

Positional Accuracy

Objectives (Entry)

This unit will explain the basic concept of Positional Accuracy of feature geometry. Moreover, the unit will explain the quantitative method to quantify the positional accuracy. Other topics such as cartographic quality and resolution and scale of map, which affect the positional accuracy, will also be discussed. At the end of the unit, the student will be able to judge the positional accuracy quality and will be able to calculate positional accuracy.

Positional Accuracy and Cartographic Representation of Features (Clarification)

1. Relative and Absolute Accuracy

Positional accuracy can be illustrated as Relative Accuracy and Absolute Accuracy.

Positional Relative Accuracy as the measure of how objects are positioned relative to each other. It is always illustrated as (+ or -) meter or feet or inch. For example: the distance measurement between two electric poles on the ground and the distance measurement between two poles on the map must be within certain relative accuracy (+ or -) meter or feet or inch. Typical GIS mapping required (+ or -) 6 inches (15.24 cm) to (+ or -) 10 feet (304.8 cm). Relative Accuracy Standard is an indicator or a measure of maximum allowable deviations (distance or interval) between two spatial objects on the map (two poles on the map) and on the ground. (The same two poles on the ground).

Positional Absolute Accuracy as the indicator or measure of how a spatial objects is accurately positioned on the map with respect to its true position on the ground, within an absolute reference frame such as UTM coordinate system. According to the United States National Map Accuracy Standard, 1:24000 scale maps have absolute accuracy of (+ or -) 40feet (1219.2 cm), which is equivalent to (+ or -) 1/50 of an inch (2.54 cm) in the map units. Therefore, positions (latitude and longitude) of most features on the map will be shown within 40 feet (1219.2 cm) or less from their true position (latitude and longitude) on the surface of the earth. Typical GIS mapping required absolute accuracy (+ or -) 1feet (2.54 cm) to (+ or -) 100feet (3048 cm).

2. Quantitative method to measure the Positional Accuracy

The position accuracy can be quantified using the measured positions and true positions based on the following method adapted from adapted from Principals of Geographic Information Systems by P.A Burrough.

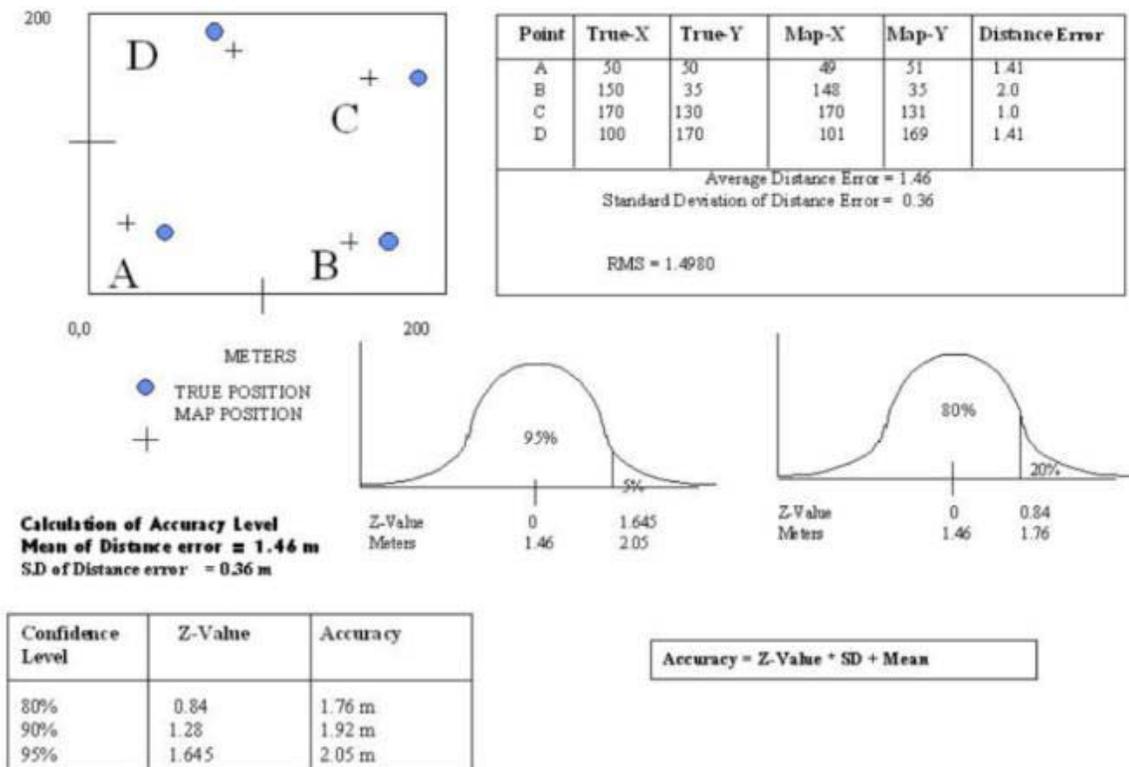
This method can be used to test the positional accuracy of spatial object or map drawn on the different media.

