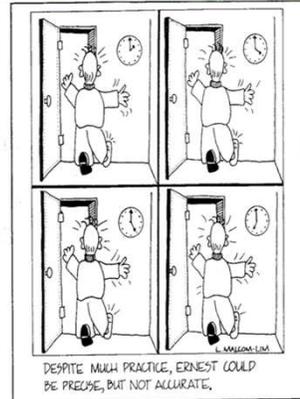


MENTORING MONDAYS
09 MAR 2026
JERRY MAHUN, PLS

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JERRYMAHUN.COM



Standards and Specifications

Upcoming FS/PS sessions

Mar 9 Survey Standards

Apr 6 Basic Riparian Concepts

May 6 Map Accuracy Standards

Jun 8 GIS Concepts

Jul 13 Photo: Single Vert Photos

Aug 10 Photo: Stereo Photos

I. DEFINITIONS

A. Standard: a goal or level to be achieved.
Science & Engineering: expressed as a tangible number

B. Specification:
Procedures to achieve a standard.
Structured and repeatable measurement methodology.

Evaluation methodology
Systematic way to verify standard has been met



C. Work together
Everyone shoots for the same identifiable goal and uses the same rules to achieve and verify.

Mentoring
MONDAYS

I. DEFINITIONS

Engineering Example

Engineer specifies concrete with a 4000 psi compressive strength and maximum 2-inch slump for a bridge deck - two standards.

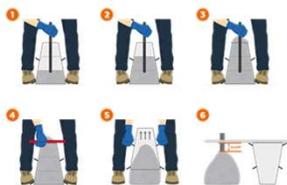
Specifications: American Society for Testing and Materials (ASTM)

C150-24 Std Spec for Portland Cement

C1611-21 Std Test Method for Slump Flow of Self-Consolidating Concrete

C470-23 Std Spec for Molds for Forming Concrete Test Cylinders

C873-23 Std Test Method for Comp Strength of Concrete Cylinders



Mentoring
MONDAYS

I. DEFINITIONS

D. Surveying Standards: Positional Certainty

Expressed either in relative or absolute terms.

Standards only applicable where project has specific formal accuracy needs.
Highway construction corridor vs Lot drainage plan

"Classic" standards were derived from long-used measurement types: angles, distances, elevations.

Standards levels refined as instrumentation accuracies increased.



Mentoring
MONDAYS

I. DEFINITIONS

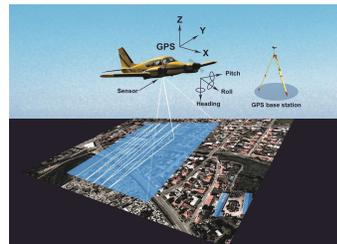
D. Surveying Standards

Different measurement technologies developed and rapidly adopted.

Didn't fit in existing standards framework.

Increased digital data collection, transmittal, integration.

Surveying role expansion; diversification; specializations.



Mentoring
MONDAYS

I. DEFINITIONS

D. Surveying Standards



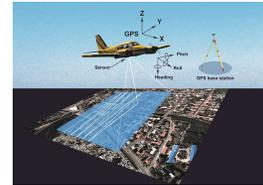
Different measurement technologies readily adopted.
Didn't fit in existing standards framework.

Increased digital data collection, transmittal, integration.

Surveying role expansion; diversification; specializations.

"Simple" Standards & Specifications (S&S) had to evolve.

Presentation emphasis on Control Survey S&S



Mentoring
MONDAYS

II. EVOLUTION

A. Pre-1970s

1921: *Special Publication No. 26*
General Instructions for the Field Work
of the U.S. Coast and Geodetic Survey

Evolved as instrumentation improved.

1957: Electronic Distance
Measurement.

Huge impact.

Replaced time-consuming taping.



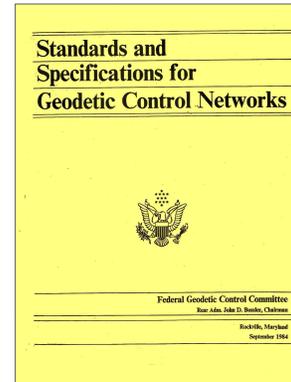
Mentoring
MONDAYS

II. EVOLUTION

B. Federal Geodetic Control Committee (FGCC)

Formally organized in early 1974.

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



Developed the *Standards and Specifications for Geodetic Control Networks*.
 Last issued in 1984.

Initially developed for expansion and densification of the Federal control network

Mentoring
MONDAYS

II. EVOLUTION

B. Federal Geodetic Control Committee (FGCC)

1. Content; Organization

2. Standards	2-1
2.1 Horizontal control network standards	2-1
2.2 Vertical control network standards	2-2
2.3 Gravity control network standards	2-3
3. Specifications	3-1
3.1 Introduction	3-1
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3.4 Inertial surveying	3-5
3.5 Geodetic leveling	3-6
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3.7 Satellite Doppler positioning	3-9
3.8 Absolute gravimetry	3-12
3.9 Relative gravimetry	3-13

Mentoring
MONDAYS

II. EVOLUTION

B. Federal Geodetic Control Committee (FGCC)

1. Content; Organization

Specifications are divided into categories

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.

