

State Plane Coordinates – Azimuths and Convergence Angles and California Laws on the California Coordinate System

State Plane Coordinates - Continued

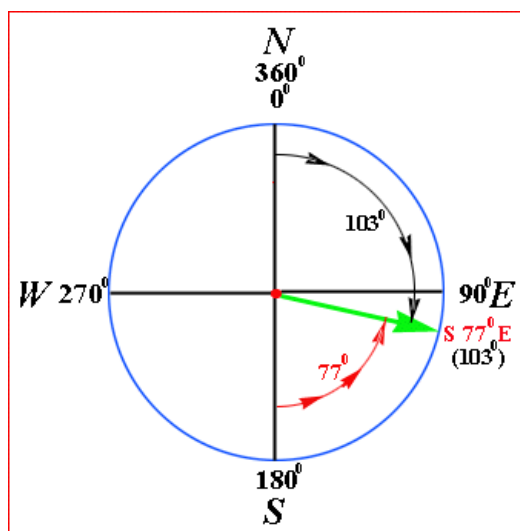
The last two lessons dealt with concepts and calculation methods for the forward computation of converting a NAD83 geographic latitude and longitude to a CCS83 northing and easting, the inverse computation of converting a CCS83 northing and easting to a NAD83 geographic latitude and longitude, and the zone to zone transformation of a CCS83 northing and easting.

This lesson will talk about azimuths, the relationship between astronomically determined azimuths and geographic azimuths, and the convergence angle (mapping angle) and how it is used to relate geographic azimuths to grid azimuths. It will also go into a discussion of the California laws that affect the CCS system including the California Resources Code, Sections 8801 – 8819.

Azimuths and Convergence Angles

Before discussing azimuths a brief review of “north” is necessary. (This information as well as the brief general discussion on azimuths) should be well understood by the student from previous periods in the apprenticeship program.) There are several types of north. Some of them are astronomic north, geographic north, grid north, and magnetic north.

Astronomic north is with respect to the astronomic meridian, which varies from point to point in an irregular manner under the influence of gravity. Geographic north is with respect to the reference ellipsoidal meridian, which differs from the astronomic meridian by a varying amount. Grid north is with respect to a central meridian of a mapping projection. Finally, magnetic north is the direction of the magnetic field of the earth. This also varies from point to point (and over time) in an irregular manner. The astronomic north is often used (incorrectly) in computations associated with geographic values, although the geographic north is what is required. Magnetic north and azimuths related to it will be left out of the remainder of this lesson.



The selection of north (or in some instances south) is dependent on the intended uses of the resultant surveying products. From the selected north, azimuths can be developed.

An azimuth is defined as:

1. *The horizontal angle of the observer's bearing in surveying, measured clockwise from a referent direction, as from the north, or from a referent celestial body, usually Polaris.*
2. *An azimuth is defined as a horizontal angle reckoned clockwise from the meridian.*

Because astronomic north, geographic north, and grid north are different, the produced azimuths for the same line between two stations on the earth are different.

Astronomic Azimuth and its Relationship to a Geographic Azimuth

In addition to having a different north, an astronomic azimuth is fundamentally based on the true shape and rotation of the earth, while a geographic azimuth is based on an underlying reference ellipsoid.

The relationship between astronomic azimuths and geographic azimuths, known as the Laplace correction or Laplace equation, was created from the observations made at several known stations. These stations are known as Laplace stations, named after the French mathematician Pierre-simon Laplace (1749-1827). At these stations the deflection of the vertical, or the angle between the plumb line (this line is affected by gravity) and the normal to the reference ellipsoid, was resolved into a north-south component that is equal to the difference between the astronomic latitude and the geographic latitude, and an east-west component proportional to the difference between astronomic longitude and geographic longitude. These corrections are known as Laplace corrections

The relationship between an astronomic azimuth and a geographic azimuth is realized by the following equation:

$$\text{Geographic azimuth} = \text{Astronomic azimuth} + \text{Laplace correction}$$

Geographic Azimuth and its Relationship to a Grid Azimuth

Now the discussion will shift back to the ideas that are relevant to the state plane coordinate system, CCS83.

