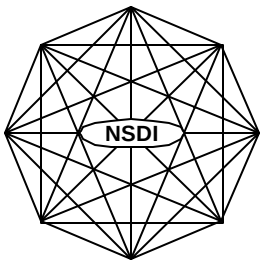
FGDC-STD-007.4-2002



National Spatial Data Infrastructure

Geospatial Positioning Accuracy Standards PART 4: Standards for Architecture, Engineering, Construction (A/E/C) and Facility Management

Facilities Working Group
Federal Geographic Data Committee

Federal Geographic Data Committee
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
Federal Emergency Management Agency • Library of Congress
National Aeronautics and Space Administration • National Archives and Records Administration
Tennessee Valley Authority

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.

For more information about the committee, or to be added to the committee's newsletter mailing list, please contact:

Federal Geographic Data Committee Secretariat
c/o U.S. Geological Survey
590 National Center
Reston, Virginia 22092

Telephone: (703) 648-5514
Facsimile: (703) 648-5755
Internet (electronic mail): gdc@usgs.gov
Anonymous FTP: ftp://fgdc.er.usgs.gov/pub/gdc/
World Wide Web: http://fgdc.er.usgs.gov/fgdc.html

CONTENTS

TABLES

4.1 INTRODUCTION

4.1.1 Objective

PART 4 provides accuracy standards for engineering drawings, maps, and surveys used to support planning, design, construction, operation, maintenance, and management of facilities, installations, structures, transportation systems, and related projects. It is intended to support geospatial mapping data used in various engineering documents, such as architectural, engineering, and construction (A/E/C) drawings, site plans, regional master planning maps, and related Geographical Infomation System (GIS), Computer-Aided Drafting and Design (CADD), and Automated Mapping/Facility Management (AM/FM) products. These products are typically created from terrestrial, satellite, acoustic, or aerial mapping techniques that output planimetric, topographic, hydrographic, or feature attribute data.

4.1.2 Scope

This standard defines accuracy criteria, accuracy testing methodology, and accuracy reporting criteria for object features depicted on A/E/C spatial data products and related control surveys. It references established voluntary standards that may be used for some smaller-scale A/E/C mapping applications. In addition, Appendix A contains general guidance for specifying accuracy criteria for selected types of A/E/C features or control surveys. Using the standards and guidance contained in this section, end users of A/E/C products (e.g., planners, designers, constructors) can specify surveying and mapping accuracy requirements needed for their projects or specific CADD/GIS layers, levels, or entities. From these specifications, data producers (e.g., surveyors, mappers, photogrammetrists) can determine the instrumentation, procedures, and quality control processes required to obtain and verify the defined accuracies.

4.1.3 Applicability

These standards are applicable to geospatial data products used on various A/E/C or facilities management projects. A/E/C projects are normally confined to small geographical areas typically less than 4,000 ha (10,000 acres) where simple survey techniques are employed to establish project control points, perform topographic or photogrammetric mapping, or provide construction layout and alignment control. Unlike geospatial map products covered under PART 3, A/E/C data products are often only locally referenced within a project site, may not contain absolute georeferenced coordinates, and are typically compiled at scales larger than 1:20,000 (1 in = 1,667 ft). These standards may apply to the following types of engineering applications: transportation systems (roads, railroads, airfields, canals); utility systems (water supply, sanitary sewer, fuel, communication, electrical, mechanical); residential, commercial, recreational, and industrial structures and facilities; flood control and navigation systems (dams, levees, locks); architectural site or landscape plans; engineering master planning studies; environmental mapping, modeling, and assessment studies; hydraulic and hydrological studies; geophysical exploration surveys; and construction measurement and payment surveys. These standards do not generally apply to - architectural, mechanical, or electrical detail data inside of a building or structure that are typically used with a CADD system for engineering and design.

4.1.4 Related Standards

This standard was largely taken from existing U.S. Army Corps of Engineers engineering, surveying, and mapping standards, and from Department of Defense Tri-Service Facility Engineering CADD/GIS standards--see References. The American Society for Photogrammetry and Remote Sensing (ASPRS) "Accuracy Standards for Large-Scale Maps" outlined in PART 3, Appendix B, also is directly applicable to PART 4--see paragraph 4.4.1 for specific relationships between ASPRS and Part 4.

This PART 4 may be used in conjunction with, or independent of, other Parts of the overall Geospatial Positioning Accuracy Standard.

PART 1 Reporting Methodology applies directly to this Part, in particular, accuracy standard reporting. Certain portions of Part 2, Standards for Geodetic Networks, apply to A/E/C projects or features within an A/E/C project that are connected by control surveys to an established regional geodetic control network (i.e., geo-referenced).

