IV. Standards and Specifications

A. Definitions
B. Control
C. Map
D. Boundary

IV. Standards and Specifications

A. Definitions

Standard: a goal or level to be achieved.

Specification: a set of rules defining procedures to achieve a standard.
Specifications are a structured and repeatable methodology.

A standard must be achieved by design not by accident.

IV. Standards and Specifications

B. Control Surveys

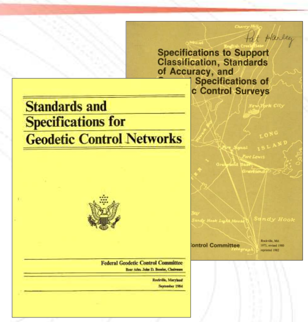
1. Traditional

a. Responsible Agency

FGCC - *Federal Geodetic Control Committee*

Representatives from federal agencies, eg,
- National Geodetic Survey
- US Geological Survey
- US Forest Service
- US Department of Transportation
- etc.

1984 Standards and Specifications.



IV. Standards and Specifications

B. Control Surveys

1. Traditional

b. Standards

Multi-level standards depending on use.

(1) Horizontal

Standard expressed in relative terms;

minimum distance precision between directly connected points

	First Order	Second Order		Third Order	
		Class I	Class II	Class I	Class II
Precision	1/100,000	1/50,000	1/20,000	1/10,000	1/5,000
Use	Primary national network, Metro area networks, Scientific studies.	Additional control to strengthen and densify primary network.	Further densification, Supplemental control.	Provide greater accessibility for lower accuracy local survey needs.	

IV. Standards and Specifications

B. Control Surveys

1. Traditional

b. Standards

Multi-level standards depending on use.

(2) Vertical

Standard expressed in relative terms;

maximum elevation difference to other points based on distance

	First Order		Second Order		Third Order
	Class I	Class II	Class I	Class II	Third Order
Relative Accy*	0.5 mm√K	0.7 mm√K	1.0 mm√K	1.3 mm√K	2.0 mm√K
Use	Basic framework of the National Network and of Metro area control; Extensive engr projects		Secondary Nat'l & Mertro control	Control Densification	Local control

*K: distance in km

IV. Standards and Specifications

B. Control Surveys

1. Traditional

c. Specifications

Divided into 5 sections

Section	Purpose
Network geometry	General layout to ensure geometric strength and adequate coverage.
Instrumentation	Types and characteristics of equipment of necessary to meet requisite measurement precisions.
Calibration procedures	Nature and frequency of equipment calibration; Tolerance levels.
Field procedures	Appropriate methods of observations; measurement frequency and tolerances.
Office procedures	Data analysis, testing, and adjustments.

IV. Standards and Specifications

B. Control Surveys

1. Traditional

c. Specifications

Can be extremely detailed depending on:

- Horizontal or vertical survey
- Order and class

Example: Triangulation

- Angle observations for first- and second-order class I surveys can only be made at night.
- Angle measurements: see table

Order / *Class*	*First*	*Second* *I*	*Second* *II*	*Third* *I*	*Third* *II*
Directions					
Number of positions	16	16	8 or 12†	4	2
Standard deviation of mean not to exceed	0.4"	0.5"	0.8"	1.2"	2.0"
Rejection limit from the mean	4"	4"	5"	5"	5"
Reciprocal Vertical Angles (along distance sight path)					
Number of independent observations direct/reverse	3	3	2	2	2
Maximum spread	10"	10"	10"	10"	20"
Maximum time interval between reciprocal angles (hr)	1	1	1	1	1

IV. Standards and Specifications

B. Control Surveys

2. Interim

1984 Standards developed before GPS and digital levels were prevalent.

a. GPS: Because GPS measurements were more accurate than traditional angle and distances, three new horizontal orders were introduced.

Order	*Distance Precision*
AA	1:100,000,000
A	1:10,000,000
B	1:1,000,000

b. Digital levels: Vertical orders did not change but *Instrument*, *Calibration*, and *Field Procedure* sections were updated to incorporate the new technology.

IV. Standards and Specifications

B. Control Surveys

2. Interim

c. Responsible Agency

(1) FGDC: Federal Geographic Data Committee (fgdc.gov)

Established in 1990 to create policies, specifications, and standards in support of the National Spatial Data Infrastructure (NSDI).