Mentoring
MONDAYS

II. EVOLUTION

B. Federal Geodetic Control Committee (FGCC)

2. Standards

a. Horizontal

Standard expressed in relative terms;

minimum accuracy between directly connected points

	First Order	Second Order		Third Order	
		Class I	Class II	Class I	Class II
Accy: 1/a	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.	

$$a = \frac{d}{S}$$

d distance between points
S std dev between pts; min const'd ls adj

Mentoring
MONDAYS

II. EVOLUTION

B. Federal Geodetic Control Committee (FGCC)

2. Standards

a. Horizontal

Example:

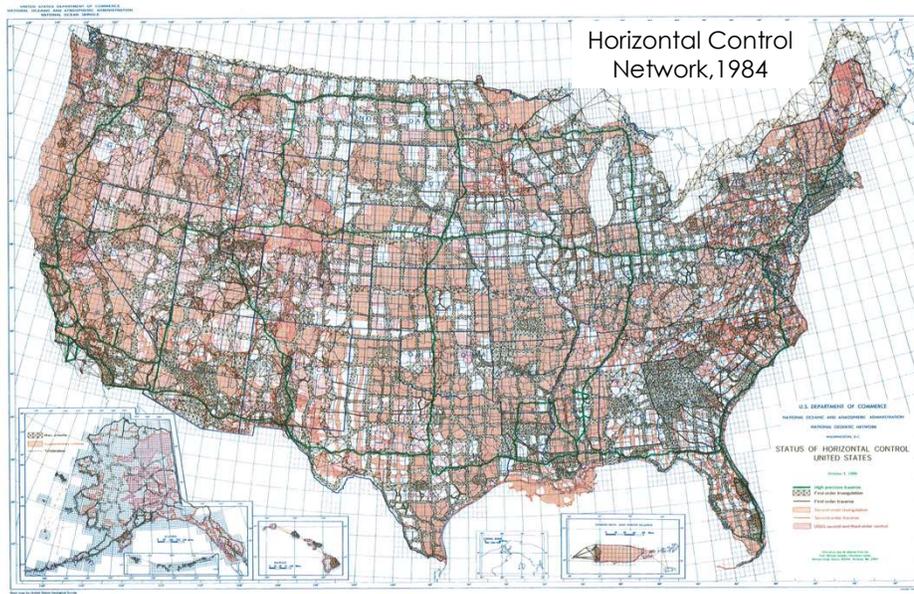
Maximum allowed error for Second Order Class I triangulation stations 10 km apart?

Second Order Class I Min Accy is 1/50,000

$$\text{Max Err} = \frac{1}{50,000} \times 10 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 20 \text{ cm}$$

Mentoring
MONDAYS

II. EVOLUTION



Mentoring
MONDAYS

II. EVOLUTION

B. Federal Geodetic Control Committee (FGCC)

2. Standards

b. Vertical

Maximum elevation difference to other points based on distance

	First Order		Second Order		Third Order
	Class I	Class II	Class I	Class II	
dElev rate, b	0.5	0.7	1.0	1.3	2.0
Use	Basic framework of the National Network and of Metro area control; Extensive engr projects		Secondary Nat'l & Metro control	Control Densification	Local control

$$b = \frac{S}{\sqrt{K}}$$

b constant rate; mm/\sqrt{km}

K dist between points; km

S std. dev of elev diff between pts from min const'd ls adj; mm

Mentoring
MONDAYS

II. EVOLUTION

B. Federal Geodetic Control Committee (FGCC)

2. Standards

b. Vertical

Example:

Second Oder Class I level run between two points 2.0 km apart.

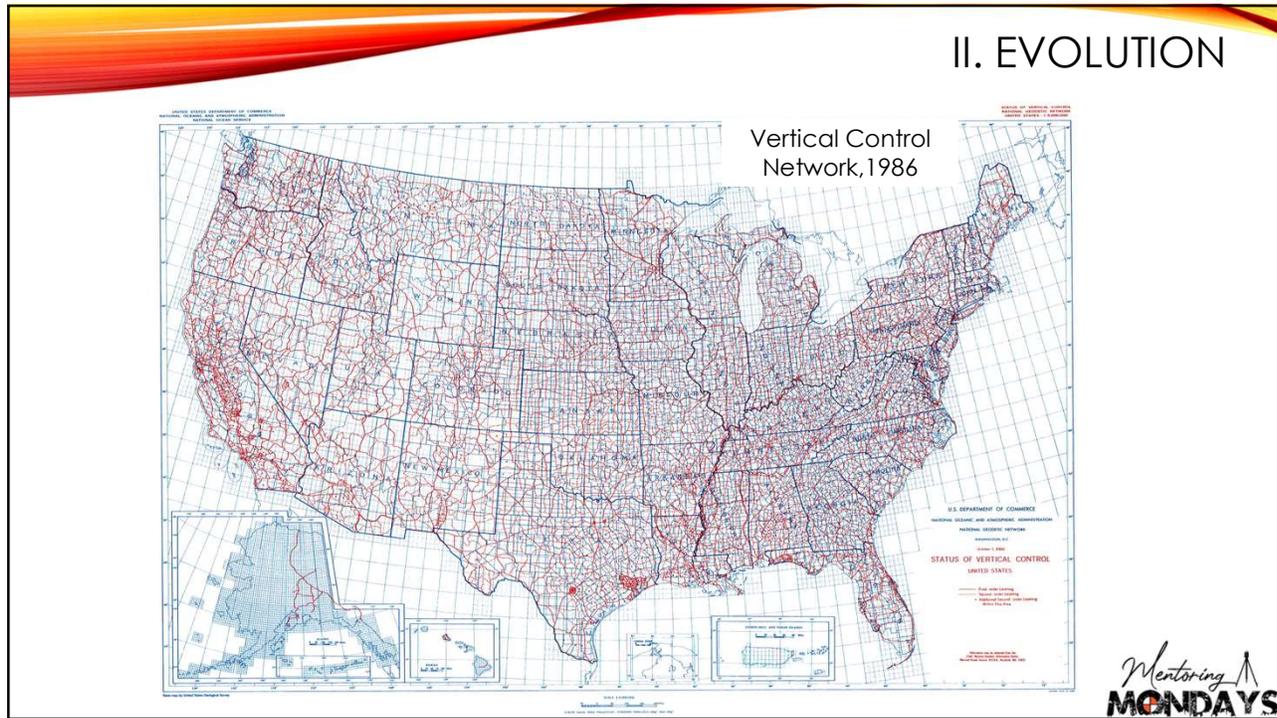
What is maximum allowable elevation difference between them?

