

GPS Surveying Standards and Specifications - Introduction

Whenever a survey is performed there are requirements on the quality of the results of that survey. Each project will have a different set of requirements, depending on the intended use of the survey results. A project may have requirements that are specific to the unique circumstances for the survey data, however, the basic requirements are typically accepted Standards and Specifications. These Standards and Specifications will dictate the survey requirements and the quality of the results when producing data with a total station, level, by photogrammetric techniques, Lidar, Remote Sensing, other mapping techniques, or Global Positioning System (GPS) techniques.

What are Standards and Specifications? A **Standard** is an acknowledged measure of comparison for quantitative or qualitative value - a criterion. To put it another way specific to survey data, a Standard is a limit on the error of the survey data as quantified by a precision measure or an positional accuracy measure. On the other hand, a **Specification** is a detailed list of equipment requirements and the field and office procedures to follow in order to achieve the desired quantitative or qualitative results.

Standards and Specifications are two sides of the same coin. You can't have one without the other. Simply stating the quality of the results without stating the specifications that were followed does not give the complete picture of the survey results. For example, you could claim a very high accuracy for the survey results, however, if you only "winged out" the points surveyed the high accuracy is virtually meaningless. So, the evaluation of the quality of the reported results is contingent on the specifications used for that survey.

Note: some organizations call their specifications guidelines. The difference between specifications and guidelines is specifications are well defined procedures that must be followed, while guidelines are well defined procedures that are recommended to follow. For the purposes of this topic the term specification will be used.

Many different organizations have their own Standards and Specifications for surveying data. For, example, the Federal Geographic Data Committee, The Federal Geodetic Control Committee (currently, identified as the Federal Geodetic Control Subcommittee) the National Geodetic Survey, other federal agencies, state departments including the state Departments of Transportation, local government entities, and private businesses all have Standards and Specifications for survey data. Most, if not all, of the different Standards and Specifications are based on those produced by the Federal Geographic Data Committee, The Federal Geodetic Control Committee, and the National Geodetic Survey.

Standards

A Standard for surveying data is the qualitative measure of that data and is based on several factors. Those factors include the specifications followed for the survey, the quality of

the control for the survey (typically this is stated in the specifications), and the sources of errors in the surveying measurements.

Before describing the Standards and Specifications that are specific to GPS surveys, two different types of measures on the qualitative results of survey data needs to be understood. They are the Standards that require survey data to meet a **precisional ratio** criterion and the Standards that require survey data to meet a **positional accuracy** criterion.

Precisional Ratio

The precisional ratio is a measure of the “line length” dependent error and is expressed as either a ratio or a part per million (ppm); however, the ratio and ppm are expressions that are equivalent. A precisional ratio expressed as a ratio has the form: x:y, where x is the error and y is the length of the line. For example, a precisional ratio of 1:10,000 means that there is one unit of error over a line length of 10,000 units. Note: the precisional ratio is unit independent. In other words, 1 foot error in 10,000 feet is equivalent to 1 meter error in 10,000 meters. The equivalent ppm expression for 1:10,000 is 100 ppm.

Typically, precisional ratios are associated with an Order and/or a Class. The list of the classifications is:

- AA Order: 1:100,000,000 or .01 ppm.
- A Order: 1:10,000,000 or .1 ppm.
- B Order: 1:1,000,000 or 1 ppm
- First Order: 1:100,000 or 10 ppm
- Second Order – First Class: 1:50,000 or 20 ppm
- Second Order – Second Class: 1:20,000 or 50 ppm
- Third Order: 1:10,000 or 100 ppm

Positional Accuracy

The positional accuracy reporting standard is considered to be a better standard than the precisional ratio standard. This is because survey results from different surveying systems (total stations, GPS, etc) are able to be evaluated in a consistent manner. For example, it is much easier for a GPS survey to produce high precisional ratios than it is for a total station survey, however, the positional accuracies are consistent.

The positional accuracy for survey data is a qualitative measure of survey data that is the radius of a circle of uncertainty (error) such that the true or theoretical location of the station will fall within that circle 95% of the time for horizontal values and a linear uncertainty value (error) such that the true or theoretical value of the station falls within +/- of that linear uncertainty 95% of the time for vertical values.

There are two positional accuracy values that may be reported as the standard for the results of a particular survey. They are Local Accuracy and Network Accuracy. The following are the definitions of the two:

Local Accuracy: The *local accuracy* of a control point is a value that represents the uncertainty in the coordinates of the control point relative to the coordinates of other directly connected,

adjacent control points at the 95-percent confidence level. The reported local accuracy is an approximate average of the individual local accuracy values between this control point and other observed control points used to establish the coordinates of the control point.