Addresses all aspects of spatial data, not just surveying.

(2) FGCS: Federal Geodetic Control Subcommittee

FGCC becomes the FGCS under the umbrella of the FGDC.

FGDC-STD-007.2-1998

Geospatial Positioning Accuracy Standards adopted by FGCS

IV. Standards and Specifications

B. Control Surveys

3. Current Standards

FGDC-STD-007.2-1998

Federal Geographic Data Committee FGDC-STD-007.2-1998
Draft Geospatial Positioning Accuracy Standards
Part 2: Standards for Geodetic Networks

CONTENTS

Page

IV. Standards and Specifications

B. Control Surveys

3. Current Standards

a. Position Uncertainty

Standards are defined by position uncertainty at the 95% confidence interval.

These are applicable for:
- horizontal
- ellipsoid height
- orthometric height

Accuracy Classification	*95% CI, m*
1 mm	0.001
2	0.002
5	0.005
1 cm	0.010
2	0.020
5	0.050
1 dm	0.100
2	0.200
5	0.500
1 m	1.000
2	2.000
5	5.000
10	10.000

IV. Standards and Specifications

B. Control Surveys

3. Current Standards

b. Methodology

FGDC-STD-007.2-1998 changes how specifications are defined for a standard.

Instead of identifying equipment and specific field procedures, an *Accuracy Determination* procedure is used:

- Minimally constrained least squares adjustment to ensure correct observation weighting and freedom from blunders.

- Local and network accuracy measures computed by random error propagation to determine the provisional accuracy.

- Accuracy checked by comparing minimally constrained adjustment results against established control; must meet a 95% CI.

IV. Standards and Specifications

B. Control Surveys

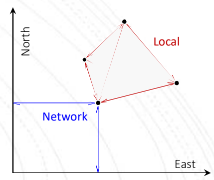
3. Current Standards

b. Methodology

Accuracies:

Local – point position uncertainty relative to other directly connected adjacent points at the 95% confidence interval.

Network - point position uncertainty relative to the geodetic datum at the 95% confidence interval.