PART 2 does not apply to engineering, construction, topographic, or photogrammetric mapping surveys that are referenced to boundary control or physical features (streets, structures, etc.) within, or adjacent, to the project site. If A/E/C projects, or sub features within a project, are connected by control surveys to an established regional geodetic control network (i.e., geo-referenced), then certain portions of PART 2 may be applicable.

PART 3, National Standard for Spatial Data Accuracy, applies to those A/E/C map products that are fully geo-referenced. The spatial accuracy definitions, accuracy testing, and accuracy reporting criteria in PART 3 may be used for georeferenced A/E/C map products.

PART 4 applies to engineering drawings, maps, and surveys used to support planning, design, construction, operation, maintenance, and management of facilities, installations, structures, transportation systems, and related projects. Part 4 also applies to marine construction and dredging of navigation channels, including related hydrographic surveying support.

PART 5 should be consulted for hydrographic surveying standards applicable to preparation of nautical charts.

4.1.5 Standards Development Procedures

This standard was developed and periodically reviewed by the FGDC Facilities Working Group during the period 1996-1998. The initial draft of the standard was taken from U.S. Army Corps of Engineers Engineer Circular 1110-1-87, Standards for Maps, Drawings, Engineering Surveys, Construction Site Plans, and Related Geospatial Data Products.

4.1.6 Maintenance Authority

The U.S. Army Corps of Engineers is responsible for developing and maintaining the A/E/C geospatial positional accuracy data standards for the Facilities Working Group of the Federal Geographic Data Committee. Address questions concerning the standards to: Headquarters, U.S. Army Corps of Engineers, ATTN: CECW-EP, 20 Massachusetts Avenue NW, Washington, D.C. 20314-1000.

4.2 SPATIAL ACCURACY

As defined in PART 1, horizontal spatial accuracy is the circular error of a data set's horizontal coordinates at the 95% confidence level. Vertical spatial accuracy is defined by the linear error of a data set's vertical coordinates at the 95% confidence level. A spatial data set may include CADD/GIS object features, such as points, lines, areas, volumes. Accuracy reported at the 95% confidence level means that 95% of positional accuracies will be equal to or smaller than the reported accuracy value. The reported accuracy value is the cumulative result of all uncertainties, including those introduced by local project control coordinates, field topographic surveys, photogrammetric compilation, or final extraction of ground coordinate values in the spatial data. The reference scheme for radial or linear errors must be defined as relative to absolute geospatial reference networks or local (internal construction) schemes. Spatial data may be compiled to comply with one level of accuracy in the vertical component and another in the horizontal component.

4.3 REFERENCE DATUMS AND COORDINATE SYSTEMS

A/E/C projects should be referenced to local boundary control, spatial datums, plane coordinate grids, or vertical reference planes commonly used in the project area. Where practical and feasible, A/E/C projects should be referenced to national coordinate systems: horizontal coordinates should be in a system (e.g., State Plane Coordinate System, Universal Transverse Mercator Grid) based upon the North American Datum of 1927 (NAD 27) or North American Datum of 1983 (NAD 83), and vertical coordinates should be based on the National Geodetic Vertical Datum of 1929 (NGVD 29) or the North American Vertical Datum of 1988 (NAVD 88)--see PART 2. In most instances, however, A/E/C projects are not referenced to geodetic datums but are accurately tied into existing project or boundary control schemes relevant to the work. Reference datums and coordinate systems used shall be clearly identified in reporting A/E/C project data sets--see PART 1.

4.3.1 Local Construction Control

Projects that are not referenced to national coordinate systems based on geodetic datums shall be classified and reported as having a local reference or construction control system--local X-Y grid, chainage-offset, local reference benchmark elevation, etc. Accuracies of spatial data points are determined, reported, and certified relative to this local construction control scheme. If the

relationship between the local coordinate system and a National coordinate system is known, describe the relationship between the two systems. If the relationship between the local coordinate system and a National coordinate system is unknown, identify the local coordinate system but state that the relationship in "UNKNOWN"--see PART 1.

4.3.2 NSRS Referenced Control

Accuracies of A/E/C data set coordinates that are referenced to a National coordinate system are determined and reported relative to NSRS accuracies.