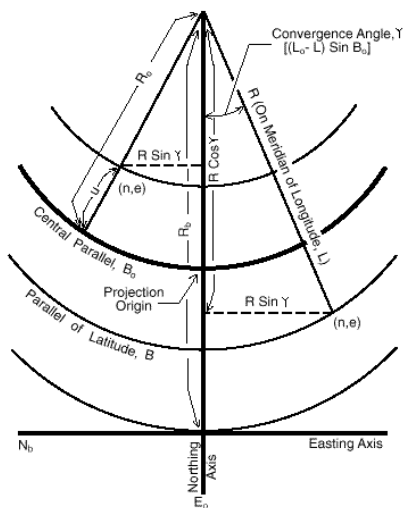


Figure 11-4. Conversion triangle.

To the left is the now familiar picture of the conversion triangle showing the relationship of the NAD83 geographic system to the CCS83 grid. The convergence angle (γ) for a particular station is the angle between the geographic longitude of that station projected to the apex of the Lambert secant cone and the grid's north axis. Note: the convergence angle (γ) varies with longitude.

In the previous lessons, the forward and inverse computations were discussed. As part of those computations, the convergence angle (mapping angle) between the NAD83 geographic system and the CCS83 grid system was computed. If the station has a known geographic coordinate of latitude and longitude then the convergence angle is calculated with the following equation and definitions:



Geographic to Grid Conversion

- Determine the Plane Convergence: **g**

$$\gamma = (L_0 - L)\sin(B_0)$$

g = convergence angle

L = west longitude of the station

L_0 = longitude of the projection and grid origin
(tableted constant)

$\sin(B_0)$ = sine of the latitude of the projection origin
(tableted constant)

If the station has a known CCS83 northing and easting then the convergence angle is calculated with the following equation and definitions:



Grid to Geographic Conversion

- Determine the Plane Convergence: **g**

$$\mathbf{g} = \arctan[(e - E_0)/(R_b - n + N_b)]$$

g = convergence angle at the station

e = easting of station

E_0 = easting of the projection origin (tableted constant)

R_b = mapping radius of the grid base (tableted constant)

n = northing of the station

N_b = northing of the grid base (tableted constant)

Note: When calculating a geographic azimuth from a grid azimuth or the reverse the station used to calculate the convergence angle must be specified.

The relationship of the geographic azimuth and the grid azimuth from a particular station is computed from the following equation and definition:

Geographic Azimuth and Grid Azimuth

- Determine Grid Azimuth: t or Geographic Azimuth: a

$$t = a - g + d$$

t = Grid azimuth

a = Geographic azimuth

g = Convergence angle (mapping angle)

d = Arc to chord correction, known as the second order term (ignore this term for lines less than 5 miles long)

Note: d is the correction for the length of a line along the arc of the reference ellipsoid to the corresponding chord for that length. It is also called the second order term and is often represented as $(t - T)$, where t is the grid azimuth and T is the projected geodetic azimuth. d increases directly to the change in eastings of a line and with the distance of the station used for the computation from the central meridian. It is usually minute and can be neglected for lines that are under 5 miles long.

Example: The following is an example of the calculation:

Example

Station "Class-3" has CCS83 Zone 1 Coordinates of $n = 593305.300$ and $e = 2082990.092$, and a grid azimuth to a natural sight of $320^\circ 37' 22.890''$. Compute the geographic azimuth from Class-3 to the same natural sight.