$$s = 1.0 \text{ mm}/\sqrt{\text{km}} \times \sqrt{2.0 \text{ km}} = \pm 1.41 \text{ mm}$$



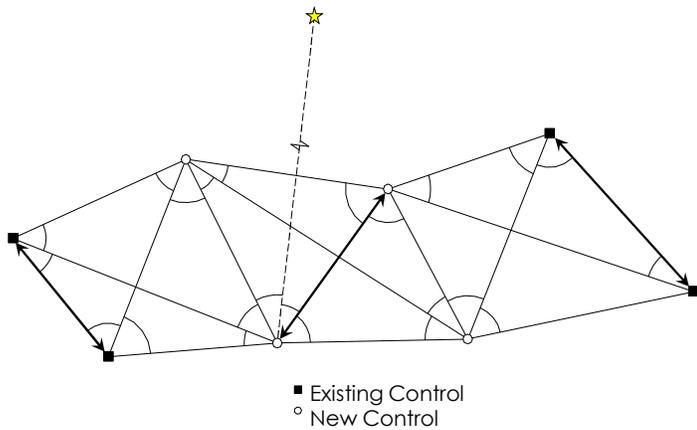
Mentoring
MONDAYS

II. EVOLUTION



II. EVOLUTION

B. Federal Geodetic Control Committee (FGCC)
3. Specifications
Triangulation



Mentoring MONDAYS

3.2 Triangulation

Triangulation is a measurement system comprised of joined or overlapping triangles of angular observations supported by occasional distance and astronomic observations. Triangulation is used to extend horizontal control.

Network Geometry

Order Class	First I	Second II	Third I	Third II
Station spacing not less than (km)	15	10	5	0.5
Average minimum distance angle [†] of figures not less than	40°	35°	30°	25°
Minimum distance angle [†] of all figures not less than	30°	25°	20°	20°
Base line spacing not more than (triangles)	5	10	12	15
Astronomic azimuth spacing not more than (triangles)	8	10	10	12

[†] Distance angle is angle opposite the side through which distance is propagated.

Instrumentation

Only properly maintained theodolites are adequate for observing directions and azimuths for triangulation. Only precisely marked targets, mounted stably on tripods or supported towers, should be employed. The target should have a clearly defined center, resolvable at the minimum control spacing. Optical plummets or collimators are required to ensure that the theodolites and targets are centered over the marks. Microwave-type electronic distance measurement (EDM) equipment is not sufficiently accurate for measuring higher-order base lines.

Order Class	First I	Second II	Third I	Third II
Theodolite, least count	0.2"	0.2"	1.0"	1.0"

Field Procedures

Theodolite observations for first-order and second-order, class I surveys may only be made at night. Reciprocal vertical angles should be observed at times of best atmospheric conditions (between noon and late afternoon) for all orders of accuracy. Electronic distance measurements need a record at both ends of the line of wet and dry bulb temperatures to ±1°C, and barometric pressure to ±5 mm of mercury. The theodolite and targets should be centered to within 1 mm over the survey mark or eccentric point.

Order Class	First I	Second II	Third I	Third II
Directions	16	16	8 or 12 [‡]	4
Number of positions	16	16	8 or 12 [‡]	4
Standard deviation of mean not to exceed	0.4"	0.5"	0.8"	1.2"
Rejection limit from the mean	4"	4"	5"	5"

Reciprocal Vertical Angles (along distance sight path)

Number of independent observations

direct/reverse	3	3	2	2
Maximum spread	10"	10"	10"	20"
Maximum time interval between reciprocal angles (hr)	1	1	1	1

Astronomic Azimuths

Observations per night

16	16	16	8
2	2	1	1

Standard deviation of mean not to exceed

0.45"	0.45"	0.6"	1.0"
-------	-------	------	------

Rejection limit from the mean

5"	5"	5"	6"
----	----	----	----

Electro-Optical Distances

Minimum number of days

2*	2*	1	1
----	----	---	---

Minimum number of measurements/day

2 [‡]	2 [‡]	2 [‡]	1
----------------	----------------	----------------	---

Minimum number of concentric observations/ measurement

2	2	1	1
---	---	---	---

Minimum number of offset observations/ measurement

2	2	2	1
---	---	---	---

Maximum difference from mean of observations (mm)

40	40	50	60
----	----	----	----

Minimum number of readings/observation (or equivalent)

10	10	10	10
----	----	----	----

Maximum difference from mean of readings (mm)

‡	‡	‡	‡
---	---	---	---

Infrared Distances

Minimum number of days

—	2*	1	1
---	----	---	---

Minimum number of measurements

—	2 [‡]	2 [‡]	1
---	----------------	----------------	---

Minimum number of concentric observations/ measurement

—	1	1	1
---	---	---	---

Minimum number of offset observations/ measurement

—	2	1	1
---	---	---	---

Maximum difference from mean of observations (mm)

—	5	5	10
---	---	---	----

Minimum number of readings/observation (or equivalent)

—	10	10	10
---	----	----	----

Maximum difference from mean of readings (mm)

—	‡	‡	‡
---	---	---	---

* 8 ft 0.3", 12 ft 1.0" resolution.
[†] two or more instruments.
[‡] one measurement at each end of the line.
[‡] as specified by manufacturer.
[‡] carried out at both ends of the line.