The distance error of each tested point; average distance error, standard deviation (S.D) of distance error, root mean square error (RMS) and accuracy at different confident level can be calculated.

The detail calculation was illustrated as follow. According to the result at the 80% confidence level, 80% of the tested points are shown on the map within the 1.76± meters from their true position. This method can be used to validate the positional accuracy of data that meet the accuracy standard of project or not.

The result should be compared with allowable error on the ground, which will be discussed in the next section

TESTING THE POSITIONAL ACCURACY OF MAP



Detail Calculation of Positional Accuracy

$$\text{Distance Error of Individual Pair} = (X_{\text{true}} - X_{\text{map}})^2 + (Y_{\text{true}} - Y_{\text{map}})^2$$

$$= 1.41, 2.0, 1.0, 1.41$$

$$\text{Average Distance Errors (Xavg)} = (1.41 + 2.0 + 1.0 + 1.41) / 4 = 1.46$$

$$\text{Standard Deviation of Distance Error} = (\sum (X - X_{\text{avg}})^2 / n)$$

X	Xavg	X-Xavg	(X-Xavg) ²
1.41	1.46	-0.05	0.0025
2.00	1.46	0.54	0.2916
1.00	1.46	-0.46	0.2116
1.41	1.46	-0.05	0.0025
			\sum 0.5082

$$\text{S.D of distance error} = 0.5082/4 = 0.36$$

RMS... Calculation

$$\text{RMS} = ((e_1^2 + e_2^2 + e_3^2 + \dots + e_{n2}) / n)$$

$$e_1 = 1.41 \quad e_1^2 = 1.9881$$

$$e_2 = 2.00 \quad e_2^2 = 4.0000$$

$$e_3 = 1.00 \quad e_3^2 = 1.0000$$

$$e_4 = 1.41 \quad e_4^2 = 1.9881$$

$$\sum e_{n2} \quad 8.9762$$

$$\text{RMS} = 8.9762/4 = 1.4980$$

3. Acceptable error and allowable RMS based on National map Accuracy Standard

Acceptable error on the ground can be calculated by multiplying **Acceptable error on the map and scale conversion**. **Allowable RMS** can be calculated by **dividing the Acceptable error on the ground by Z score probability occurrence**.

Conversion of accuracy standards into statistical analyses of the allowable RMS requires that confident level, for example 95% of the accidental errors shall not be larger than 1.64 times the RMS (that is, 1.64 standard deviations at 95% confident level, assuming a normal distribution in error.) Therefore:

Allowable RMS = (Acceptable error on the ground / Z score probability of occurrence)

Allowable RMS = (Acceptable error on the ground / 1.64)

Acceptable error on the ground can be treated as Absolute Positional Accuracy.

Allowable RMS can be calculated depending on the specific use of data and output from the project.

The following table illustrates the relationship between compilation map scale and absolute positional accuracy.

See the interactive calculation of allowable error at the GITTA Page.

Map Scale	Accuracy
1:600	50.90 cm
1:1200	101.50 cm
1:2400	115.88 cm
1:4800	406.30 cm
1:24000	1219.2 cm

The following table illustrates the positional accuracy requirement for GIS applications.