Example

- Determining the Plane Convergence Angle and the Geographic Azimuth or the Grid Azimuth

$$g = \arctan[(e - E_0)/(R_b - n + N_b)]$$

$$g = \arctan[(2082990.092 - 2000000.000)/$$
$$(7556554.6408 - 593305.300 + 500000.000)]$$

$$g = \arctan[0.0111198338]$$

$$g = 0^\circ 38' 13.536''$$



Example

- Determine Grid Azimuth: t or Geodetic Azimuth: a

$$t = a - g$$

$$a = t + g$$

$$a = 320^\circ 37' 22.890'' + 0^\circ 38' 13.536''$$

$$a = 321^\circ 15' 36.426''$$

Problem:



Problem

Station "D7" has CCS83 Zone 6 Coordinates of $n = 489321.123$ and $e = 2160002.987$, and a grid azimuth to a natural sight of $45^\circ 25' 00.000''$. Compute the geodetic azimuth from D7 to the same natural sight.

Note: the solution to this problem is at the end of the lesson.

California Laws and the California Coordinate System

Whether a surveyor is licensed or working for a licensed land surveyor and is producing a survey based on the CCS system, the surveyor should be aware of and understand the laws pertaining to the CCS system.

There are two codes in California law that has sections that relate to the CCS system. They are the Business and Professions Code, which contains the Land Surveyor's Act (LSAct) and the Public Resources Code (PRC).

The LSAct is the law that defines the practice of land surveying in California. One of the sections, section 8726, defines the tasks that are specific to a land surveyor. The subsection that relates to the CCS system is section 8726 (f). The text follows:

8726. A person, including any person employed by the state or by a city, county, or city and county within the state, practices land surveying within the meaning of this chapter who, either in a public or private capacity, does or offers to do any one or more of the following:

(a) Locates, relocates, establishes, reestablishes, or retraces the alignment or elevation for any of the fixed works embraced within the practice of civil engineering, as described in Section 6731.

(b) Determines the configuration or contour of the earth's surface, or the position of fixed objects thereon or related thereto, by means of measuring lines and angles, and applying the principles of mathematics or photogrammetry.

(c) Locates, relocates, establishes, reestablishes, or retraces any property line or boundary of any parcel of land, right-of-way, easement, or alignment of those lines or boundaries.

(d) Makes any survey for the subdivision or resubdivision of any tract of land. For the purposes of this subdivision, the term "subdivision" or "resubdivision" shall be defined to include, but not be limited to, the definition in the Subdivision Map Act (Division 2(commencing with Section 66410) of Title 7 of the Government Code) or the Subdivided Lands Law (Chapter 1 (commencing with Section 11000) of Part 2 of Division 4 of this code).

(e) By the use of the principles of land surveying determines the position for any monument or reference point which marks a property line, boundary, or corner, or sets, resets, or replaces any monument or reference point.

(f) Geodetic or cadastral surveying. As used in this chapter, geodetic surveying means performing surveys, in which account is taken of the figure and size of the earth to determine or predetermine the horizontal or vertical positions of points, monuments, or stations for use in the practice of land surveying or for stating the position of geodetic control points, monuments, or stations by **California Coordinate System** coordinates.

(g) Determines the information shown or to be shown on any map or document prepared or furnished in

connection with any one or more of the functions described in subdivisions (a), (b), (c), (d), (e), and (f).

(h) Indicates, in any capacity or in any manner, by the use of the title "land surveyor" or by any other title or by any other representation that he or she practices or offers to practice land surveying in any of its branches.

(i) Procures or offers to procure land surveying work for himself, herself, or others.

(j) Manages, or conducts as manager, proprietor, or agent, any place of business from which land surveying work is solicited, performed, or practiced.

(k) Coordinates the work of professional, technical, or special consultants in connection with the activities authorized by this chapter.

(l) Determines the information shown or to be shown within the description of any deed, trust deed, or other title document prepared for the purpose of describing the limit of real property in connection with any one or more of the functions described in subdivisions (a) to (f), inclusive.

(m) Creates, prepares, or modifies electronic or computerized data in the performance of the activities described in subdivisions (a), (b), (c), (d), (e), (f), (k), and (l).