Network Accuracy: The *network accuracy* of a control point is a value that represents the uncertainty in the coordinates of the control point with respect to the geodetic datum at the 95-percent confidence level. For the National Spatial Reference System (NSRS – the system created and maintained by the National Geodetic Survey) network accuracy classification, the datum (NAD83) is considered to be best expressed by the geodetic values at the Continuously Operating Reference Stations (CORS) supported by NGS. By this definition, the local and network accuracy values at CORS sites are considered to be infinitesimal, i.e., to approach zero.

The following is a list of standard positional accuracy levels.

Accuracy 95-Percent
Classification Confidence

Less Than or
Equal to:

1-Millimeter:	0.001 meters
2-Millimeter:	0.002 meters
5-Millimeter:	0.005 meters
1-Centimeter:	0.010 meters
2-Centimeter:	0.020 meters
5-Centimeter:	0.050 meters
1-Decimeter:	0.100 meters
2-Decimeter:	0.200 meters
5-Decimeter:	0.500 meters
1-Meter:	1.000 meters
2-Meter:	2.000 meters
5-Meter:	5.000 meters
10-Meter:	10.000 meters

It should be noted that a positional accuracy of greater than 10 meters may be reported when necessary.

GPS Surveys Standards and Specifications - General

Adhering to job specific Standards and Specifications is essential to producing acceptable survey products for the customer. Many of these requirements are based on the accepted federal Standards and Specification for GPS surveys described above. Standards and Specifications also provide for an increase in the confidence of the GPS surveyor in the quality of the survey data. Whenever possible all of the specifications should be followed for both Static GPS surveys and RTK surveys.

Also, as GPS equipment improves, GPS satellite constellations are improved, new GPS satellite constellations are implemented, or GPS surveying techniques are improved Standards and Specifications need to be revised. This is an ongoing process that will never end. The

student should stay abreast of the revisions to current Standards and Specifications or the creation of new ones.

Static GPS Survey – Standards and Specifications

The main Standards and Specifications for static GPS surveys are the “Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques”, produced by the Federal Geodetic Control Committee in 1988 and 1989 and the “Geospatial Positioning Accuracy Standards” produced by the Federal Geographic Data Committee in 1998. The complete text of the FGCS Standards and Specifications can be located at http://www.ngs.noaa.gov/FGCS/tech_pub/GeomGeod.pdf . The complete text of the FGDC Standards can be located at <http://www.fgdc.gov/standards/documents/standards/accuracy/> . The FGCC documents are based on precision ratios and the FGDC are based on positional accuracies. The student should read and understand these documents.

Differential GPS Survey – Standards and Specifications

Requirements on DGPS surveys that utilize corrections for the code phases (psuedoranges) will be contained in the requirements for specific projects. This section will deal with the Standards and Specifications that are specific to Real time Kinematic (RTK) surveys.

At present, there are some organizations that have produced Standards and Specifications for RTK surveys. However, most of them only contain rudimentary requirements. The only detailed RTK specifications currently published are those produced by the California Department of Transportation (Caltrans). They can be located at <http://www.dot.ca.gov/hq/esc/geometronics/SurveysManual/06%20Surveys.pdf> . The student should read and understand this document.

Topic 2: GPS – Conclusion

GPS surveying may seem like “black box” technology where the surveyor simply sets up and pushes the on/off button. However, as was learned in this lesson, it is essential that the surveyor knows how the GPS system works and the error sources associated with it.

In the first lesson the concepts about the structure of the GPS system was discussed. This included the description of the control segment, the space segment and the user segment. It was also discussed the structure of the carrier phase signal and the code phase information that is on those signals. This was followed by a discussion of psuedoranges and carrier phase ranges, the data that is essential to compute the distances from the GPS antennae to the satellites that are in view. This lesson then ended with error sources in the GPS system, which included anti-spoofing and selective availability, positional dilution of precision (PDOP), atmospheric delays (ionospheric and tropospheric), multipath, and blunders.

In the second lesson the idea of “relative positioning” in order to produce accurate values from GPS surveying was introduced. This was followed by a discussion between the distinction of independent and dependent baselines for static GPS surveys. This distinction was then discussed within the planning of a static GPS survey. The lesson then discussed the planning and subsequent observation guidelines for the static survey. The rest of the lesson talked about

how to process the baselines, the statistical indicators on that process, and the network adjustment to produce the final results.

The third lesson discussed the GPS relative positioning technique of Differential GPS. This included the difference between Real Time Kinematic (RTK) GPS surveys and DGPS surveys based on the code phase information. The lesson then discussed the data communication link, initialization, calibration and how to conduct a RTK survey.

This lesson discussed Standards and Specifications associated with the performance of GPS surveys.

The interested student is encouraged to follow up with additional reading, attending conferences and seminars, and discussing the subject with others that are in the GPS surveying field.