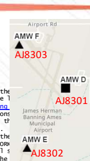
IV. Standards and Specifications

B. Control Surveys

Accuracies example: NSRS point *AMW F*

```
AJ8303 ************************************************************************
AJ8303  SACS        -  This is a Secondary Airport Control Station.
AJ8303  DESIGNATION -  AMW F
AJ8303  PID         -  AJ8303
AJ8303  STATE/COUNTY-  IA/STORY
AJ8303  COUNTRY     -  US
AJ8303  USGS QUAD   -  SLATER (2018)
AJ8303
AJ8303                        *CURRENT SURVEY CONTROL
AJ8303  ______________________________________________________________________
AJ8303* NAD 83(2011) POSITION- 41 59 55.26242(N) 093 37 31.13374(W)   ADJUSTED
AJ8303* NAD 83(2011) ELLIP HT-   251.419 (meters)        (06/27/12)   ADJUSTED
AJ8303* NAD 83(2011) EPOCH   -  2010.00
AJ8303* NAVD 88 ORTHO HEIGHT -   281.00  (meters)      921.9   (feet) GPS OBS
AJ8303  ______________________________________________________________________
AJ8303  NAVD 88 orthometric height was determined with geoid model    GEOID99
AJ8303  GEOID HEIGHT    -        -29.528 (meters)                     GEOID99
AJ8303  GEOID HEIGHT    -        -29.661 (meters)                     GEOID18
AJ8303  NAD 83(2011) X  -   -300,177.724 (meters)                     COMP
AJ8303  NAD 83(2011) Y  - -4,737,783.775 (meters)                     COMP
AJ8303  NAD 83(2011) Z  -  4,245,663.436 (meters)                     COMP
AJ8303  LAPLACE CORR    -        -12.31  (seconds)                    DEFLEC18
AJ8303
AJ8303  Network accuracy estimates per FGDC Geospatial Positioning Accuracy
AJ8303  Standards:
AJ8303         FGDC (95% conf, cm)     Standard deviation (cm)     CorrNE
AJ8303            Horiz  Ellip            SD_N   SD_E   SD_h      (unitless)
AJ8303  -------------------------------------------------------------------
AJ8303  NETWORK    0.54   1.33            0.25   0.18   0.68      0.08885749
AJ8303  -------------------------------------------------------------------
AJ8303  Click here for local accuracies and other accuracy information.
```

```
AJ8303  Horiz and Ellip are the                    soid height accuracies
AJ8303  at the 95% confidence l                    raphic Data Committee
AJ8303  Geospatial Positioning                     SD_N, SD_E and SD_h are
AJ8303  the standard deviations                    oordinates (NETWORK) or
AJ8303  of the difference in th                    in latitude, longitude
AJ8303  and ellipsoid height.                      ss) correlation
AJ8303  coefficient between the                    de components of either
AJ8303  the coordinate (NETWORK                    rence (LOCAL).  Dist is
AJ8303  the three-dimensional s                    stance, in km, between
AJ8303  station AJ8303 and the                     ation.  Local stations
AJ8303  are stations processed simultaneously in a session regardless of
AJ8303  distance.
AJ8303
AJ8303  Accuracy and standard deviation values are given in cm.
AJ8303
AJ8303  Type/PID  Horiz  Ellip  Dist(km)  SD_N   SD_E   SD_h        CorrNE
AJ8303  -------------------------------------------------------------------
AJ8303  NETWORK   0.54   1.33             0.25   0.18   0.68   +0.08885749
AJ8303  -------------------------------------------------------------------
AJ8303  LOCAL (002 points):
AJ8303  AJ8301    0.22   0.24    0.80     0.10   0.07   0.12   +0.11156016
AJ8303  AJ8302    0.26   0.51    1.30     0.12   0.09   0.26   +0.12574389
AJ8303
AJ8303  MEDIAN    0.24   0.37    1.05
AJ8303  -------------------------------------------------------------------
```



IV. Standards and Specifications

B. Control Surveys

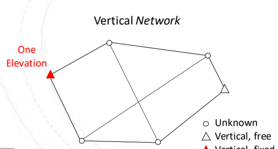
3. Current Standards

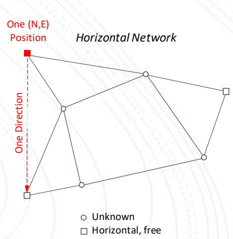
b. Methodology

Minimally constrained network adjustment.

All the measurements

Just enough control to fix the network in space



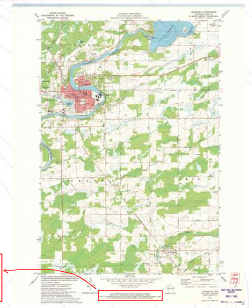


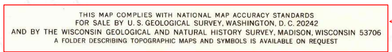
IV. Standards and Specifications

C. Map Accuracy

1. US National Map Accuracy Standards (USNMAS)

- Date back to 1937; latest version is 1947
- Purposes:
  - To assure the graphic accuracy of publicly funded maps.
  - Ensure efficient accurate data exchange between federal agencies.





IV. Standards and Specifications

C. Map Accuracy

1. US National Map Accuracy Standards (USNMAS)

a. Horizontal
- Error of ≤10% of pts tested on map must be within:
  - 1/30 inch at scales > 1:20,000,
  - 1/50 inch at scales < 1:20,000
- Points meas'd at publication scale.
- Only for well-defined points.

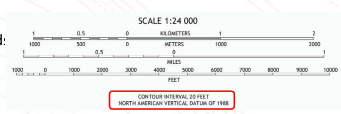
b. Vertical
- ≤10% of elevs tested can exceed one-half the contour interval.
- Vertical error can be compensated by allowable horiz error for the map scale

IV. Standards and Specifications

C. Map Accuracy

1. US National Map Accuracy Standards

c. Example: USGS 7.5' topoquad



Horizontal standard
- Scale 1:24,000 < 1:20,000
  - Use 1/50" positional accuracy.
- 1/50" x 20,000/1 = 400"
- 400" x 1'/12" = 33.3'
- 90% of tested points must be within ±33.3' of their map position.

