5. Survey Control

Print

Geographic positions are specified relative to a fixed reference. Positions on the globe, for instance, may be specified in terms of angles relative to the center of the Earth, the equator, and the prime meridian. Positions in plane coordinate grids are specified as distances from the origin of the coordinate system. Elevations are expressed as distances above or below a vertical datum such as mean sea level, or an ellipsoid such as GRS 80 or WGS 84, or a geoid.

Land surveyors measure horizontal positions in geographic or plane coordinate systems relative to previously surveyed positions called **control points**. In the U.S., the National Geodetic Survey (NGS) maintains a **National Spatial Reference System (NSRS)** that consists of approximately 300,000 horizontal and 600,000 vertical control stations (Doyle,1994). Coordinates associated with horizontal control points are referenced to NAD 83; elevations are relative to NAVD 88. In a Chapter 2 activity, you may have retrieved one of the datasheets that NGS maintains for every NSRS control point, along with more than a million other points submitted by professional surveyors.

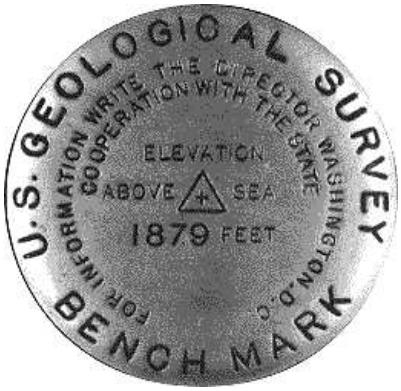

Figure 5.6.1 Benchmark used to mark a vertical control point.

Thompson, 1988

In 1988, NGS established **four orders of control point accuracy**, which are outlined in the table below. The minimum accuracy for each order is expressed in relation to the horizontal distance separating two control points of the same order. For example, if you start at a control point of order AA and measure a 500 km distance, the length of the line should be accurate to within 3 mm base error, plus or minus 5 mm line length error (500,000,000 mm × 0.01 parts per million).

Four orders of control point accuracy

Order	Survey activities	Maximum base error (95% confidence limit)	Maximum Line-length dependent error (95% confidence limit)

Order	Survey activities	Maximum base error (95% confidence limit)	Maximum Line-length dependent error (95% confidence limit)
AA	Global-regional dynamics; deformation measurements	3 mm	1:100,000,000 (0.01 ppm)
A	NSRS primary networks	5 mm	1:10,000,000 (0.1 ppm)
B	NSRS secondary networks; high-precision engineering surveys	8 mm	1:1,000,000 (1 ppm)
C	NSRS terrestrial; dependent control surveys for mapping, land information, property, and engineering requirements	1st: 1.0 cm 2nd-I: 2.0 cm 2nd-II: 3.0 cm 3rd: 5.0 cm	1st: 1:100,000 2nd-I: 1:50,000 2nd-II: 1:20,000 3rd: 1:10,000

Control network accuracy standards used for U.S. National Spatial Reference System (Federal Geodetic Control Committee, 1988).

Doyle (1994) points out that horizontal and vertical reference systems coincide by less than ten percent. This is because

> *....horizontal stations were often located on high mountains or hilltops to decrease the need to construct observation towers usually required to provide line-of-sight for triangulation, traverse and trilateration measurements. Vertical control points however, were established by the technique of spirit leveling which is more suited to being conducted along gradual slopes such as roads and railways that seldom scale mountain tops. (Doyle, 2002, p. 1)*

You might wonder how a control network gets started. If positions are measured relative to other positions, what is the first position measured relative to? The answer is: the stars. Before reliable timepieces were available, astronomers were able to determine longitude only by careful observation of recurring celestial events, such as eclipses of the moons of Jupiter. Nowadays, geodesists produce extremely precise positional data by analyzing radio waves emitted by distant stars. Once a control network is established, however, **surveyors produce positions using instruments that measure angles and distances between locations on the Earth's surface.**

‹ 4. Systematic vs. Random Errors up 6. Measuring Angles ›

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