Office Procedures

Order Class	First I	Second II	Third I	Third II
Triangle Closure				
Average not to exceed	1.0"	1.2"	2.0"	3.0"
Maximum not to exceed	3"	3"	5"	10"
Side Checks				
Mean absolute correction by side equation not to exceed	0.3"	0.4"	0.6"	2.0"

A minimally constrained least squares adjustment will be checked for blunders by examining the normalized residuals. The observation weights will be checked by inspecting the postadjustment estimate of the variance of unit weight. Distance standard errors computed by error propagation in this correctly weighted least squares adjustment will indicate the provisional accuracy classification. A survey variance factor ratio will be computed to check for systematic error. The least squares adjustment will use models which account for the following:

- semimajor axis of the ellipsoid (a = 6378137 m)
- reciprocal flattening of the ellipsoid (1/f = 298.2572221)
- mark elevation above mean sea level (known to ± 1 m)
- geoid heights (known to ± 6 m)
- deflections of the vertical (known to ± 3")
- geoid correction
- slew normal correction
- height of instrument
- height of target
- sea level correction
- arc correction
- geoid height correction
- second velocity correction
- crustal motion



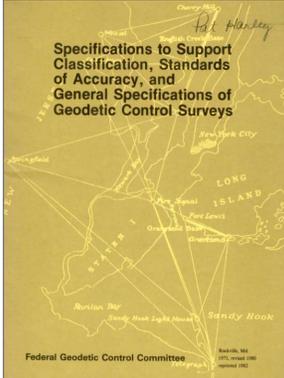
II. EVOLUTION

B. Federal Geodetic Control Committee (FGCC)

4. Augmenting Specifications

- Additional descriptive information
- Reconnaissance
- Network design
- Monumentation detail
- Error control
- Some limited alternative equipment use





II. EVOLUTION

C. Transitive Technologies

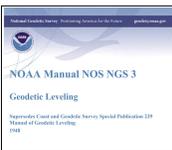
1. Digital Levels & Barcode Rods

Digital levels and bar code scales added to the Vertical FGCC-S&S.
Required massaging of *Instrumentation* and *Calibration* sections

Network *Geometry* and *Field Procedures* were modified.

Still around due to

NGS *Height Modernization* and *GPS on Benchmark* initiatives
GPS vertical (in)accuracy



Carl Zeiss Jena NI 002

Mentoring
MONDAYS

II. EVOLUTION

C. Transitive Technologies

2. GPS - Relative

First appeared in early 1980s.

Despite only a partial SV constellation and long static obs time, could routinely achieve 1/300,000 accy

*Geometric Geodetic Accuracy Standards and Specifications for Using GPS
Relative Positioning Techniques 1985-1988*

AA Order 1/100,000,000

A Order 1/10,000,000

B Order 1/1,000,000

Fundamentally changed surveying and S&S.



Macrometer V-1000
Earliest commercially available
GPS relative receiver.

Mentoring
MONDAYS

II. EVOLUTION

D. Federal Geodetic Control Subcommittee (FGCS)

1. What's in a Name?

Fundamental shift in S&S development

Bringing together other related spatial fields

S&S development & implementation across specialties

More emphasis on analysis

Federal Geographic Data Committee: Umbrella

Facilities Working Group

Subcommittee on Marine and Coastal Spatial Data

Subcommittee for Base Cartographic Data

Federal Geodetic Control Subcommittee (FGCS) - reconstituted FGCC



FGCC became the FGCS under the FGDC - got it?

Mentoring
MONDAYS

II. EVOLUTION

D. Federal Geodetic Control Subcommittee (FGCS)

2. Integrated Approach to Spatial Standards

Geo-Positioning Standards

Part 1: Reporting Methodology, FGDC-STD-007.1-1998

Part 2: Standards for Geodetic Networks, FGDC-STD-007.2-1998

Part 3: National Standard for Spatial Data Accuracy, FGDC-STD-007.3-1998

Part 4: Standards for Architectural, Engineering, Construction, and Facility Management, FGDC-STD-007.4-2002

Part 5: Standards for Nautical Charting Hydrographic Surveys, FGDS-STD-007.5-2005

FGCS is responsible for Part 2

Mentoring
MONDAYS

II. EVOLUTION

D. Federal Geodetic Control Subcommittee (FGCS) 3. Survey Standards

Federal Geographic Data Committee		FGDC-STD-007.2-1998
Draft Geospatial Positioning Accuracy Standards		
Part 2: Standards for Geodetic Networks		
CONTENTS		
		Page
2.1	Introduction	2-1
2.1.1	Objective	2-1
2.1.2	Scope	2-1
2.1.3	Applicability	2-1
2.1.4	Related Standards	2-1
2.1.5	Standards Development Procedures	2-2
2.1.6	Maintenance	2-2
2.2	Testing Methodology and Reporting Requirements	2-3
2.2.1	Accuracy Standards	2-3
2.2.2	Accuracy Determination	2-4
2.2.3	Accuracy Reporting	2-5
2.3	References	2-6



II. EVOLUTION

D. Federal Geodetic Control Subcommittee (FGCS)

3. Survey Standards

"Section 2.2.1 Accuracy Standards

Note that the following accuracy standards supersede and replace the accuracy standards found in FGCC 1984 and FGCC 1988 (see Section 2.3). The classification standard for geodetic networks is based on accuracy. Accuracies are categorized separately according to Table 2.1 for horizontal, ellipsoid height, and orthometric height. Note: although the largest entry in Table 2.1 is 10 meters, the accuracy standards can be expanded to larger numbers if needed."