Any department or agency of the state or any city, county, or city and county which has an unregistered person in responsible charge of land surveying work on January 1, 1986, shall be exempt from the requirement that the person be licensed as a land surveyor until the person currently in responsible charge is replaced.

The review, approval, or examination by a governmental entity of documents prepared or performed pursuant to this section shall be done by, or under the direct supervision of, a person authorized to practice land surveying.

The LSAct also states a requirement for the control points used to produce a CCS value. This is contained in section 8771.5. The text is below.

8771.5. When coordinates in the **California Coordinate System** are shown for points on a record of survey map the map may not be recorded unless it also shows, or is accompanied by a map showing, the control scheme through which the coordinates were determined from points of known coordinates.

The PRC is the most important law with respect to the CCS system as that is where the CCS system is legally defined. The following are some important points addressed in the PRC:

- The PRC describes both CCS27 and CCS83.
- It defines the reference ellipsoids for both CCS27 and CCS83.

- It defines the Lambert Conformal Conic projection as the mapping projection to derive CCS27 or CCS83 values.
- It defines the two standard parallels, central meridian, and the point of control for each zone in both CCS27 and CCS83.
- It defines the counties contained in each zone for both CCS27 and CCS83.
- It defines the requirements for the control stations used to produce CCS values.
- It defines some surveying requirements for the survey that produces the CCS values (section 8813).
- It defines the reporting requirements on the survey and results for a CCS survey.
- It does not preclude the use of other coordinate systems.
- It legally defines the U.S. survey foot and the conversion factor between the U.S. survey foot and the meter for use with the CCS system.

The text of PRC, section 8801-8819 follows:

CALIFORNIA CODES
PUBLIC RESOURCES CODE
SECTION 8801-8819

8801. (a) The system of plane coordinates that has been established by the United States Coast and Geodetic Survey for defining and stating the positions or locations of points on the surface of the earth within the State of California is based on the North American Datum of 1927 and is identified as the "California Coordinate System."

After January 1, 1987, this system shall be known as the "California Coordinate System of 1927."

(b) The system of plane coordinates which has been established by the National Geodetic Survey for defining and stating the positions or locations of points on the surface of the earth within the State of California and which is based on the North American Datum of 1983 shall be known as the "California Coordinate System of 1983."

(c) As used in this chapter:

(1) "NAD27" means the North American Datum of 1927.

(2) "CCS27" means the California Coordinate System of 1927.

(3) "NAD83" means the North American Datum of 1983.

(4) "CCS83" means the California Coordinate System of 1983.

(5) "USC&GS" means the United States Coast and Geodetic Survey.

(6) "NGS" means the National Geodetic Survey or its successor.

(7) "FGCS" means the Federal Geodetic Control Subcommittee or its successor.

(8) "CSRC" means the California Spatial Reference Center or its successor.

(9) "CSRS-H" means the California Spatial Reference System-Horizontal.

(10) For the purposes of State Plan Coordinates, first order or better FGCS accuracy standards are considered equivalent to two centimeter or better horizontal accuracy as defined by the Federal Geographic Data Committee's

"Geospatial Positioning Accuracy Standards, Part 2: Standards for Geodetic Networks." Second order or better accuracy is similarly considered as equivalent to five centimeter or better accuracy pursuant to the same federal standards.

(d) The use of the term "State Plane Coordinates" refers only to CCS27 and CCS83 coordinates.

(e) The system of horizontal geodetic control stations within California whose horizontal positions have been determined by Global Positioning System survey methods in accordance with first order or better FGCS standards and specifications and whose positions are published by the NGS, CSRC, or its successor, shall be known as the "California Spatial Reference System-Horizontal."

8802. For CCS27, the state is divided into seven zones. For CCS83, the state is divided into six zones. Zone 7 of CCS27, which encompasses Los Angeles County, is eliminated and the area is included in Zone 5.