4.4 ACCURACY STANDARDS FOR A/E/C MAPS AND DRAWINGS

A/E/C drawings and related spatial data sets may have accuracy standards specified relative to (1) a required performance standard based on detailed project requirements, or (2) an established standard such as National Map Accuracy Standard (NMAS) or ASPRS. Typically, detailed site plan drawings at scales as large as 1:360 (1 in = 30 ft) have acceptable quality levels relative to critical construction specifications (e.g., required accuracy of invert elevations, road/curb grades, building locations, etc.). Preliminary planning or reconnaissance maps at smaller scales typically use general industry standards, such as ASPRS, NMAS, etc. Both types of standards may be specified for portions of CADD levels on the same project. Accuracy is evaluated and reported based on intended field data acquisition methodology or independent tests. For most A/E/C mapping, performance-based (outcome-based) specifications detail the end results to be achieved (i.e., map feature accuracy or accuracy standard) and not the means, or technical procedures, used to achieve those results. Performance specifications define the required accuracy criteria standards for each feature, object, class, layer, level, etc. of topographic and planimetric features depicted, along with related mapping limits, feature location and attribute requirements, scale, contour interval, map format, sheet layout, final data transmittal, archiving or storage requirements, and quality assurance procedures that will be used to verify conformance with the specified accuracy. Table A-3 in Appendix A provides examples of accuracy specifications commonly used for various types of A/E/C projects.

4.4.1 ASPRS Large-Scale Accuracy Standards

For generalized A/E/C site mapping work at scales from 1:2,400 (1 in = 200 ft) to 1:20,000 (1 in = 1,667 ft), the ASPRS "Accuracy Standards for Large-Scale Maps" may be used as a reference accuracy standard. The ASPRS accuracy standard is linearly dependent on the target horizontal scale or target contour interval; thus it is only applicable to mapped features that are compiled using a consistent type of data acquisition process (e.g., photogrammetry) where all spatial objects receive approximately the same accuracy. The ASPRS standard may not be especially applicable to detailed CADD/GIS features at larger scales down to 1:240 (1 in. = 20 ft) where CADD/GIS accuracies are usually project dependent, not scale dependent, and where accuracy standards are best defined based on project needs. As described in PART 3, the ASPRS standard defines map accuracy by comparing the mapped location of selected well-defined points to their "true" location, as determined by a more accurate, independent field survey. Alternately, when no independent

check is feasible or practicable, a map's accuracy may be estimated based on the accuracy of the technique used to locate mapped features--e.g., photogrammetry, GPS, total station, planetable. The ASPRS standard may be specified for site plans that are developed using conventional ground topographic surveying techniques (i.e., electronic total stations, planetables, kinematic DGPS).

4.4.2 Multiple Accuracies in A/E/C Drawings or CADD Levels

4.4.2.1 Horizontal and Vertical Accuracies

Spatial data may have different accuracies in the horizontal and vertical components.

4.4.2.2 A/E/C CADD/GIS Feature Layer/Level Accuracies

A/E/C data is often separated into various layers or levels in CADD/GIS systems. For example, planimetric features, utility invert elevations, and topographic elevations are often separated into three different levels or layers. These layers often contain objects or geographic areas that were surveyed/compiled to widely differing accuracies--e.g., utility invert elevations accurate to 0.05 ft versus topographic contours accurate to only 5 ft . If readily available, useful, and practical, these variable accuracies may be retained as an attribute to the layer or feature. In addition, accuracy information about these layers or features should be recorded in the accuracy section of the metadata for this database.

4.5 ACCURACY STANDARDS FOR A/E/C CONTROL SURVEYS

Control surveys are performed to locate, align, and stake out construction for civil and military projects, e.g., buildings, utilities, roadways, runways, flood control and navigation projects, training ranges, etc. They provide the base horizontal and vertical control used for preliminary studies, photogrammetric and topographic mapping, detailed site plan drawings for construction plans, construction stake out, construction measurement and payment, preparing as-built drawings, installation master planning mapping, and future maintenance and repair activities. Two types of survey accuracies may be specified: (1) Positional accuracy or (2) Relative closure ratio accuracy. PART 2 geodetic survey accuracy standards are not applicable to locally referenced A/E/C projects covered under this PART 4 standard.

4.5.1 Positional Accuracy

Base control surveys should be performed to a 95% positional confidence level consistent with the engineering or construction application or specifications. In general, horizontal and vertical control point accuracies should be twice as accurate as positional or elevation tolerances required for features or objects on the site plans or maps. Determination and verification of 95% radial positional accuracies will require use of rigorous least-squares adjustment techniques similar to that required under PART 2.

4.5.2 Relative Closure Ratio Accuracy

The accuracy of A/E/C control surveys may be evaluated, classified, and reported based on closure ratios for the horizontal point or the vertical elevation difference, as obtained in the field when points or benchmarks are redundantly occupied. This relative accuracy standard is applicable to most types of survey equipment and practices (e.g., total station traverses, differential GPS, differential spirit leveling). Many state codes and/or state minimum technical standards require that accuracies of A/E/C surveys be evaluated and reported using survey closure ratios. Tables A-1 and A-2 in Appendix A contain orders of closure commonly specified in A/E/C work. There is no simple correlation between relative closure accuracies and 95% radial positional accuracies; thus, determining a closure order based on a specified feature accuracy requirement is, at best, only an approximate process (see guidance in Appendix A). Where practical and allowable, positional accuracy standards should be used instead of closure accuracy standards.