Table 2.1 -- Accuracy Standards
Horizontal, Ellipsoid Height, and Orthometric Height

Accuracy Classification	95-Percent Confidence
	Less Than or Equal to:
1-Millimeter	0.001 meters
2-Millimeter	0.002 "
5-Millimeter	0.005 "
1-Centimeter	0.010 "
2-Centimeter	0.020 "
5-Centimeter	0.050 "
1-Decimeter	0.100 "
2-Decimeter	0.200 "
5-Decimeter	0.500 "
1-Meter	1.000 "
2-Meter	2.000 "
5-Meter	5.000 "
10-Meter	10.000 "



II. EVOLUTION

D. Federal Geodetic Control Subcommittee (FGCS)

3. Survey Standards

Sec 2.2.2 Accuracy Determination

1. Measurements, et al, examined to verify compliance with specifications of the intended accuracy.
2. Minimally constrained least squares adjustment to ensure correct observation weighting and freedom from blunders.
3. Local and network accuracy measures computed by random error propagation to determine the provisional accuracy.
4. Accuracy checked by comparing minimally constrained adjustment results against established control; must meet a 95 percent confidence level.



II. EVOLUTION

D. Federal Geodetic Control Subcommittee (FGCS)

3. Survey Standards

Accuracies are based on a **correctly weighted**, minimally constrained, least squares adjustment.

Weights are based on measurement, equipment, and setup errors.
Less error, greater weight.

A priori estimates

Can up date based on adjustment results

Positioning performance

Precision Static	H: 3 mm + 0.1 ppm V: 3.5 mm + 0.4 ppm
Static/Fast Static ¹	H: 3 mm + 0.5 ppm V: 5 mm + 0.8 ppm
PPP	H: 3 cm RMS ² V: 5 cm RMS ² Convergence time: < 5 mins ³
RTK ⁴	H: 5 mm + 0.5 ppm V: 10 mm + 0.8 ppm
RTK, TILT Compensated	RTK + 5 mm + 0.5 mm / ° tilt Compensation up to 60°

Project Options

Adjustment	General	Instrument	Listing File	Other Files
Conventional				
Distance Constant:	0.050000	FeetUS		
Distance PPM:	5.000			
Angle:	5.000000	Seconds		
Direction:	5.000000	Seconds		
Azimuth / Bearing:	5.000000	Seconds		
Zenith:	10.000000	Seconds		
Elev Diff Constant:	0.050000	FeetUS		
Elev Diff PPM:	0.000			
Centering Errors:				
Horiz Instrument:	0.000000	FeetUS		
Horiz Target:	0.000000	FeetUS		
Vertical:	0.000000	FeetUS		

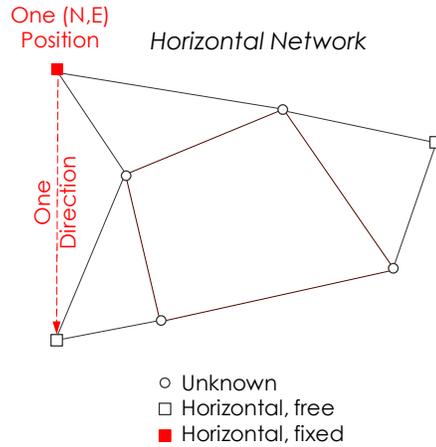
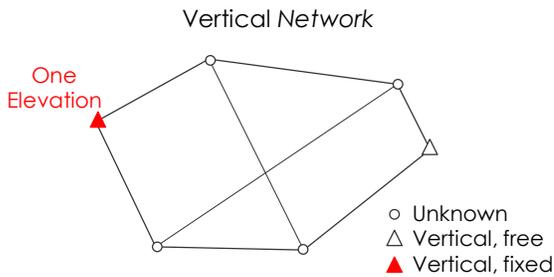


II. EVOLUTION

D. Federal Geodetic Control Subcommittee (FGCS)

3. Survey Standards

Accuracies are based on a correctly weighted, **minimally constrained**, least squares adjustment.



II. EVOLUTION

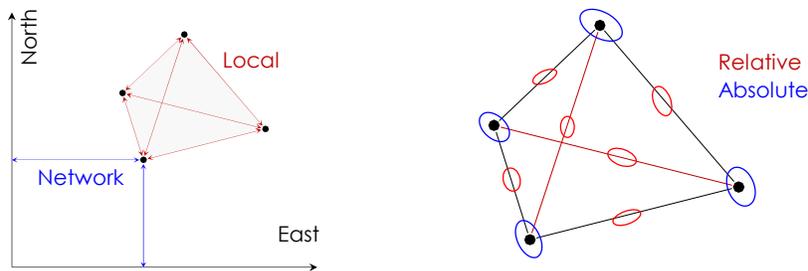
D. Federal Geodetic Control Subcommittee (FGCS)

3. Survey Standards

Local and Network Accuracy

Local – point position uncertainty relative to other directly connected adjacent points at the 95% confidence interval, a.k.a. *Relative*

Network - point position uncertainty relative to the geodetic datum at the 95% confidence interval, a.k.a. *Absolute*



II. EVOLUTION

E. So Are the FGCC-S&S Dead and Buried?

No, they exist as legacy

FGCC-S&S created in 1974

Replaces by FGCS-GS2 n 1998

In between:

NAD 1927

NGVD 29

NAD 1983 (86) - All observations plus new terrestrial

NAD 1983 (xx) - State HARNs individually added

NAD 1983 (NSRS 2007) - Only GPS observations

NAD 1983 (2011) - Only GPS observations

NAVD 88

↑ Legacy Data
Passive points

↓ No Legacy Data



E.1. NAD 27 Datasheet

OCTOBER 1957
PUBLISHED AND PRINTED BY:
U.S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
WASHINGTON, D.C.