Vertical standard
- CI = 20'
- 1/2 x 20' = 10'
- 90% of tested points must be within ±10' of their vertical map position.

IV. Standards and Specifications

C. Map Accuracy

2. FGDC

FGDC-STD-007.3-1998

National Standard for Spatial Data Accuracy (NSSDA), 1998

Uses Root Mean Squares Errors (RMSE) to determine positional accuracy at 95% CI.

RMS: square root of the average of the squared discrepancies.

e, n, z	Positions from map or digital data
E, N, Z	Positions from survey measurements
dE, dN, dZ	Discrepancy between map and survey positions
	dE = e – E
	dN = n – N
	dZ = z – Z

IV. Standards and Specifications

C. Map Accuracy

2. FGDC

Lotsa equations

Mean difference

$$MPV_E = \frac{\Sigma(dE_i)}{n} \qquad MPV_N = \frac{\Sigma(dN_i)}{n} \qquad MPV_Z = \frac{\Sigma(dZ_i)}{n}$$

Std Dev difference

$$\sigma_E = \sqrt{\frac{\Sigma(dE_i - MPV_E)^2}{n-1}} \qquad \sigma_N = \sqrt{\frac{\Sigma(dN_i - MPV_N)^2}{n-1}} \qquad \sigma_Z = \sqrt{\frac{\Sigma(dZ_i - MPV_Z)^2}{n-1}}$$

RMSE

$$RMSE_E = \sqrt{\frac{\Sigma(dE_i)^2}{n}} \qquad RMSE_N = \sqrt{\frac{\Sigma(dE_i)^2}{n}}$$

$$RMSE_Z = \sqrt{\frac{\Sigma(dZ_i)^2}{n}}$$

Vertical RMSE

Horiz RMSE

$$RMSE_R = \sqrt{RSME_E{}^2 + RSME_N{}^2}$$

95% CI

$$RMSE_R = 1.7308 \times RMSE_R \qquad RMSE_Z = 1.9600 \times RMSE_Z$$

IV. Standards and Specifications

C. Map Accuracy

2. FGDC

Example

	Map			Survey					
Pt	e	n	z	E	N	Z	dE	dN	dZ
GCP1	3,584.394	7,449.934	477.127	3,584.534	7,450.004	477.198	-0.140	-0.070	-0.071
GCP2	3,872.190	12,939.180	412.406	3,872.290	12,939.280	412.396	-0.100	-0.100	0.010
GCP3	3,893.089	1,979.824	487.292	3,893.072	1,979.894	487.190	0.017	-0.070	0.102
GCP4	3,927.194	16,084.129	393.591	3,927.264	16,083.979	393.691	-0.070	0.150	-0.100
GCP5	16,737.074	16,675.999	451.305	16,736.944	16,675.879	451.218	0.130	0.120	0.087
						MPV	-0.033	0.006	0.006
						Std.Dev	0.108	0.119	0.091
						RMSE	0.102	0.106	
						$RMSE_R$	0.147		0.081
						95% CI	0.255		0.160

Coordinates and elevations are in meters.

IV. Standards and Specifications

D. Boundary

1. ALTA/NSPS

American Land Title Association® (ALTA)
National Society of Professional Surveyors (NSPS)

Minimum Standard Detail Requirements
For ALTA/NSPS Land Title Surveys

MINIMUM STANDARD DETAIL REQUIREMENTS FOR ALTA/NSPS LAND TITLE SURVEYS
(Effective February 23, 2026)

IV. Standards and Specifications

D. Boundary

1. ALTA/NSPS

Section 3: Survey Standards and Standards of Care

Sub-Section E: Measurement Standards

i. "**Relative Positional Precision**" is the accepted indicator of measurement quality on an ALTA/NSPS Land Title Survey. It is defined as the length of the semi-major axis, expressed in meters or feet, of the error ellipse of the line connecting the monuments or witnesses marking adjacent boundary corners of the surveyed property at the 95 percent confidence level. Relative Positional Precision is most commonly estimated by the results of a correctly weighted least squares adjustment of the survey, or alternatively it can be estimated by the standard deviation of the distance between the monument or witness marking any boundary corner of the surveyed property and the monument or witness marking an immediately adjacent boundary corner of the surveyed property (called local accuracy) that can be computed using the full covariance matrix of the coordinate inverse between any given pair of points, understanding that Relative Positional Precision is based on the 95 percent confidence level.