4.6 ACCURACY TESTING AND VERIFICATION

Project specifications will specify the geographic extent of data to be tested and the amount of testing (if any). Map testing should be performed within a fixed time period after delivery. Normally, a mapping organization will perform quality control tests under quality assurance oversight by the requesting agency. Accuracies of A/E/C features are reported at the 95% confidence level. Field observed X, Y or Z coordinate differences are converted to 95% confidence errors following the procedures outlined in PART 3. Horizontal accuracy is tested by comparing the planimetric coordinates of well-defined ground points with coordinates of the same points from an independent source of higher accuracy, following the methodology outlined under PART 3. Vertical accuracy is tested by comparing the elevations of well-defined points with elevations of the same points as determined from a source of higher accuracy, also following the methodology outlined in PART 3. Both ground surface topography and object elevations may be tested.

4.7 ACCURACY REPORTING AND CERTIFICATION

4.7.1 Tested Products

Maps, surveys, and related geospatial data that are tested and found to comply with a specified standard shall have a certification statement. If applicable, the statement shall clearly indicate the target map scale at which the map or feature layer was developed.

4.7.2 Untested Products

Due to the high cost of field testing, not all deliverable map products will be tested. In such cases, the statement shall clearly indicate that the procedural ground surveying or aerial mapping specifications were designed and performed to meet a certain accuracy standard (project dependent, ASPRS, NMAS, etc.), but that the accuracy is estimated. An estimated accuracy statement is especially applicable to CADD, GIS, or FM databases that may be compiled from a variety of sources containing known or unknown accuracy reliability.

4.7.3 Reporting Units

Report accuracy of A/E/C spatial data in ground units using either metric (SI) units or English (IP) units, consistent with the project units.

4.7.4 Variable Accuracies

Report varying accuracies in the same spatial data set if information exists that relates accuracy to individual portions/objects of the data set, and only if such detailed sub-feature data set reporting is practical and warranted. If data of varying accuracies are composited and cannot be separately identified AND the data set is tested, report the accuracy value for the composited data. If a composited data set is not tested, report the accuracy value for the least accurate data set component.

4.7.5 Reporting Statements

Report tested and non-tested accuracies following general guidance provided in PART 3 (Accuracy Reporting).

4.8 REFERENCES

American Society for Photogrammetry and Remote Sensing (ASPRS) Specifications and Standards Committee, 1990, ASPRS Accuracy Standards for Large-Scale Maps: Photogrammetric Engineering and Remote Sensing, v. 56, no. 7, p. 1,068-1,070.

Federal Geographic Data Committee, Part 1, Reporting Methodology, Geospatial Positioning Accuracy Standards, FGDC-STD-0007.1-1998, Washington, D.C., 1998.

Federal Geographic Data Committee, Part 2., Standards for Geodetic Networks, Geospatial Positioning Accuracy Standards, FGDC-STD-007.2-1998: Washington, D.C., 1998.

Federal Geographic Data Committee, Part 3., National Standard for Spatial Data Accuracy, Geospatial Positioning Accuracy Standards, FGDC-STD-007.3-1998: Washington, D.C., 1998.

U.S. Army Corps of Engineers, Engineer Circular 1110-1-87, Standards for Maps, Drawings, Engineering Surveys, Construction Site Plans, and Related Geospatial Data Products, 1 July 1996.

U.S. Department of Defense, Tri-Service CADD/GIS Technology Center, Tri-Service A/E/C CADD Standards and Spatial Data Standards, (latest version at <http://tsc.wes.army.mil>)

APPENDIX A

RECOMMENDED A/E/C SURVEYING AND MAPPING STANDARDS

(Informative)

A.1 A/E/C CONTROL SURVEY STANDARDS

Engineering and construction surveys are normally specified, classified, and reported based on the horizontal (linear) point closure ratios or the vertical elevation difference closures. This performance criterion is most commonly specified in Federal agency, State, and local surveying standards. These control surveys are performed to establish control, location, alignment, and grade of various types of construction.