HORIZONTAL CONTROL DATA

by the
Coast and Geodetic Survey
NORTH AMERICAN 1927 DATUM

QUAD 420891 STATION 1027
MISC
LATITUDE 42°30' TO 43°00'
LONGITUDE 89°00' TO 89°30'
DIAGRAM NK 16-4 ROCKFORD

ADJUSTED HORIZONTAL CONTROL DATA

NAME OF STATION: YAHARA
STATE: Wisconsin LOCALITY: Madison-Portage-Waukesha Area
Second-Order Triangulation SOURCE: G-11889 FIELD SKETCH: Wis. No. 33

GRID DATA	COORDINATES (Feet)	PLANE AZIMUTH ANGLE (Seconds)	MARK
STATE: Wis.	2,292,711.61	181° 05' 09"	AZIMUTH MARK
ZONE: 8	315,803.86	+ 0 25 47	
CODE: 4809			
STATE: W			
ZONE: 8			
CODE: 4809			

GEODETIC DATA	POSITION		SECOND-ORDER GEODETIC AZIMUTH (From mark)	DISTANCE (Meters)	ELEVATION (Meters)	ELEVATION (Feet)
	LATITUDE	LONGITUDE				
PLEASANT SPRINGS USGS	42° 51' 47.2765	89° 07' 55.3241	177° 43' 52.0"	10,052.632		
ALBION			272 11 44.87	6,059.904		
UTICA RADIO STATION ESE 29 TOWER			175 46 47.6	10,954.94		
AZIMUTH MARK			102 00 56.1			

DESCRIPTION OF TRIANGULATION STATION

NAME OF STATION: YAHARA STATE: Wisconsin COUNTY: DADE
YEAR: 1957 Described by: B. W. Jester
CHEF OF PARTY: W. N. Martin

NOTE: HEIGHT OF TELEGRAPH ABOVE STATION MARK 1 METERS HEIGHT OF LIGHT ABOVE STATION MARK 1 METERS
DISTANCES AND DIRECTIONS TO ADJUTANT MARKS, REFERENCE MARKS AND PROVISIONAL POINTS WHICH CAN BE SEEN FROM THE GROUND AT THE STATION

MARK	OBJECT	BEARING	DISTANCE	DIRECTION	
16a	PLEASANT SPRINGS (USGS 1676)1947	N (Approx.)	0.3 mile	00 00 00.0	
11a	Azimuth mark	N	28.46	11 40 13.0	
11b	R.M. 1	N	65.40	19 52 57.0	
11c	R.M. 2	N	(Approx.)	7.0 mile	03 24.6

The station is located about 4.0 miles west-north-west of Edgerton and about 6.0 miles southeast of Stoutton on property owned and occupied by Mr. Elmer Lee. It is 33 feet west of the centerline of a paved road, 14 feet north of the centerline of a gravel driveway, 90 feet east of the southeast corner of a red barn and 75 feet southeast of the southeast corner of a corn crib. The monument is 8 inches below the ground surface and the disk is stamped YAHARA 1957.

To reach the station from the junction of U.S. Highway 51 and State Highway 59 in Edgerton, go north on Highway 51 for 3.2 miles to a side road left. Turn left and go west for 0.25 mile to a paved crossroad. Continue ahead, west, for 1.6 miles to a T-road. Turn left and go south for 1.0 mile to a side road right. Turn right and go west for 1.45 miles to a crossroad. Turn right and go north for 0.1 mile to the station on left, west side of the road.

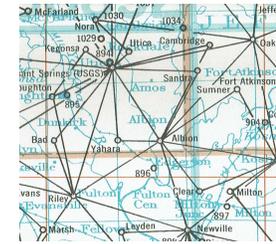
To reach the azimuth mark from the station go north on the paved road for 0.25 mile to The Milwaukee Road railroad crossing. Continue ahead, north for 0.05 mile to the azimuth mark on the right, east side of the road.

Reference mark 1 is 28 feet west of the centerline of the paved road, 50 feet southeast of the southeast corner of the corn crib and 42 feet south of the centerline of the gravel driveway. The monument is flush and the disk is stamped YAHARA NO 1 1957.

Reference mark 2 is 34 feet east of the centerline of the paved road, 50 feet south of a power pole with a transformer box on the east side and 55 feet northeast of the intersection of the gravel driveway and paved road. The monument is flush and the disk is stamped YAHARA NO 2 1957.

The azimuth mark is 26 feet east of the centerline of the paved road, 3 feet south of a fence corner, 34 feet south of a lone 48 inch oak tree and 2 feet southwest of a white witness post. The monument is flush and the disk is stamped YAHARA 1957.

II. EVOLUTION



II. EVOLUTION

E.1. NAD 83 Datasheet

NH1309 *****
 NH1309 DESIGNATION - YAHARA
 NH1309 PID - NH1309
 NH1309 STATE/COUNTY- WI/DANE
 NH1309 COUNTRY - US
 NH1309 USGS QUAD - COOKSVILLE (2018)
 NH1309
 NH1309 *CURRENT SURVEY CONTROL
 NH1309
 NH1309* NAD 83(1991) POSITION- 42 51 47.40667(N) 089 07 55.72846(W) ADJUSTED
 NH1309* NAVD 88 ORTHO HEIGHT - 277.66 (+/-2cm) 911.0 (feet) VERTCON3
 NH1309
 NH1309 GEOID HEIGHT - -34.155 (meters) GEOID18
 NH1309 LAPLACE CORR - -0.02 (seconds) DEFLEC18
 NH1309 HORZ ORDER - THIRD
 NH1309 VERT ORDER - THIRD ? (See Below)
 NH1309
 NH1309 The horizontal coordinates were established by classical geodetic methods
 NH1309 and adjusted by the National Geodetic Survey in November 1991.
 NH1309
 NH1309 The NAVD 88 height was computed by applying the VERTCON shift value to
 NH1309 the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 NH1309
 NH1309 SUPERSEDED SURVEY CONTROL
 NH1309
 NH1309 NAD 83(1986) - 42 51 47.39576(N) 089 07 55.72916(W) AD () 3
 NH1309 NAD 27 - 42 51 47.37660(N) 089 07 55.32410(W) AD () 3
 NH1309 NGVD 29 277.68 (m) 911.0 (f) LEVELING 0



