnerships, or contracts with other entities), shall ensure, prior to obligating funds for such activities, that data will be collected in a manner that meets all relevant standards adopted through the FGDC process.”

1.1.4 Related Standards

1.1.4.1 FGDC Standards

The Spatial Data Transfer Standard (SDTS) (ANSI-NCITS, 1998) specifies that a data quality report accompany the data in a standard transfer. Because the quality report will function in the assessment for fitness of use, it must also be obtainable in its entirety and separately from the actual data. The quality report consists of five portions: lineage, **positional accuracy**, attribute accuracy, logical consistency, and completeness. Positional accuracy reported according to Geospatial Positioning Accuracy Standards will be included in the data quality report.

Part 2, Data Quality Information, of Content Standards for Digital Geospatial Metadata (Federal Geographic Data Committee, 1998) adopts the five elements of data quality specified by SDTS. Consequently, positional accuracy reported according to Geospatial Positioning Accuracy Standards will be encoded in Metadata.

1.1.4.2 ISO Technical Committee (TC) 211 Geographic Information/Geomatics Standards

ISO Standard 15046-13, Geographic Information - Quality Principles defines a data quality model and identifies **positional accuracy** as a data quality element and various subelements of positional accuracy. It provides a means of measuring how well the data set maps geospatial phenomena according to its product specification.

ISO Standard 15046-14, Geographic Information - Quality - Evaluation Procedures provides data quality evaluation models for both data producers and data users. The procedures are used to determine data quality results consistent with the data quality model defined by ISO Standard 15046-13. They establish a framework to report data quality results in metadata and when necessary, in a separate data quality report.

1.1.5 Standards Development Procedures

Part 2, Standards for Geodetic Networks and Part 3, National Standard for Spatial Data Accuracy (NSSDA) were originally developed independently. Following the first public review of the NSSDA, in its previous version as National Cartographic Standards for Spatial Accuracy, the NSSDA was aligned with emerging standards from the Federal Geodetic Control Subcommittee (FGCS). The FGCS has broad participation from various Federal agencies. Noting how individual FGDC subcommittees and working groups were developing accuracy standards, the FGCS membership agreed to sponsor an FGDC standards project to compile the various accuracy standards into one document and minimize redundancies. The FGDC Standards Working Group has endorsed this approach. This is the first FGDC standards project to integrate standards for various data themes and applications.

1.1.6 Maintenance Authority

The U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, National Geodetic Survey, maintains Part 1, Reporting Methodology, Geospatial Positioning Accuracy Standards for the Federal Geographic Data Committee. Address questions concerning Part 1, Reporting Methodology, Geospatial Positioning Accuracy Standards to: Director, National Geodetic Survey, NOAA, N/NGS, 1315 East-West Highway, Silver Spring, Maryland 20910.

1.2 Accuracy Standard

All spatial data activities should develop a classification scheme following the standard given below. The standard for reporting positional accuracy is defined for horizontal and/or vertical coordinates, depending on the characteristics of the data sets.

Horizontal: The reporting standard in the horizontal component is the radius of a circle of uncertainty, such that the true or theoretical location of the point falls within that circle 95-percent of the time.

Vertical: The reporting standard in the vertical component is a linear uncertainty value, such that the true or theoretical location of the point falls within +/- of that linear uncertainty value 95-percent of the time. The reporting accuracy standard should be defined in metric (International System of Units, SI) units. However, accuracy will be reported in English (inch-pound) units where the point coordinates or elevations are reported in English units.

The method used to evaluate accuracy should be described. Examples include: statistical testing, least squares adjustment results, comparison with values of higher accuracy, repeat measurements, estimation, etc. The accuracy standard for point data in each part of the document will identify the type of application and if applicable, the accuracy level recommended for that application.

Coordinate values should be based on National datums. Horizontal coordinate values should preferably be referenced to the North American Datum of 1983 (NAD 83). Vertical coordinate values should preferably be referenced to North American Vertical Datum of 1988 (NAVD 88). However, it is recognized that many legacy maps and geospatial data are referenced to older national datums, such as the North American Datum of 1927 (NAD 27) and the National Geodetic Vertical Datum of 1929 (NGVD 29).

If coordinate values are not referenced to the National datum but their relationship to the national datum is known, identify the datum and its relationship to a National datum. If the relationship between the local datum and the National datum is not specified, identify the datum, but state that its relationship to a National datum is unspecified.

1.3 References

American National Standards Institute, Information Technology - Spatial Data Transfer Standard (SDTS) (ANSI-NCITS 320:1998): New York, New York.

Clinton, William J., 1994, Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure. Washington, D.C., Federal Register, Volume 59, Number 71, pp. 17671-17674.

