

CHAPTER 4

GPS FIELD SURVEYS

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A) GENERAL

This section presents guidance to field personnel performing GPS surveys for DOT projects. The primary emphasis in this chapter is on static, and real time kinematic (RTK) GPS measurements. The following are some general GPS field survey procedures that should be performed at each station, observation, and/or session on a static GPS survey.

Receiver Setup

GPS receivers shall be set up in accordance with manufacturer's specifications prior to beginning any observations. To eliminate any possibility of missing the beginning of the observation session, all equipment should be set up with power supplied to the receivers at least 5 min prior to the beginning of the observation session. Most receivers will lock-on to satellites within 1-2 min of powering.

Antenna Setup

All tribrachs used on a project should be calibrated and adjusted periodically to insure accuracy, since centering errors represent a major error source in all survey work, not just GPS surveying.

Height of Instrument Measurement

Height of instrument (HI) refers to the correct measurement of the distance of the GPS antenna above the reference monument over which it has been placed. HI measurements will be made both before and after each observation session. The HI will be made from the monument to a standard reference point on the antenna. These standard reference points for each antenna will be established prior to the beginning of the observations so all observers will be measuring to the same point. HI measurements shall be determined to the nearest .01-ft (1-millimeter). It should be noted whether the HI is an uncorrected height or true height.

Field GPS Observation Recording Procedures

Field recording log sheets will be completed for each station and/or session. The amount of record-keeping detail will be project-dependent; low-order topographic mapping points need not have as much descriptive information as would permanently marked primary control points. The typical data sheet ([see page 4-3](#)) may be included on this field log record.

GPS POINT OBSERVATION RECORD

Type of Measurement: _____ **Static** _____ **Fast Static**

Observer _____ **Receiver Number** _____

Antenna Height 2.0591 _____ (if not fixed height) _____ (meters)

Type of Measurement: _____ **Static** _____ **Fast Static**

File Name _____ **Station Occupied** _____

Station Mark Identification _____

Proposed Observation _____ **Start** _____ **Stop** _____

Comments and Description:

B) DIFFERENTIAL GPS HORIZONTAL POSITIONING TECHNIQUES

Differential GPS carrier phase surveying is used to obtain the highest precision from GPS and has direct application to most topographic and engineering survey activities. DOT uses two different GPS differential surveying techniques:

1. Static
2. Real Time Kinematic

Procedures for performing each of these methods are described below. These procedures are guidelines for conducting a field survey. Manufacturers' procedures should be followed, when appropriate, for conducting a GPS field survey. Project horizontal control densification can be performed using any one of these methods. Procedurally, both methods are similar in that each measures a 3D baseline vector between a receiver at one point (usually of known state plane coordinates) and a second receiver at another point, resulting in a vector difference between the two points occupied. The major distinction between static and kinematic baseline measurements involves the method by which the carrier wave integer cycle ambiguities are resolved; otherwise, they are functionally the same processes.

- 1. Static GPS Survey Techniques** - Two GPS receivers are used to measure a GPS baseline distance. The line between a pair of GPS receivers from which simultaneous GPS data have been collected and processed is a vector referred to as a baseline. The station coordinate differences are calculated in terms of a 3D, earthcentered coordinate system that utilizes X-, Y-, and Z-values based on the WGS 84 geocentric ellipsoid model. These coordinate differences are then subsequently shifted to fit the local project coordinate system.
 - a) General** - GPS receiver pairs are set up over stations of either known or unknown location. Typically one of the receivers is positioned over a point whose coordinates are known (or have been carried forward as on a traverse), and the second is positioned over another point whose coordinates are unknown, but are desired. Both GPS receivers must receive signals from the same four (or more) satellites for a period of time that can range from a few minutes to several hours, depending on the conditions of observation and precision required.
 - b) Static Baseline Occupation Time** - Station occupation time is dependent on baseline length, number of satellites observed, and the GPS equipment used. In general, 30 min to 2 hr is a good approximation for baseline occupation time for shorter baselines of 1- 20 miles(1-30kilometers).

Since there is no definitive guidance for determining the required baseline occupation time, the results from the baseline reduction (and subsequent adjustments) will govern the adequacy of the observation irrespective of the actual observation time. The most prudent policy is to exceed the minimum estimated times, especially for lines where reoccupation would be difficult or field data assessment capabilities are limited.

B) DIFFERENTIAL GPS HORIZONTAL POSITIONING TECHNIQUES (CONTINUED)

- c) Satellite Visibility Requirements** - The stations that are selected for survey must have an unobstructed view of the sky for at least 15 deg or greater above the horizon during the "observation window." An observation window is the period of time when observable satellites are in the sky and the survey can be successfully conducted.
 - d) Common Satellite Observations** - It is critical for a static survey baseline reduction/solution that the receivers simultaneously observe the same satellites during the same time interval. For instance, if receiver No. 1 observes a satellite set during the time interval 1,000 to 1,200 and another receiver, receiver No. 2, observes that same satellite set during the time interval 1,100 to 1,300, only the period of common observation, 1,100 to 1,200, can be processed to formulate a correct vector difference between these receivers.
 - e) Data Post-processing.** - After the observation session has been completed, the received GPS signals from both receivers are then processed (i.e., "post-processed") in a computer to calculate the 3D baseline vector components between the two observed points. From these vector distances, local or geodetic coordinates may be computed and/or adjusted.
 - f) Receiver Operation and Data Reduction** - Specific receiver operation and baseline data post-processing requirements are very manufacturer-dependent. The user is strongly advised to consult and study manufacturer's operations manuals thoroughly along with the baseline data reduction examples.
 - g) Accuracy of Static Surveys** - Accuracy of GPS static surveys is the most accurate and can be used for any order survey.
- 2. RTK Surveying Techniques** - RTK surveying requires two receivers, recording observations simultaneously, and allows the rover receiver to be moving. RTK surveying techniques also use dual-frequency LI/L2 GPS observations and can handle loss of satellite lock.
- a) General** - The RTK technology allows the rover receiver to initialize and resolve the integer ambiguities without a period of static initialization. With RTK, if loss of satellite lock occurs, initialization can occur while in motion. The integers can be resolved at the rover within 10-30 sec, depending on the distance from the base station.
 - b) Survey Procedure** - RTK surveying requires dual frequency LI/L2 GPS receivers. One of the GPS receivers is set over a known point, while the other receiver may be free to travel from point to point. If the survey is performed in real time, a radio link and a processor or data collector are needed. The radio link is used to transfer the raw data from the reference station to the rover.
 - c) Accuracy of RTK Surveys** – RTK surveys can be accurate to within 0.02 to 0.05 feet, providing a good static network and calibration were performed prior to performing the RTK survey.