

Design Standards Letter

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Subject: Procedures for Determining Geodetic Bearing and Distances with Conversion from Grid Coordinates to Latitude and Longitude

Body

ALL DIVISION AND DISTRICT ENGINEERS

A problem confronting Engineers, Surveyors, and Photogrammetrists is converting state plane coordinates to a geographic latitude and longitude position or performing the inverse. A program has been prepared to run on the 360 Model 50 computer which performs these conversions and computes a Geodetic Bearing between any two given stations or points.

State plane coordinates in Missouri are based on a Transverse Mercature Projection using a reduced scale for the central meridian of each designated zone. Missouri has three zones: East, Central, and West. The central meridians for the three zones have the following longitudes:

East $90^{\circ} 30' 00''$
Central $92^{\circ} 30' 00''$
West $94^{\circ} 30' 00''$

The state plane coordinates have the following limits in feet:

X - Coordinate 80,000 - 920,000
Y - Coordinate 0 - 1,800,000

The X-Coordinate of each central meridian begins at 500,000, thus preventing negative coordinates.

NOTE: Overlapping of zones is permitted as long as the zone is considered the same for that particular problem and as long as the coordinates match the overlap.

A grid bearing is a directional vector which describes the angle of latitude or departure. This is satisfactory for a flat surface such as the state plane grid system. The earth is a curved surface, therefore, a correction must be made for any grid bearings computed on the earth's surface. This correction is called "Convergence". A corrected grid bearing is a Geodetic Bearing.

Convergence equals the difference in Longitudes of the Central Meridian and a P.I. Station times the sine of the Latitude of the P.I. Station. Another form of convergence is a Station to Station Convergence which equals the difference in Longitudes of two P.I. Stations times the average latitude of the two P.I. Stations.

The accuracy of this program is inversely proportional to the length of the bearing line. In other words, the accuracy decreases as the length of the bearing line increases. Accuracy is very good for bearing lines 5 miles or less in length.

Form SP-261 should be filled out as follows: (See Attached Sample Input Form.)

I. Identification Card

At the top of the form is a box labeled "Identification Card". This card is always filled out to identify the problem.

II. Station I.D. Card

A. The second box is labeled "Station I.D.(s)".

Under the first heading of "Station Number" are listings of all station numbers used for computing Geodetic Bearings. These numbers are right justified, and should not contain any alphanumeric characters. They must be numerical.

B. Under "X-Coord" and "Y-Coord" headings are listed the X and Y coordinates for each corresponding station number. These are right justified coordinates.

C. Under "Latitude" and "Longitude" headings are listed the latitude and longitude for each corresponding station. These right justified columns are used ONLY if X and Y coordinates are unknown, and the latitude and longitude are known. If this is the case, then the X and Y coordinate columns are left blank whenever the latitude and longitude columns are filled in for a particular problem.

(Latitude Limitations: $35^{\circ} 50'$ to 41° Approximately)

(Longitude Limitations: $89^{\circ} 00'$ to 98° Approximately)

D. Under the column labeled "Zone", a code is filled in for each station. This will label each zone containing the coordinates used in determining a Geodetic Bearing. The codes are:

E - Eastern Zone

C - Central Zone

W - Western Zone

Each set of two stations with a computed Geodetic Bearing must show the same zone code. This includes overlapped zones.

III. Station from - Station To Card

Under these right justified columns are listed sets of two stations which will have Geodetic Bearings calculated.

The "From" station is the beginning station and the "To" station is the ending station.

The stations in these columns must be the same as those listed on the Station ID (s) Card

IV. Computer Output (See Attached Sample Output)

A. The output consists of a header line and two tables:

(1) The header line is the identification card. This will always be printed first.

(2) The first table lists the Station Numbers, their corresponding X and Y coordinates, the Latitude and Longitude for each station, the Convergence and the Station Zone.

a. (aa), (bb), (ee), and (ff) are input examples of known X and Y coordinates.

b. (cc), (dd), (gg), and (hh) use latitude and longitude input. Notice that the first output table is the same for both examples; i.e. either case gives Station Number, X-Coordinate, Y-Coordinate, Latitude, Longitude, Convergence, and Zone.

(3) The second table lists the "From" and "To" Station Numbers, their Geodetic Bearing, the Distance between them in feet, and the Station to Station Convergency.

Leland D. Fletcher
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