Federal Geographic Data Committee, 1998, Content Standards for Digital Geospatial Metadata (version 2.0), FGDC-STD-001-1998: Washington, D.C., Federal Geographic Data Committee, 66 p.

Geodetic Survey Division, 1996, Accuracy Standards for Positioning, Version 1.0: Ottawa, Canada, Natural Resources Canada, 28 p.

National Geodetic Survey, 1986, Geodetic Glossary: Rockville, Maryland, National Geodetic Survey, 274 p.

Subcommittee for Base Cartographic Data, 1998, Final Draft Content Standards for Digital Gridded Land Elevation Data: Reston, Virginia, U.S. Geological Survey, 37 p.

Draft standards not released to the public:

ISO/Technical Committee 211 Geographic information/Geomatics, Working Group 3 - Geospatial Data Administration, ISO Standard 15046-13 Geographic Information - Quality - Principles

ISO/Technical Committee 211 Geographic information/Geomatics, Working Group 3 - Geospatial Data Administration, ISO Standard 15046-14 Geographic Information - Quality - Evaluation Procedures

Appendix 1-A
Glossary of Terms
(informative)

The following are definitions of various terms used throughout the Geospatial Positioning Accuracy Standards.

accuracy - closeness of an estimated (e.g., measured or computed) value to a standard or accepted [true] value of a particular quantity. (National Geodetic Survey, 1986).

NOTE Because the true value is not known, but only estimated, the accuracy of the measured quantity is also unknown. Therefore, accuracy of coordinate information can only be estimated (Geodetic Survey Division, 1996).

accuracy testing - process by which the accuracy of a data set may be checked.

check point - one of the points in the sample used to estimate the positional accuracy of the data set against an independent source of higher accuracy.

component accuracy - positional accuracy in each x, y, and z component.

confidence level - the probability that the true (population) value is within a range of given values.

NOTE in the sense of this standard, the probability that errors are within a range of given values.

dataset - identifiable collection of related data.

datum - any quantity or set of such quantities that may serve as a basis for calculation of other quantities. (National Geodetic Survey, 1986)

elevation - height of a point with respect to a defined vertical datum.

ellipsoidal height - distance between a point on the Earth's surface and the ellipsoidal surface, as measured along the perpendicular to the ellipsoid at the point and taken positive upward from the ellipsoid.

NOTE also called geodetic height (National Geodetic Survey, 1986)

horizontal accuracy - positional accuracy of a dataset with respect to a horizontal datum. (Adapted from Subcommittee for Base Cartographic Data, 1998)

horizontal error - magnitude of the displacement of a feature's recorded horizontal position in a dataset from its true or more accurate position, as measured radially and not resolved into x, y.

independent source of higher accuracy - data acquired independently of procedures to generate the dataset that is used to test the positional accuracy of a dataset.

NOTE the independent source of higher accuracy shall be of the highest accuracy feasible and practicable to evaluate the accuracy of the data set.

local accuracy - The *local accuracy* of a control point is a value that represents the uncertainty in the coordinates of the control point relative to the coordinates of other directly connected, adjacent control points at the 95-percent confidence level. The reported local accuracy is an approximate average of the individual local accuracy values between this control point and other observed control points used to establish the coordinates of the control point.

network accuracy - The *network accuracy* of a control point is a value that represents the uncertainty in the coordinates of the control point with respect to the geodetic datum at the 95-percent confidence level. For NSRS network accuracy classification, the datum is considered to be best expressed by the geodetic values at the Continuously Operating Reference Stations (CORS) supported by NGS. By this definition, the local and network accuracy values at CORS sites are considered to be infinitesimal, i.e., to approach zero.

orthometric height - distance measured along the plumb line between the geoid and a point on the Earth's surface, taken positive upward from the geoid. (adapted from National Geodetic Survey, 1986).

positional accuracy - describes the accuracy of the position of features (adapted from ISO Standard 15046-13)

precision - in statistics, a measure of the tendency of a set of random numbers to cluster about a number determined by the set. (National Geodetic Survey, 1986).

NOTE If appropriate steps are taken to eliminate or correct for biases in positional data, precision measures may also be a useful means of representing accuracy. (Geodetic Survey Division, 1996).

root mean square error (RMSE) - square root of the mean of squared errors for a sample.

spatial data - information that identifies the geographic location and characteristics of natural or constructed features and boundaries of earth. This information may be derived from, among other things, remote sensing, mapping, and surveying technologies (Federal Geographic Data Committee, 1998).

NOTE also known as geospatial data.

vertical accuracy - measure of the positional accuracy of a data set with respect to a specified vertical datum. (adapted from Subcommittee for Base Cartographic Data, 1998).

vertical error - displacement of a feature's recorded elevation in a dataset from its true or more accurate elevation.

well-defined point - point that represents a feature for which the horizontal position is known to a high degree of accuracy and position with respect to the geodetic datum.