Each zone of CCS27 is a Lambert conformal conic projection based on Clarke's Spheroid of 1866, which is the basis of NAD27. The points of control of zones one to six, inclusive, bear the coordinates: Northing (y) = 000.00 feet and Easting (x) = 2,000,000 feet. The point of control of Zone 7 bears the coordinates: Northing (y) = 4,160,926.74 feet and Easting (x) = 4,186,692.58 feet.

Each zone of CCS83 is a Lambert conformal conic projection based on the Geodetic Reference System of 1980, which is the basis of NAD83. The point of control of each of the six zones bear the coordinates: Northing (y) = 500,000 meters and Easting (x) = 2,000,000 meters.

The area included in the following counties constitutes Zone 1 of CCS27 and CCS83: Del Norte, Humboldt, Lassen, Modoc, Plumas, Shasta, Siskiyou, Tehama, and Trinity.

The area included in the following counties constitutes Zone 2 of CCS27 and CCS83: Alpine, Amador, Butte, Colusa, El Dorado, Glenn, Lake, Mendocino, Napa, Nevada, Placer, Sacramento, Sierra, Solano, Sonoma, Sutter, Yolo, and Yuba.

The area included in the following counties constitutes Zone 3 of CCS27 and CCS83: Alameda, Calaveras, Contra Costa, Madera, Marin, Mariposa, Merced, Mono, San Francisco, San Joaquin, San Mateo, Santa Clara, Santa Cruz, Stanislaus, and Tuolumne.

The area included in the following counties constitutes Zone 4 of CCS27 and CCS83: Fresno, Inyo, Kings, Monterey, San Benito, and Tulare.

The area included in the following counties and Channel Islands constitutes Zone 5 of CCS27: Kern, San Bernardino, San Luis Obispo, Santa Barbara (excepting Santa Barbara Island), and Ventura (excepting San Nicholas Island) and the Channel Islands of Santa Cruz, Santa Rosa, San Miguel, and Anacapa.

The area included in the following counties and Channel Islands constitutes Zone 5 of CCS83: Kern, Los Angeles (excepting San Clemente and Santa Catalina Islands), San Bernardino, San Luis Obispo, Santa Barbara (excepting Santa

Barbara Island), and Ventura (excepting San Nicholas Island) and the Channel Islands of Santa Cruz, Santa Rosa, San Miguel, and Anacapa.

The area included in the following counties and Channel Islands constitutes Zone 6 of CCS27 and CCS83: Imperial, Orange, Riverside, and San Diego and the Channel Islands of San Clemente, Santa Catalina, Santa Barbara, and San Nicholas.

The area included in Los Angeles County constitutes Zone 7 of CCS27.

8803. Zone 1 coordinates shall be named, and, on any map on which they are used, they shall be designated as "CCS27, Zone 1 or CCS83, Zone 1."

On their respective spheroids of reference: (1) the standard parallels of CCS27, Zone 1 and CCS83, Zone 1 are at north latitudes 40 degrees 00 minutes and 41 degrees 40 minutes, along which parallels the scale shall be exact; and (2) the point of control of coordinates is at the intersection of the zone's central meridian, which is at 122 degrees 00 minutes west longitude, with the parallel 39 degrees 20 minutes north latitude.

8804. Zone 2 coordinates shall be named, and, on any map on which they are used, they shall be designated as "CCS27, Zone 2 or CCS83, Zone 2."

On their respective spheroids of reference: (1) the standard parallels of CCS27, Zone 2 and CCS83, Zone 2 are at north latitudes 38 degrees 20 minutes and 39 degrees 50 minutes, along which parallels the scale shall be exact; and (2) the point of control of coordinates is at the intersection of the zone's central meridian, which is at 122 degrees 00 minutes west longitude, with the parallel 37 degrees 40 minutes north latitude.

8805. Zone 3 coordinates shall be named, and, on any map on which they are used, they shall be designated as "CCS27, Zone 3 or CCS83, Zone 3."