General Activity	Conceptual Accuracy Requirement
Tax mapping	60.96 – 152.4 cm
Final Engineering Design	30.48 – 304.8 cm
Conceptual Plan	60.96 – 3048 cm
Preliminary Facility Layout	60.96 – 304.8 cm
Vehicle Routing	304.8 – 1524 cm
Master Plans	609.6 – 3048 cm
Urban Planning	152.4 – 304.8 cm

4. Resolution and Scale of the Map

The resolution of a map is the accuracy with which the location and shape of map features can be depicted for a given map scale.

Scale affects resolution. In a larger-scale map, the resolution of features more closely matches real-world features because the extent of reduction from ground-to-map is less. In a smaller-scale map, the map resolution diminishes because features must be smoothed and simplified, or not shown at all.

For example, at a scale of 1:63,360 (in which 1 inch = one mile), it is difficult to represent area features smaller than 1/8 of a mile wide or 1/8 of a mile long,

because they will be 1/8 of an inch wide or long on the map.

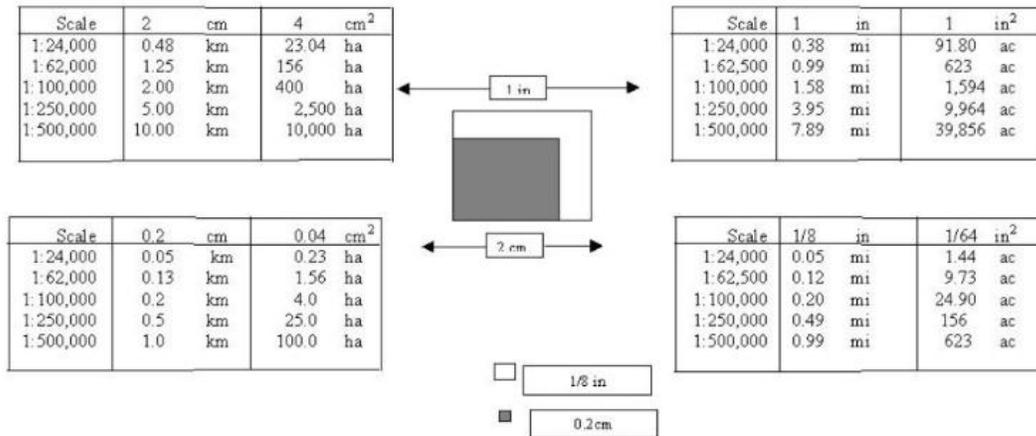
Minimum Mapping Units

As scale decreases; long narrow features such as streams and roads must be represented as lines and smaller area features as points. The minimum sizes and dimensions are sometimes called minimum mapping units. When maps are being compiled, the minimum mapping units might be stated as a series of rules to follow.

For example, long narrow features such as streams and rivers will be represented as lines if their width is less than 1/8 inch. If a polygon is smaller than 1/8 inch on a site, it will be represented as a point, and so on.

The following table illustrates the relationship of scale and resolution.

Resolution



The map resolution table illustrates the relationship with scale, map distance, ground distance, map area, ground area and minimum mapping unit.

Positional Accuracy, cartographic quality, scales and resolution can be illustrated as the attributes of spatial errors.

Calculate the Positional Accuracy (Act)

Calculate Average Distance Error, Standard Deviation of Distance Error, RMS, Positional accuracy at 80%, 90% and 95% Confidence level based on the following data set.

Point	TrueX	TrueY	MapX	MapY
A	53	58	54	60
B	48	86	51	84
C	30	36	28	36
D	70	172	68	174
E	20	25	20	25
F	174	203	171	204

Question (self assessment)

- 1:100000-scale land use map is going to be digitized. Calculate the maximum allowable RMS based on the US Map Accuracy standard.
- In 1 inch = 1 mile scale map, it is possible to plot 1/8 mile by 1/8 mile area as the polygon. Yes/No
- The map resolution illustrates the relationship with scale, map distance, ground distance, map area, ground area and minimum mapping unit. Yes/No

The Questions will be modified.