Local accuracy standards for survey control will vary with the type of construction. Commonly specified and reported Orders of horizontal closure accuracy standards are shown in Table A-1. Relative accuracy closure ratios for horizontal A/E/C surveys typically range from a minimum of 1:2,500 up to 1:20,000. Lower accuracies (1:2,500-1:5,000) are acceptable for earthwork, dredging, embankment, beach fill, and levee alignment stakeout and grading, and some site plan, curb and gutter, utility building foundation, sidewalk, and small roadway stakeout. Moderate accuracies (1:5,000) are used in most pipeline, sewer, culvert, catch basin, and manhole stakeouts, and for general residential building foundation and footing construction, major highway pavement, bridges, and concrete runway stakeout work. Somewhat higher accuracies (1:10,000-1:20,000) are used for aligning longer bridge spans, tunnels, and large commercial structures. For extensive bridge or tunnel projects, 1:50,000 or even 1:100,000 relative accuracy alignment work may be specified.

Orders of elevation closure ratio standards are shown in Table A-2. Most construction work is performed to Third-Order standards. These standards are applicable to most types of engineering and construction survey equipment and practices (e.g., total station traverses, differential GPS, differential spirit leveling).

Table A-1
Minimum Closure Standards for Engineering and Construction Control Surveys

Classification Order	Closure Standard	
Engr & Const Control	Distance (Ratio)	Angle (Secs)
Second-Order, Class I	1:50,000	3oN [1]
Second-Order, Class II	1:20,000	5oN
Third-Order, Class I	1:10,000	10oN
Third-Order, Class II	1: 5,000	20oN
Construction (Fourth-Order)	1: 2,500	60oN

[1] N = Number of angle stations

Table A-2
Minimum Elevation Closure Standards for Vertical Control Surveys

Classification Order	Elevation Closure Standard (ft)[1]	(mm)
First-Order, Class I	0.013oM	3oK
First-Order, Class II	0.017oM	4oK
Second-Order, Class I	0.025oM	6oK
Second-Order, Class II	0.035oM	8oK
Third-Order	0.050oM	12oK
Construction Layout	0.100oM	24oK

[1] oM or oK = square root of distance in Miles or Kilometers

A.2 TYPICAL ACCURACY STANDARDS FOR SELECTED A/E/C PROJECTS

General guidance for determining project-specific mapping accuracy standards is contained in Table A-3 at the end of this Appendix. This table may be used in developing specifications for map scales, feature location and elevation tolerances, and contour intervals for typical A/E/C projects. Since Table A-3 is based on current industry practices (and primarily those used by the Corps of Engineers), the scales and corresponding 95% positional tolerances shown in this table will differ from the ASPRS positional or elevation accuracy standards. Where available, project-

specific accuracy standards should be used rather than generic standards such as ASPRS. Metric (SI) conversions from IP units are only approximate since standardized use of SI units is still under development.

A.2.1 Target Scale and Contour Interval Specifications

Table A-3 provides commonly used map scales and contour intervals for a variety of A/E/C applications. The selected target scale for a map or construction plan should be based on the detail necessary to portray the project site. Topographic elevation density or related contour intervals are specified consistent with existing site gradients and the accuracy needed to define site layout, drainage, grading, etc., or perform quantity take offs. Photogrammetric mapping flight altitudes or ground topographic survey accuracy and density requirements are determined from the design map target scale and contour interval. In practice, design or real property features are located or layed out during construction to a far greater relative accuracy than that which can be scaled at the target (plot) scale, such as property corners, utility alignments, first-floor or invert elevations, etc. Coordinates/elevations for such items are usually directly input as feature attributes in a CADD or AM/FM database.

A.2.2 Feature Location Tolerances

Table A-3 indicates recommended positional and elevation tolerances of planimetric features at the 95% confidence level. These tolerances define the primary topographic mapping effort necessary to delineate physical features on the ground. A/E/C feature tolerances are defined relative to adjacent points within the confines of a specific area, map sheet, or structure--not to the overall project, installation boundaries, or an external geodetic control network. These relative accuracy tolerances are determined between two points that must functionally maintain a given accuracy tolerance between themselves, such as adjacent property corners; adjacent utility lines; adjoining buildings, bridge piers, approaches, or abutments; overall building or structure site construction limits; runway ends; catch basins; levee baseline sections; etc. Feature tolerances indicated are determined from the functional requirements of a typical project/structure (e.g., field construction/fabrication, field stakeout or layout, alignment, etc.). Few A/E/C projects require that relative accuracies be rigidly maintained beyond the range of the detailed design drawing for a project/structure (or its equivalent CADD design file limit). In many instances, a construction feature may need to be located to an accuracy well in excess of its plotted/scaled accuracy on a construction site plan; therefore, feature location tolerances should not be used to determine the required scale of a drawing. In these instances, surveyed coordinates, internal CADD grid coordinates, or rigid relative dimensions are used.