On their respective spheroids of reference: (1) the standard parallels of CCS27, Zone 3 and CCS83, Zone 3 are at north latitudes 37 degrees 04 minutes and 38 degrees 26 minutes, along which parallels the scale shall be exact; and (2) the point of control of coordinates is at the intersection of the zone's central meridian, which is at 120 degrees 30 minutes west longitude, with the parallel 36 degrees 30 minutes north latitude.

8806. Zone 4 coordinates shall be named, and, on any map on which they are used, they shall be designated as "CCS27, Zone 4 or CCS83, Zone 4."

On their respective spheroids of reference: (1) the standard parallels of CCS27, Zone 4 and CCS83, Zone 4 are at north latitudes 36 degrees 00 minutes and 37 degrees 15

minutes, along which parallels the scale shall be exact; and (2) the point of control of coordinates is at the intersection of the zone's central meridian, which is at 119 degrees 00 minutes west longitude, with the parallel 35 degrees 20 minutes north latitude.

8807. Zone 5 coordinates shall be named, and, on any map on which they are used, they shall be designated as "CCS27, Zone 5 or CCS83, Zone 5."

On their respective spheroids of reference: (1) the standard parallels of CCS27, Zone 5 and CCS83, Zone 5 are at north latitudes 34 degrees 02 minutes and 35 degrees 28 minutes, along which parallels the scale shall be exact; and (2) the point of control of coordinates is at the intersection of the zone's central meridian, which is at 118 degrees 00 minutes west longitude, with the parallel 33 degrees 30 minutes north latitude.

8808. Zone 6 coordinates shall be named, and, on any map on which they are used, they shall be designated as "CCS27, Zone 6 or CCS83, Zone 6."

On their respective spheroids of reference: (1) the standard parallels of CCS27, Zone 6 and CCS83, Zone 6 are at north latitudes 32 degrees 47 minutes and 33 degrees 53 minutes, along which parallels the scale shall be exact; and (2) the point of control of coordinates is at the intersection of the zone's central meridian, which is at 116 degrees 15 minutes west longitude, with the parallel 32 degrees 10 minutes north latitude.

8809. Zone 7 coordinates shall be named, and, on any map on which they are used, they shall be designated as "CCS27, Zone 7."

On its respective spheroid of reference: (1) the standard parallels of CCS27, Zone 7 are at north latitudes 33 degrees 52 minutes and 34 degrees 25 minutes, along which parallels the scale shall be exact; and (2) the point of control of coordinates is at the intersection of the zone's central meridian, which is at 118 degrees 20 minutes west longitude, with the parallel 34 degrees 08 minutes north latitude.

8810. The plane coordinates of a point on the earth's surface, to be used in expressing the position or location of the point in the appropriate zone of CCS27 or CCS83, shall consist of two distances, expressed in feet and decimals of a foot or meters and decimals of a meter. When the values are expressed in feet, the "U.S. Survey foot," (one foot = 1200/3937 meters) shall be used as the standard foot for CCS27 and CCS83. One of these distances, to be known as the "East x-coordinate," shall give the distance east of the Y axis; the other, to be

known as the "North y-coordinate," shall give the distance north of the X axis. The Y axis of any zone shall be parallel with the central meridian of that zone. The X axis of any zone shall be at right angles to the central meridian of that zone.

8811. If the survey of any parcel of land extends from one coordinate zone into another, the positions of all points delineated upon the map thereof may be referred to either of these zones. The zone which is used shall be specifically named in the title upon the map.

8812. Prior to January 1, 2000, state plane coordinates shall be based on, or derived from, the plane coordinates of monumented second order or better horizontal control stations that have been published by the USC&GS or NGS. Any survey or map that uses those coordinates shall be based on, and show, established field-observed direct connections to at least two stations of corresponding or better accuracy whose credentials are based upon published stations of the USC&GS or NGS. The geodetic positions of CCS27 and CCS83 stations that are used to increase the density of control and that purport to be of second order or better accuracy shall have been surveyed in conformity with the applicable survey standards and specifications in effect at the time of the survey as defined by the FGCS.

