Topic Page: Global Positioning System

Definition: **Global Positioning System (GPS)** from *Dictionary of Information Science and Technology*

a worldwide system of satellites and corresponding receivers that compute physical locations on the Earth's surface. Common uses include personal tracking, navigation, and automatic vehicle location technologies. (Ira & Berge, 2009)

Summary Article: **Global Positioning System (GPS)**
From *Encyclopedia of Geographic Information Science*

Coordinates of objects, people, or places represent fundamental information required for any GIS. Since achieving initial operational capability in December 1993, the *Global Positioning System (GPS)* has allowed users to determine position easily, quickly, and cheaply. With the global market predicted to top $20 billion by 2008, GPS has rapidly become the primary technique for location determination for GIS-related applications.

GPS is a military system run by the U.S. Department of Defense, which maintains a constellation of 24 satellites (plus several spares) at an altitude of about 20,000 km. The satellites transmit signals on L-band frequencies onto which timing codes are modulated. A receiver with knowledge of these codes can measure the time taken for a signal to arrive from any particular satellite and, hence, by multiplying the time taken by the speed of light, compute its range to that satellite. Information about the position of the satellites is also modulated onto the transmitted signals. Position is computed by combining satellite positions and the measured satellite-receiver ranges in a range resection solution.

A minimum of four satellites must be visible for a receiver to achieve full 3D positioning (the fourth satellite is required to account for the time offset between the receiver and the satellites). The L-band signals of GPS are greatly weakened by obstructions such as buildings and forest canopies, and the operation of standard, off-the-shelf receivers can become severely restricted if direct line of sight from satellites to receiver is not available. In clear operating conditions, the Department of Defense quotes the accuracy of the GPS Standard Positioning Service (SPS) as being 13 m in the horizontal (95% confidence) and 22 m in the vertical (95% confidence). GPS positions tend to be less accurate in the vertical because of the geometrical distribution of the satellites in the sky above a receiver.

Although GPS costs U.S. taxpayers around $400 million per year to maintain, including the replacement of aging satellites, GPS SPS is freely available for civilian applications. Because it is a passive system, a user needs only a receiver capable of receiving and decoding the GPS signals to be able to determine location in real time at any time and any place in the world. GPS receivers vary greatly in cost and capability. Less-expensive receivers typically receive and decode only a single L-band signal (known as the *L1 C/A code*). More advanced receivers can also receive a second GPS signal (L2) and record the incoming phase of both signals, resulting in substantially more precise measurements. Such units are used for surveying and geodetic applications where centimeter-level accuracy is required.

Two aspects of GPS receivers are of importance to GIS users. First, some receivers can record and link attribute data to GPS location data. The data may then be transferred to a personal computer (PC) or other device. The standard format for transferring this type of data is the NMEA 0183 protocol (and the newer NMEA 2000), which is freely available from the U.S. National Marine Electronics Association.

Second, many of the errors inherent in GPS range observations, mainly signal propagation errors caused by the atmosphere, errors in the position of the satellite, and errors in the timing of the satellite on-board clocks, may be reduced by the input of *differential corrections* into a receiver. Such corrections are provided commercially by differential service providers who use control networks of GPS receivers to monitor the errors associated with the system. Models for these errors are transmitted to the user via a communication link (e.g., FM radio) in the RTCM SC-104 format. Receivers with the capacity to receive differential corrections can typically improve on the accuracy of the SPS by a factor of 10 or better.

GPS operates on the World Geodetic System 1984 (WGS84) datum. GPS receivers usually output coordinates in either geodetic (latitude, longitude, and height) or UTM (east, north, and height) coordinate systems. However, care must be taken to ensure that output coordinates are given in the datum required by the user, as GPS receivers have the capability of outputting positions in a wide variety of coordinate systems and datums. Current and, particularly, historic national datums can often be different from WGS84, and backward compatibility between data sets collected with GPS and older data sets can be a major problem for GIS users. Accurate coordinate transformations are often required between newer and older data sets. Users should be aware that GPS does not directly provide height above mean sea level, but relies on a secondary “geoid” correction, usually applied automatically within the receivers. Where height is critical, users should contact their national geodetic agency to ensure that they are using the best available geoid values.

GPS is the only fully operating member of a family of Global Navigation Satellite Systems (GNSS). The Russian GLONASS system has been partially operational since the early 1990s, but problems with the system have meant little market penetration. Of more significance is Galileo, a European initiative, designed and run by the European Space Agency and scheduled to be fully operational by 2012. Although similar in concept, unlike GPS, Galileo will be a civilian system, with the possibility of providing users with increased accuracies on a “pay-per-view” basis. The first Galileo satellite was launched in December 2005. In the future, receivers capable of receiving signals from both Galileo and GPS are likely to achieve stand-alone, real-time positioning accuracy of less than 1 meter.

See also

Coordinate Systems

Datum

Geodesy

Geodetic Control Framework

Transformation, Coordinate

Universal Transverse Mercator (UTM)

Further Readings

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