A.3 A/E/C TOPOGRAPHIC SURVEYS AND CONSTRUCTION SITE PLANS

Topographic surveys and construction site plan surveys are performed for the master planning, design, and construction of installations, buildings, housing complexes, roadways, airport facilities, flood control structures, navigation locks, etc. Construction plans are developed using electronic/DGPS total stations, plane tables, or low-altitude photogrammetric mapping methods. Some of the more common surveys are described below:

A.3.1 Reconnaissance Topographic Surveys

Reconnaissance surveys are typically performed at scales from 1:4,800 (1 in = 400 ft) to 1:12,000 (1 in = 1,000 ft). They provide a basis for general studies, site suitability decisions, or preliminary site layouts. General location of existing roads and facilities are depicted, and only limited feature and rough elevation detail is shown – 5- to 10-foot contour intervals usually being adequate. Enlarged USGS 1:24,000 maps may be substituted in many cases.

A.3.2 General/Preliminary Site Plans.

General or Preliminary site plans are performed at scales from 1:2,400 (1 in = 200 ft) to 1:4,800 (1 in = 400 ft). They depict general layout for potential construction, proposed transportation systems, training areas, and existing facilities.

A.3.3 Detailed Topographic Surveys for Construction Plans

These surveys are performed at scales from 1:240 (1 in = 20 ft) to 1:2,400 (1 in = 200 ft) and at contour intervals of 0.2 m or 0.5 m (1 or 2 ft). They are performed to prepare a base map for detailed site plans (general site layout plan, utility plan, grading plan, paving plan, airfield plan, demolition plan, etc.). The scope of mapping is confined to an existing/proposed building area. These drawings are used as a base for subsequent as-built drawings of facilities and utility layout maps (i.e., AM/FM databases).

A.3.4 As-Built Surveys and AM/FM Mapping

As-built drawings may require topographic surveys of constructed features, especially when field modifications are made to original designs. These surveys, along with original construction site plans, should be used as a base framework for a facility's AM/FM database. Periodic topographic surveys also may be required during maintenance and repair projects in order to update the AM/FM database.

Table A-3. RECOMMENDED ACCURACIES AND TOLERANCES: ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Vertical SI/IP	Contour Interval SI/IP
DESIGN, CONSTRUCTION, OPERATION & MAINTENANCE OF MILITARY FACILITIES				
Maintenance and Repair (M&R)/Renovation of Existing Installation Structures, Roadways, Utilities, Etc				
General Construction Site Plans & Specs:	1:500	100 mm	50 mm	250 mm
Feature & Topographic Detail Plans	40 ft/in	0.1-0.5 ft	0.1-0.3 ft	1 ft
Surface/subsurface Utility Detail Design Plans	1:500	100 mm	50 mm	N/A
Elec, Mech, Sewer, Storm, etc	40 ft/in	0.2-0.5 ft	0.1-0.2 ft	
Field construction layout		0.1 ft	0.01-0.1 ft	
Building or Structure Design Drawings	1:500	25 mm	50 mm	250 mm
	40 ft/in	0.05-0.2 ft	0.1-0.3 ft	1 ft
Field construction layout		0.01 ft	0.01 ft	
Airfield Pavement Design Detail Drawings	1:500	25 mm	25 mm	250 mm
	40 ft/in	0.05-0.1 ft	0.05-0.1 ft	0.5-1 ft
Field construction layout		0.01 ft	0.01 ft	
Grading and Excavation Plans	1:500	250 mm	100 mm	500 mm
Roads, Drainage, Curb, Gutter etc.	30-100 ft/in	0.5-2 ft	0.2-1 ft	1-2 ft
Field construction layout		1 ft	0.1 ft	
Recreational Site Plans	1:1,000	500 mm	100 mm	500 mm
Golf courses, athletic fields, etc.	100 ft/in	1-2 ft	0.2-2 ft	2-5 ft
Training Sites, Ranges, and Cantonment Area Plans	1:2,500 100-200 ft/in	500 mm 1-5 ft	1,000 mm 1-5 ft	500 mm 2 ft
General Location Maps for Master Planning	1:5,000	1,000 mm	1,000 mm	1,000 mm
AM/FM and GIS Features	100-400 ft/in	2-10 ft	1-10 ft	2-10 ft
Space Management Plans	1:250	50 mm	N/A	N/A
Interior Design/Layout	10-50 ft/in	0.05-1 ft		
As-Built Maps: Military Installation Surface/Subsurface Utilities (Fuel, Gas, Electricity, Communications, Cable,		100 mm 0.2-1 ft	100 mm 0.2 ft	250 mm 1 ft