8813. After December 31, 1999, any survey or map that uses state plane coordinates or geodetic positions shall be based on, and show, field-observed direct connections to at least two stations that are one of the following:

(a) Included in the CSRS-H.

(b) Located outside the State of California and meet all the requirements for inclusion in the CSRS-H, as defined in subdivision

(e) of Section 8801, except for the requirement that they be inside California.

(c) Shown on a subdivision map, record of survey, or a map filed with the county surveyor by a public officer and whose horizontal positions have been determined by Global Positioning System survey methods in accordance with first order or better FGCS standards and specifications and whose state plane coordinates are based on field-observed direct, nontrivial connections to at least two stations that are included in subdivision (a) or (b).

8814. State plane coordinates may be used for property identification on any map, survey, conveyance, or other instrument which delineates or affects the title to real property or which delineates, describes, or refers to the property, or any part thereof. However, to constitute,

when recorded, constructive notice thereof under the recording laws, the delineating, describing, or referring to the property, or part thereof, shall also refer to data appearing of record in any office, the records of which constitute constructive notice under the recording laws. That record data shall be sufficient to identify the property without recourse to those coordinates, and in case of conflict between them, the references to that recorded data shall be controlling for the purpose of determining constructive notice under the recording laws.

8815. The use of the term "California Coordinate System" on any map or document or in any field notes shall be suffixed either with "27" (shown as "CCS27") for coordinates based on NAD27 or with "83" (shown as "CCS83") for coordinates based on NAD83.

8815.1. When CCS83 coordinates are shown on any map or document, the map, corner record, or document shall state the epoch (date) that is the basis of the coordinate values shown. The epoch shall be shown on the map, corner record, or document by an appropriate note on the map, corner record, or document or by adding a suffix in parentheses after CCS83 that states the epoch; for example, "CCS83 (1991.35)" is the epoch in a decimal year format.

8815.2. The epoch for a survey using CCS83 coordinate shall be the NGS-published epoch of a published coordinate for a controlling station used for that survey. Surveys performed after December 31, 1999, shall be based on the "1991.35" epoch or a subsequent epoch, as specified in Section 8815.1.

8815.3. When the published epochs of the controlling stations for a survey using CCS83 coordinates are not the same, appropriate adjustments shall be made to the horizontal positions of controlling stations so that the coordinates of all the controlling stations are consistent. These adjustments in the horizontal positions of controlling stations shall be made in accordance with procedures and values published by the NGS or CSRC.

8815.4. When a purported order of accuracy of second order or better is shown for CCS83 coordinate values on any map, corner record, or document, that map, corner record, or document shall use the order of accuracy as defined by the FGCS. If an FGCS order of accuracy is claimed for a survey or a map, it shall be justified by additional written data

that shows equipment, procedures, closures, adjustments, and a control diagram.

8816. The use of the State Plane Coordinates by any person, corporation, or governmental agency engaged in land surveying or mapping is optional.

8817. Prior to January 1, 1995, use of State Plane Coordinates for new projects may be based either on CCS27 or CCS83. On or after January 1, 1995, when State Plane Coordinates are used on new surveys and new mapping projects, the use shall be limited to CCS83. However, nothing in this section shall preclude a survey from retracement of a CCS27 survey.

8818. This chapter does not impair or invalidate land titles, legal descriptions, or jurisdictional or land boundaries and, further, this chapter does not impair or invalidate references to, or the use of, CCS 27 coordinates, except as provided in Section 8817.

8819. This chapter does not prohibit the use of new geodetic surveying technologies for which FGCS specifications have not yet been published, except that if first order or second order accuracy is claimed for any of the resulting monumented stations, the state plane coordinates shall conform to FGCS accuracy standards.



Solution to Problem

$$g = 0^{\circ} 55' 51.361'' \text{ (} 0.9309335^{\circ}\text{)}$$

$$\text{Geodetic Azimuth} = 46^{\circ} 20' 51.361''$$