II. EVOLUTION

E.1. NAD 27 Datasheet

MAY 1964
 PUBLISHED AND PRINTED BY:
 U.S. DEPARTMENT OF COMMERCE
 COAST AND GEODETIC SURVEY
 WASHINGTON D.C.

HORIZONTAL CONTROL DATA

by the
 Coast and Geodetic Survey
 NORTH AMERICAN 1927 DATUM

QUAD 420898 STATION 1015
 WIS
 LATITUDE 42°30' TO 43°00'
 LONGITUDE 89°30' TO 90°00'
 DIAGRAM NO. 16-A ROCKFORD

JOHNSON (Green County, Wis., C.A.S., 1935)

This station is in the southeast 1/4 sec. 4 T 4 N R 6 E about 4 1/2 miles airline northeast of Blanchardville, and 8.4 miles by road west of New Glarus, on land owned by S.J. Johnson, on highest ground in pasture on north side of Highway Wis. 39, about 0.25 mile west from where Highway curves and goes down steep grade; 0.4 mile east of long curve of highway; 200 feet east of intersection of north-south fenceline with right-of-way fence; 35 feet northwest of wild cherry tree in fence line; 15 feet north of right-of-way fence line; 26 feet north of center-line of Wis. 39. The mark is below the surface 12 inches. Surface, underground, reference, and at-truth marks are bronze tablets set in concrete as described in notes 1a, 7a, 11a, and 12a.

Reference mark No. 1 is east southeast of station in north line right-of-way and fence line; 51 feet east of wild cherry tree; 40 feet north of center-line of highway. The mark projects 5 inches.

Reference mark No. 2 is west southwest of station in north line of right-of-way and fence line, and 5 feet north of road bank. The mark projects 5 inches. The distance between the reference marks is 152.47 feet.

The azimuth mark is west of the station in south line of right-of-way of Wis. 39 about 100 feet east of long curve 10 feet to north and a dirt road going straight ahead; 300 feet west of cross road; 40 feet south of center-line of Wis. 39; 5 feet south of road bank. The mark projects 5 inches. Lights 100 feet above station BJUN come into view 25 feet above this station.

Lights 100 feet above station BJUN come into view 25 feet above this station.

To reach the station from the bridge over the Peatonica River to Blanchardville, follow Wis. 78 north and easterly 3.9 miles to Junction with Wis. 39. Turn right on Wis. 39 and follow 1.4 miles to station on left. From New Glarus go westerly on Wis. 39 for 8.4 miles to station on right.

OBJECT	DISTANCE	DIRECTION
DANE	0 00 00	0
R.N.No.1	81.71	23 25 05
R.N.No.2	72.95	180 01 44
As.Mk.	app. 0.35 mile	189 12 59.5
Spires, York Free Church, weather vane	1.5 st. W.V.G.	202 27 43.8
Tower, Ball, York Orthodox I.S. st. W.V.G.	204 31 57.5	
Spires, Perry Norwegian Luth. Chrch	201 10 28.8	

Height of telescope above station mark - 90 feet.

ADJUSTED HORIZONTAL CONTROL DATA

NAME OF STATION JOHNSON YEAR 1935

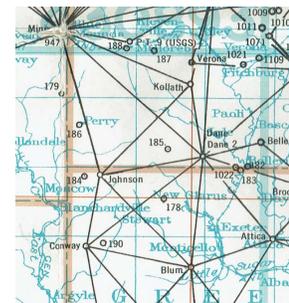
STATE Wisconsin LOCALITY Havana, Ill. to White Creek, Wisc. (North Section)

METHOD - Triangulation SOURCE G-4011 FIELD SKETCH ILL 9-11

GRID DATA	COORDINATES (FEET)	PL. ANGLE	MARK
STATE: WIS	X 2,058,415.76	88°02'50"	AZIMUTH MARK
ZONE: S	Y 307,273.04	+ 0 08 59	
CODE: 4803			
STATE:			
ZONE:			
CODE:			

GEODEIC DATA	POSITION		ELEVATION	
	LATITUDE	LONGITUDE	METERS	FEET
	42°50'34.5221	89°46'55.910		

TO STATION	GEODEIC AZIMUTH (From south)	DISTANCE	
		FEET	METERS
CONWAY	FIRST-ORDER	4,003 9100	10,090.44
MINTX	0°50'17.740	164 44 47.08	4,390 8669
KOLLATH	103 30 46.6	4,255 9667	17,591.47
DANE	160 09 19.7	4,168 8156	14,750.80
BJUN	258 28 45.12	4,252 6646	17,892.23
BJUN	314 07 56.13		
AZIMUTH MARK	TRIPED-ORDER		
YORK NOR EVAN LUTH CH SPIRE	88 11 48.3	3,339 314	2,384.3
YORK NOR EVAN LUTH CH SPIRE	101 26 35.8	3,268 836	1,857.1
MILWAUKEE ST PAUL AIRWAY BEACON NO 13	103 30 46.6	4,131 924	13,548.9
FERRY NORWEGIAN LUTHERAN CHURCH SPIRE	156 05 59.5	3,900 384	8,545.0
MT HOBBS MUNICIPAL TANK	160 09 19.7	4,274 985	18,858.8
MT HOBBS PUBLIC SCHOOLS CHIMNEY	190 53 28.1	4,260 998	18,236.9
MT HOBBS LUTHERAN CHURCH SPIRE	191 41 25.5	4,274 311	18,270.9
MT HOBBS ST IGNATIUS CHURCH SPIRE	192 42 41.7	4,274 237	18,805.4
FRIMROSE WEST CHURCH CUPOLA	192 42 41.7	4,259 768	19,078.9
FRIMROSE WEST CHURCH CUPOLA	244 25 42.5	4,018 907	10,448.0
FRIMROSE EAST CHURCH TOWER	245 05 10.4	4,021 901	10,514.8
MILWAUKEE ST PAUL AIRWAY BEACON NO 12	283 15 48.0	4,259 753	9,414.2



