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Global Positioning System (GPS)

Basics

What is GPS: GPS is a radio emitting and receiving Satellite Navigation System that measures location, elevation, velocity and time on earth. Different grades if GPS devices yield different accuracy levels. They can be used for navigation, mapping, or surveying.

How does it work: Developed and operated by the U.S. Department of Defense, the orbiting satellites, presently 31 in approximately 12,600 miles, transmit signals that allow a GPS receiver anywhere on earth to calculate its own position through trilateration. A minimum of four GPS satellite signals are required to compute positions in three dimensions and the time offset in the receiver clock.

Where does the GPS way to data collection begin: GPS data collection begins with the creation of a data dictionary. A data dictionary describes features that will be located in the field. Similar to a blank inventory table that is created in an Excel spread sheet or Access database, a data dictionary includes a sets of predetermined fields for capturing the feature IDs, names, data types (point, line or area), attribute types, styles, values, lengths, pictures, and notes, that are associated with an asset. Once it is created in an electronic format (ddf file), it can be imported and used as a drop down menu selection in a handheld GPS unit when collecting data in the field. During the collection process, GPS software defines the spatial references (x, y, z or latitude and longitude) of the tabular information. The entire data collection can be downloaded and converted into Geographic Information Systems (GIS) file and be used compatibly with mapping software.

What to look out for: While GPS data collection has improved in ease and speed, some obstacles remain. Solid or dense objects can block GPS signals. Buildings or wet trees with heavy branches and leaves can mask satellite transmission. Signal blocking can be reduced by using a high quality GPS antenna and careful mission planning.

How to improve GPS data accuracy: Differential correction is the process of correcting GPS data collected by a user, with data recorded simultaneously at a base station, in order to improve accuracy. There are two differential correction choices: (1) Real-time differential correction, and (2) Post-processing differential correction. The based station develops an error correction factor by comparing its known survey location with the error induced GPS signal.

GPS advantages and disadvantages:

- Spatial and tabular data are collected simultaneously
- Signals available free of charge
- Position accuracy is superior to conventional methods (some are within sub- cm)
- Coordinate systems and reference datum can be easily changed in the field and in the processing software
- GIS conversion is simple
- The process is relative time concise, easy, and FUN

- Requires training and retraining as technology changes
- Buildings or heavy foliage can block satellite signals
- Requires careful attention to system configuration and data collection standards and procedures

Glossary:

Global Positioning System (GPS) - a GPS system consists of an operational constellation of 24 satellites that orbit the Earth in very precise orbits twice a day. GPS satellites emit continuous navigation signals and data, which allow GPS receivers to calculate location, elevation, velocity, and time.

Trilateration - a method of determining the relative positions of objects using the geometry of triangles in a similar fashion as triangulation. Unlike triangulation, which uses angle measurements (together with at least one known distance) to calculate the subject's location, trilateration uses the known locations of two or more reference points, and the measured distance between the subject and each reference point. To accurately and uniquely determine the relative location of a point on a 2D plane using trilateration alone, generally at least 3 reference points are needed. In GPS trilateration, the fixed positions are satellites orbiting the earth with distance determined by the GPS signal travel time to a location on the surface of the earth. A four satellite trilateration provides an accurate earth position.

Selective Availability (SA) – an artificial degradation of the satellite signal created by the Department of Defense, where the user receives false pseudo range in error by up to 100 meters. Differential GPS techniques eliminated these effects. SA was ended in May, 2000. As a result, the current uncorrected accuracy is about 25-30 feet. When satellites are all in the same part of the sky, readings will be less accurate compared to when they are widely spread.

Spatial Data -data relating to the geographic location of point, area or line features, expressed in an x,y pair or a series of x,y pairs. The geographic location can be expressed in any number of geodetic or plane coordinate systems. Longitude/Latitude and State Plane NAD 83 New York East are two examples.

Tabular Data - data in tabular format which describes the spatial data. Tabular data is essential to GIS for query, analysis and display. Without it, only graphics exists. A GPS

data dictionary provides the tabular data format to join with spatial data that can be transferred to GIS software.

Data Dictionary – a set of metadata that contains definitions and representations of data elements. Within the context of a database, it is a read-only set of tables and views. It can store pre-programmed values for each asset inventory. When it is imported into a GPS, it allows for dropdown menu options when collecting data.

Differential GPS (DGPS) - a technique for reducing the error in GPS-derived positions by using additional data from a reference GPS receiver at a known position. The most common form of DGPS involves determining the combined effects of navigation message ephemeris and satellite clock errors (including the effects of SA) at a reference station and transmitting pseudorange corrections.

Dilution of Precision (DOP) - a dimensionless number that accounts for the contribution of relative satellite geometry to errors in position determination. DOP has a multiplicative effect. Generally, the wider the spacing between the satellites being tracked by a GPS receiver, the smaller the position error. The most common quantification of DOP is through the position dilution of precision (PDOP) parameter.

Hurricane Antenna – a high quality GPS antenna for handheld GPS receivers that is resistant to signal interference and multipath.

Rover - any mobile GPS receiver collecting data during a field session. The receiver's position can be computed relative to another stationary GPS base station.

Base Station (Reference Station) - a receiver that is set up at a known location specifically to collect data for differentially correction rover files. The base station calculates the error for each satellite and, through differential correction, removes SA and improves the accuracy of the roving GPS receiver positions collected at unknown locations.

Almanac - a file that contains orbit information on all satellites, clock corrections, and atmospheric delay parameters. It is transmitted by a GPS satellite to a GPS receiver, where it facilitates rapid satellite acquisition. It can be downloaded from the receiver to the GPS processing software where it is used to predict the best times to collect GPS data.

Geographic Information System (GIS) – GIS is an assembly of computer hardware, software and geographic data for capturing, storing, managing, analyzing, and displaying geographically referenced information.

To learn more about GPS/GIS:

http://www.trimble.com/gps/index.shtml

http://www.gpsworld.com/gpsworld/