Table A-3 (Contd). RECOMMENDED ACCURACIES AND TOLERANCES: ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Vertical SI/IP	Contour Interval SI/IP
Storm Water, Sanitary, Water Supply, Treatment Facilities, Meters, etc.)	1:1000 or 50-100 ft/in (Army) 1:500 or 50 ft/in (USAF)			
Housing Management GIS (Family Housing, Schools, Boundaries, and Other Installation Community Services)	1:5,000 100-400 ft/in	10,000 mm 10-15 ft	N/A	N/A
Environmental Mapping and Assessment Drawings/Plans/GIS	1:5,000 200-400 ft/in	10,000 mm 10-50 ft	N/A	N/A
Emergency Services Maps/GIS Military Police, Crime/Accident Locations, Post Security Zoning, etc.	1:10,000 400-2000 ft/in	25,000 mm 50-100 ft	N/A	N/A
Cultural, Social, Historical Plans/GIS	1:5000 400 ft/in	10,000 mm 20-100 ft	N/A	N/A
Runway Approach and Transition Zones: General Plans/Section Approach maps Approach detail	1:2,500 100-200 ft/in 1:5,000 (H) 1:1,000 (V) 1:5,000 (H) 1:250 (V)	2,500 mm 5-10 ft	2,500 mm 2-5 ft	1,000 mm 5 ft
DESIGN, CONSTRUCTION, OPERATIONS AND MAINTENANCE OF CIVIL TRANSPORTATION & WATER RESOURCE PROJECTS Site Plans, Maps & Drawings for Design Studies, Reports, Memoranda, and Contract Plans and Specifications, Construction plans & payment				
General Planning and Feasibility Studies, Reconnaissance Reports	1:2,500 100-400 ft/in	1,000 mm 2-10 ft	500 mm 0.5-2 ft	1,000 mm 2-10 ft
Flood Control and Multipurpose Project Planning, Floodplain Mapping, Water Quality Analysis, and Flood Control Studies	1:5,000 400-1000 ft/in	10,000 mm 20-100 ft	100 mm 0.2-2 ft	1,000 mm 2-5 ft

Table A-3 (Contd). RECOMMENDED ACCURACIES AND TOLERANCES: ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Feature Position Tolerance Vertical SI/IP	Contour Interval SI/IP
Soil and Geological Classification Maps	1:5,000 400 ft/in	10,000 mm 20-100 ft	N/A	N/A
Land Cover Classification Maps	1:5,000 400-1,000 ft/in	10,000 mm 50-200 ft	N/A	N/A
Archeological or Structure Site Plans & Details (Including Non-topographic, Close Range, Photogrammetric Mapping)	1:10 0.5-10 ft/in	5 mm 0.01-0.5 ft	5 mm 0.01-0.5 ft	100 mm 0.1-1 ft
Cultural and Economic Resource Mapping Historic Preservation Projects	1:10,000 1000 ft/in	10,000 50-100 ft	N/A	N/A
Land Utilization GIS Classifications Regulatory Permit Locations	1:5,000 400-1000 ft/in	10,000 mm 50-100 ft	N/A	N/A
Socio-Economic GIS Classifications	1:10,000 1000 ft/in	20,000 mm 100 ft	N/A	N/A
Grading & Excavation Plans	1:1,000 100 ft/in	1,000 mm 0.5-2 ft	100 mm 0.2-1 ft	1,000 mm 1-5 ft
Flood Control Structure Clearing & Grading Plans (e.g., revetments)	1:5,000 100-400 ft/in	2,500 mm 2-10 ft	250 mm 0.5 ft	500 mm 1-2 ft
Federal Emergency Management Agency Flood Insurance Studies	1:5,000 400 ft/in	1,000 mm 20 ft	250 mm 0.5 ft	1,000 mm 4 ft
Locks, Dams, & Control Structures Detail Design Drawings	1:500 20-50 ft/in	25 mm 0.05-1 ft	10 mm 0.01-0.5 ft	250 mm 0.5-1 ft
Spillways & Concrete Channels Design Plans	1:1,000 50-100 ft/in	100 mm 0.1-2 ft	100 mm 0.2-2 ft	1,000 mm 1-5 ft
Levees and Groins: New Construction or Maintenance Design Drawings	1:1,000 100 ft/in	500 mm 1-2 ft	250 mm 0.5-1 ft	500 mm 1-2 ft