II. EVOLUTION

E.1. NAD 83 Datasheet

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NH1608 *****
NH1608 DESIGNATION - JOHNSON
NH1608 PID - NH1608
NH1608 STATE/COUNTY- WI/GREEN
NH1608 COUNTRY - US
NH1608 USGS QUAD - BLANCHARDVILLE (2018)
NH1608
NH1608 *CURRENT SURVEY CONTROL
NH1608
NH1608* NAD 83(2011) POSITION- 42 50 34.33689(N) 089 46 56.35673(W) ADJUSTED
NH1608* NAD 83(2011) ELLIP HT- 317.474 (meters) (06/27/12) ADJUSTED
NH1608* NAD 83(2011) EPOCH - 2010.00
NH1608* NAVD 88 ORTHO HEIGHT - 351.1 (meters) 1152. (feet) VERTCON3
NH1608
NH1608 GEOID HEIGHT - -33.788 (meters) GEOID18
NH1608 NAD 83(2011) X - 17,795.734 (meters) COMP
NH1608 NAD 83(2011) Y - -4,684,039.461 (meters) COMP
NH1608 NAD 83(2011) Z - 4,314,935.105 (meters) COMP
NH1608 LAPLACE CORR - 0.56 (seconds) DEFLEC18
NH1608
NH1608 Network accuracy estimates per FGDC Geospatial Positioning Accuracy
NH1608 Standards:
NH1608 FGDC (95% conf, cm) Standard deviation (cm) CorrNE
NH1608 Horiz Ellip SD_N SD_E SD_h (unitless)
NH1608 -----
NH1608 NETWORK 3.90 3.98 1.05 1.88 2.03 -0.25097645
NH1608 -----
NH1608 Click here for local accuracies and other accuracy information.
    
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II. EVOLUTION

E.1. NAD 83 Datasheet

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NH1608 ACCURACIES - Complete network and local accuracy information.
NH1608 DESIGNATION - JOHNSON
NH1608 PID - NH1608
NH1608 Horiz and Ellip are the horizontal and ellipsoid height accuracies
NH1608 at the 95% confidence level per Federal Geographic Data Committee
NH1608 Geospatial Positioning Accuracy Standards. SD_N, SD_E and SD_h are
NH1608 the standard deviations (one sigma) of the coordinates (NETWORK) or
NH1608 of the difference in the coordinates (LOCAL) in latitude, longitude
NH1608 and ellipsoid height. CorrNE is the (unitless) correlation
NH1608 coefficient between the latitude and longitude components of either
NH1608 the coordinate (NETWORK) or coordinate difference (LOCAL). Dist is
NH1608 the three-dimensional straight-line slope distance, in km, between
NH1608 station NH1608 and the corresponding local station. Local stations
NH1608 are stations processed simultaneously in a session regardless of
NH1608 distance.
NH1608 Accuracy and standard deviation values are given in cm.
NH1608 Type/PID Horiz Ellip Dist(km) SD_N SD_E SD_h CorrNE
NH1608 -----
NH1608 NETWORK 3.90 3.98 1.05 1.88 2.03 -0.25097645
NH1608 -----
NH1608 LOCAL (007 points):
NH1608 NH0943 2.02 2.23 4.12 0.56 0.97 1.14 -0.22477372
NH1608 NH0939 1.87 3.14 5.24 0.95 0.13 1.60 +0.04331544
NH1608 NH0941 2.02 2.12 6.84 0.55 0.97 1.08 -0.23580162
NH1608 NH0936 1.48 2.61 8.21 0.75 0.16 1.33 -0.08955868
NH1608 NH0937 2.06 3.55 10.47 1.05 0.17 1.81 +0.02575059
NH1608 NH0934 2.74 2.90 11.94 0.74 1.32 1.48 -0.23214961
NH1608 NH0932 2.84 2.96 16.41 0.82 1.35 1.51 -0.26168730
NH1608
NH1608 MEDIAN 2.02 2.90 8.21
    
```



III. SUMMARY

FGCC *Standards and Specifications for Geodetic Control Networks*

Superseded by

FGCS *Standards for Geodetic Networks*,

FGCC - Legacy standard

On NSRS passive points

Adopted by Sta and Local level and may still be in use there

Control, PLS remonumentation, etc

Can still be useful in other applications

FGCS - current NSRS standard

Easy to do, but don't confuse the two:

FGCC: Orders & Classes

FGCS: Local & Network Accuracy

Mentoring
MONDAYS

Questions?



WILD T-4 The Ultimate Theodolite
Used for astronomic observations.
"Broken back" telescope: eyepiece
on horizontal axis

Weight: 60 kg (132 lbs),
Circle resolution: 0.1"H, 0.2" V
22-1/2 inch focal length
Shortest sight distance ~100m

Mentoring
MONDAYS