3. Error and Uncertainty

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Positions are the products of measurements. All measurements contain some degree of error. Errors are introduced in the original act of measuring locations on the Earth surface. Errors are also introduced when second- and third-generation data is produced, say, by scanning or digitizing a paper map.

In general, there are three sources of error in measurement: human beings, the environment in which they work, and the measurement instruments they use.

Human errors include mistakes, such as reading an instrument incorrectly, and judgments. Judgment becomes a factor when the phenomenon that is being measured is not directly observable (like an aquifer), or has ambiguous boundaries (like a soil unit).

Environmental characteristics, such as variations in temperature, gravity, and magnetic declination, also result in measurement errors.

Instrument errors follow from the fact that space is continuous. There is no limit to how precisely a position can be specified. Measurements, however, can be only so precise. No matter what instrument, there is always a limit to how small a difference is detectable. That limit is called **resolution**.

Figure 5.4.1, below, shows the same position (the point in the center of the bullseye) measured by two instruments. The two grid patterns represent the smallest objects that can be detected by the instruments. The pattern at left represents a higher-resolution instrument.

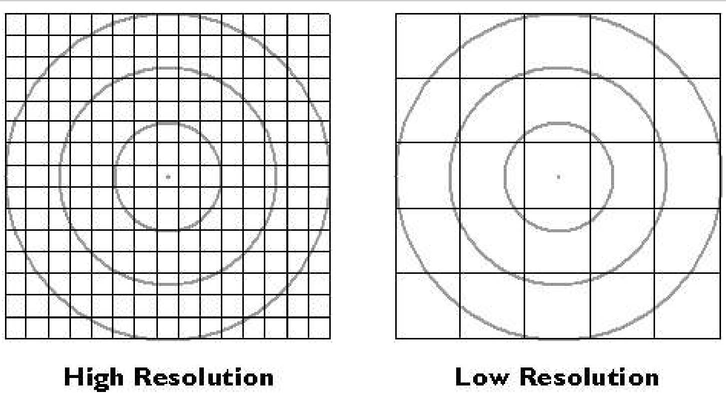

Figure 5.4.1 Resolution.

The resolution of an instrument affects the **precision** of measurements taken with it. In the illustration below, the measurement at left, which was taken with the higher-resolution instrument, is more precise than the measurement at right. In digital form, the more precise measurement would be represented with additional decimal places. For example, a position specified with the UTM coordinates 500,000. meters East and 5,000,000. meters North is actually an area 1 meter square. A more precise specification would be 500,000.001 meters East and 5,000,000.001 meters North, which locates the position within an area

1 millimeter square. You can think of the area as a zone of **uncertainty** within which, somewhere, the theoretically infinitesimal point location exists. **Uncertainty is inherent in geospatial data.**

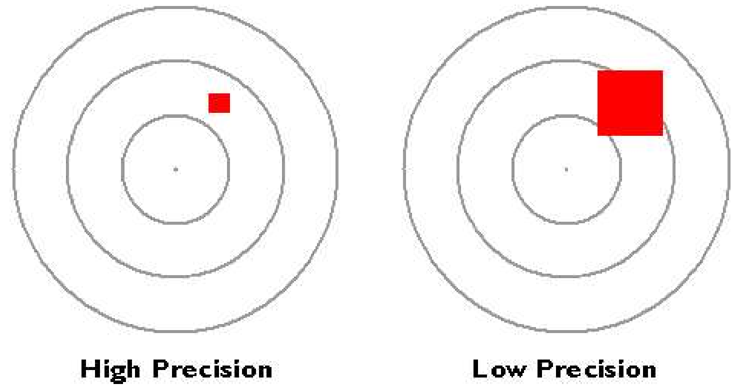

Figure 5.4.2 The precision of a single measurement.

Precision takes on a slightly different meaning when it is used to refer to a number of repeated measurements. In the Figure 5.4.3, below, there is less variance among the nine measurements at left than there is among the nine measurements at right. The set of measurements at left is said to be more precise.

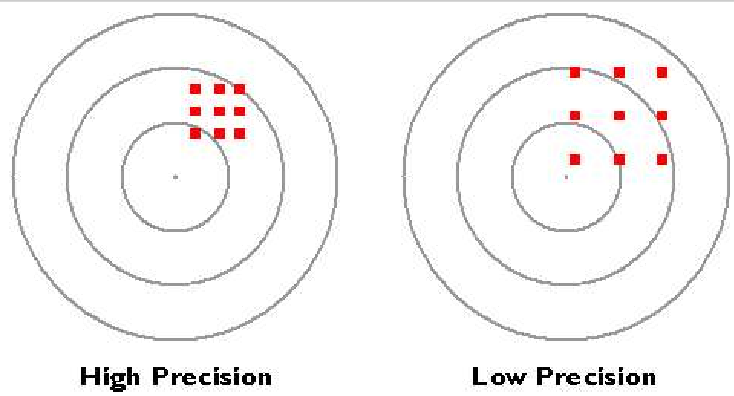

Figure 5.4.3 The precision of multiple measurements.

Hopefully, you have noticed that resolution and precision are independent from **accuracy**. As shown below, accuracy simply means how closely a measurement corresponds to an actual value.

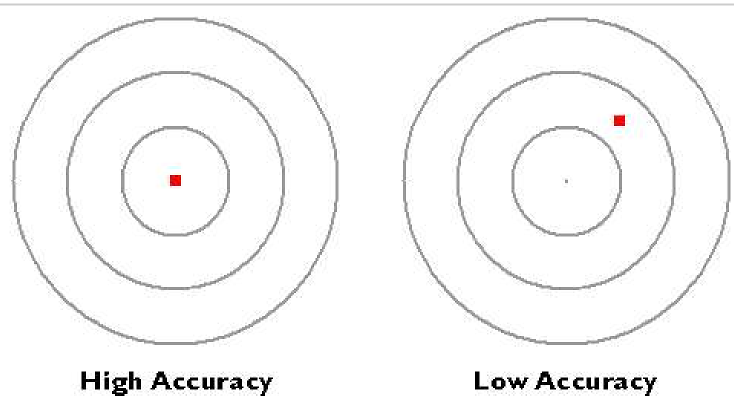

Figure 5.4.4 Accuracy.

I mentioned the U.S. Geological Survey's **National Map Accuracy Standard** in Chapter 2. In regard to topographic maps, the Standard warrants that 90 percent of well-defined points tested will be within a certain tolerance of their actual positions. Another way to specify the accuracy of an entire spatial database is to calculate the average difference between many measured positions and actual positions. The statistic is called the **root mean square error** (RMSE) of a data set.

‹ 2. Geospatial Data Quality up 4. Systematic vs. Random Errors ›

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