Table A-3 (Contd). RECOMMENDED ACCURACIES AND TOLERANCES: ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Feature Position Tolerance Vertical SI/IP	Contour Interval SI/IP
Construction In-Place Volume Measurement	1:1,000	500 mm	250 mm	N/A
Granular cut/fill, dredging, etc.	40-100 ft/in	0.5-2 ft	0.5-1 ft	
Beach Renourishment/Hurricane Protection Project Plans	1:1,000 100-200 ft/in	1,000 mm 2 ft	250 mm 0.5 ft	250 mm 1 ft
Project Condition Survey Reports				
Base Mapping for Plotting Hydrographic Surveys: line maps or aerial plans	1:2,500 200-1,000 ft/in	10,000 mm 5-50 ft	250 mm 0.5-1 ft	500 mm 1-2 ft
Dredging & Marine Construction Surveys				
New Construction Plans	1:1,000 100 ft/in	2,000 mm 6 ft	250 mm 1 ft	250 mm 1 ft
Maintenance Dredging Drawings	1:2500 200 ft/in	5,000 mm 15 ft	500 mm 2 ft	500 mm 2 ft
Hydrographic Project Condition Surveys	1:2500 200 ft/in	5,000 mm 16 ft	500 mm 2 ft	500 mm 2 ft
Hydrographic Reconnaissce Surveys	-	5,000 m 15 ft	500 mm 2 ft	250 mm 2 ft
Offshore Geotechnical Investigations Core Borings /Probings/etc.	-	5,000 mm 5-15 ft	50 mm 0.1-0.5 ft	N/A
Structural Deformation Monitoring Studies/Surveys				
Reinforced Concrete Structures: Locks, Dams, Gates, Intake Structures, Tunnels, Penstocks, Spillways, Bridges	Large-scale vector movement diagrams or tabulations	10 mm 0.03 ft (long term)	2 mm 0.01 ft	N/A
Earth/Rock Fill Structures: Dams, Floodwalls	N/A	(same as above)	30 mm	15 mm

Table A-3 (Contd). RECOMMENDED ACCURACIES AND TOLERANCES: ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Feature Position Tolerance Vertical SI/IP	Contour Interval SI/IP
Levees, etc. -- slope/crest stability & alignment		0.1 ft (long term)	0.05 ft	
Crack/Joint & Deflection Measurements: piers/monoliths--precision micrometer	tabulations	0.2 mm 0.01 inch	N/A	N/A
REAL ESTATE ACTIVITIES: ACQUISITION, DISPOSAL, MANAGEMENT, AUDIT				
Maps, Plans, & Drawings Associated with Military and Civil Projects				
Tract Maps, Individual, Detailing				
Installation or Reservation Boundaries,	1:1,000	10 mm	100 mm	1,000 mm
Lots, Parcels, Adjoining Parcels, and	1:1,200 (Army)			
Record Plats, Utilities, etc.	50-400 ft/in	0.05-2 ft	0.1-2 ft	1-5 ft
Condemnation Exhibit Maps	1:1,000	10 mm	100 mm	1,000 mm
	50-400 ft/in	0.05-2 ft	0.1-2 ft	1-5 ft
Guide Taking Lines/Boundary Encroachment	1:500	50 mm	50 mm	250 mm
Maps: Fee and Easement Acquisition	20-100 ft/in	0.1-1 ft	0.1-1 ft	1 ft
General Location or Planning Maps	1:24,000	10,000 mm	5,000 mm	2,000 mm
	2,000 ft/in	50-100 ft	5-10 ft	5-10 ft
GIS or LIS Mapping, General				
Land Utilization and Management, Forestry	1:5,000	10,000 mm	N/A	N/A
Management, Mineral Acquisition	200-1,000 ft/in	50-100 ft		
Easement Areas and Easement	1:1,000	50 mm	50 mm	-
Delineation Lines	100 ft/in	0.1-0.5 ft	0.1-0.5 ft	
HAZARDOUS, TOXIC, RADIOACTIVE WASTE (HTRW) SITE INVESTIGATION, MODELING, AND CLEANUP				
General Detailed Site Plans	1:500	100 mm	50 mm	100 mm
HTRW Sites, Asbestos, etc.	5-50 ft/in	0.2-1 ft	0.1-0.5 ft	0.5-1 ft

Table A-3 (Contd). RECOMMENDED ACCURACIES AND TOLERANCES: ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Feature Position Tolerance Vertical SI/IP	Contour Interval SI/IP
Surface Geotoxic Data Mapping and Modeling	1:500 20-100 ft/in	100 mm 1-5 ft	500 mm 1-2 ft	500 mm 1-2 ft
Contaminated Ground Water Plume Mapping/Modeling	1:500 20-100 ft/in	1,000 mm 2-10 ft	500 mm 1-5 ft	500 mm 1-2 ft
General HTRW Site Plans & Reconnaissance Mapping	1:2,500 50-400 ft/in	5,000 mm 2-20 ft	1,000 mm 2-20 ft	1,000 mm 2-5 ft