IV. Standards and Specifications

D. Boundary

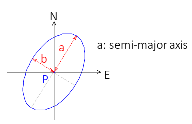
1. ALTA/NSPS

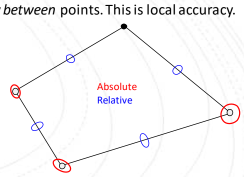
Section 3: Survey Standards and Standards of Care

Sub-Section E: Measurement Standards

Except for fixed points, each will have its own *absolute* error ellipse which an estimate of a point's position uncertainty.

A *relative* error ellipse is the uncertainty *between* points. This is local accuracy.





IV. Standards and Specifications

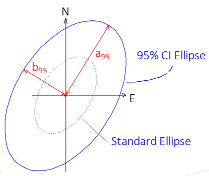
D. Boundary

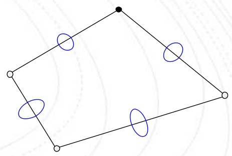
1. ALTA/NSPS

Section 3: Survey Standards and Standards of Care

Sub-Section E: Measurement Standards

Relative Position Precision (RPP) is the semi-major axis length at 95% confidence interval (CI) of a relative ellipse between adjacent property corners.





IV. Standards and Specifications

D. Boundary

1. ALTA/NSPS

Section 3: Survey Standards and Standards of Care

Sub-Section E: Measurement Standards

Maximum RPP is 2 cm (0.07 ft) plus 50 ppm between adjacent corners.

This is treated as a linear error:

$$RPP = 0.07ft + \left[D \times {}^{50}\!/_{1,000,000}\right]$$

D is the distance between points tested.

Remember: RPP is the *maximum* uncertainty; anything less is fine.

And because it is a result of random errors, it is ±.

IV. Standards and Specifications

D. Boundary

1. ALTA/NSPS

Section 3: Survey Standards and Standards of Care

Sub-Section E: Measurement Standards

Relative Position Precision

Error ellipses are determined from a properly weighted least squares adjustment of the measurements.

It is *not* a reflection of records research, evidence evaluation, or corner location.

The result of random errors in measurements.

Measurement quality is affected by:

- Equipment
- Conditions
- Procedures
- Personnel

IV. Standards and Specifications

D. Boundary

1. ALTA/NSPS

Section 3: Survey Standards and Standards of Care

Sub-Section E: Measurement Standards

"For any measurement technology or procedure used on an ALTA/NSPS Land Title Survey, the surveyor must (1) use appropriately trained personnel, (2) compensate for systematic errors, including those associated with instrument calibration, and (3) use appropriate error propagation and measurement design theory (selecting the proper instruments, geometric layouts, and field and computational procedures) to control random errors such that the maximum allowable Relative Positional Precision outlined in Section 3.E.v. below is not exceeded."

Site conditions may affect ability to achieve RPP on each line; must be noted on final plat.

IV. Standards and Specifications

D. Boundary

1. State

a. IAC 193C Engineering and Land Surveying Examining Board

IAC 193C-11.6(542B) Measurements

- Only made with instruments and methods capable of the required accuracy
- Measurements on plat shall be in conformance with the instrument capabilities.
- Min unadj'd closure: 1:5000 all traverse surveys, 1:10,000 subdiv boundaries
- Interior angle sum within 30" times the square root of the number of angles.
- Unadj'd meas error at least 1:5,000.
- 95% CI Relative positional tolerance:
  - a. Subdiv boundaries: ±(0.13 feet + 1:10,000)
  - b. All other: ±(0.26 feet + 1:5,000)
- On survey plat: Bearings or angles to the nearest 01 min, dists to 0.1 ft.

IV. Standards and Specifications

D. Boundary

1. State

Chapter 355 Standards for Land Surveying

Sec 355.5 Measurements

- Only made with instruments and methods capable of the required accuracy
- Measurements on plat shall be in conformance with the instruments capabilities.
- Interior angle sum within 30" times the square root of the number of angles.
- Dists shown in decimal ft according to federal foot definition


Questions?