GPS: Using the Global Positioning System

If you never leave home, you'll never need to ask, "Where am I?" But people have always been on the move, and always looking for a better way to get where they're going. A traveler without a map is just a wanderer, but even with a map, where landmarks are scarce—the plains, the desert, the ocean, in space—the traveler needs a means of navigation, a method for determining position, course and distance.

History is marked by incremental improvements in mapping and navigation. With each improvement, people have traveled farther, faster and with greater confidence. The pace of improvement in transportation and navigation accelerated exponentially during the last century. We have left footprints on the moon and robotic explorers on Mars. We make routine missions into space, and the presence of satellites orbiting around Earth has become part of our everyday reality.

One of the more remarkable benefits of our ability to send satellites into orbit is a new power to navigate with a precision than was undreamed of until very recently. This new navigational ability is due to the Global Positioning System (GPS), a system developed by the United States Department of Defense.

GPS was originally designed to provide navigation information for ships and planes, but with advances in miniaturization and integrated circuits, GPS receivers have become more economical and more widely applied. Today, GPS technology is installed in many cars, boats and small planes, as well as on construction and farm equipment. Portable, hand-held GPS receivers have become widely accessible and are making all kinds of work more efficient, and helping to ensure the safety of people who work or recreate outdoors.

How GPS Works

GPS is made up of a network of 24 satellites and their ground stations. The 21 primary and three back-up satellites circle the earth in predictable orbits at an altitude of approximately 10,900 miles. The satellites act as reference points that allow calculations of position that are accurate to within meters or better. Five tracking stations, situated at points around the Earth's equator, constantly monitor the signals transmitted from the satellites.

On Earth, a GPS receiver calculates its position by solving a set of equations based on the distance between it and three or more satellites. This calculation is known as "triangulation," a centuries-old surveying technique, literally taken to new heights. Location is determined by measuring the travel time of radio signals from the available satellites. Reference to at least three satellites is required for accurate horizontal location, and at least four for accurate horizontal and vertical location. The more satellites used for the calculation, the more accurately location can be pinpointed. The most precise determination of position can be achieved using the Wide Area Augmentation System (WAAS). This system is now the Federal Aviation Administration's objective standard for all civil aviation.

GPS Signals

All GPS signals are in the L band of the frequency spectrum. Because L-band waves penetrate clouds, fog, rain, storms and vegetation, GPS units can receive accurate data in foul weather or underneath a forest canopy. There are circumstances in which GPS units may not receive signals accurately: inside concrete buildings, in some mountainous regions or under especially heavy and wet forest canopies. Accuracy may also be affected by characteristics of both the satellite and the receiver. Though corrections can be made after the fact, the possibility of inaccuracies cannot be eliminated completely. Despite this, the overall reliability of current GPS technology is remarkably good.

There are three types of GPS signals: Coarse Acquisition Code, Ephemeris Data and Almanac Data.

Coarse Acquisition Code (C/A-Code), the most commonly used data received by a GPS unit, identifies the time it takes for the unit to receive a response from a satellite.

Ephemeris Data is transmitted constantly by each satellite and indicates date, time and the functional condition of the satellite.

Almanac Data indicates the exact orbital location of the satellite and is transmitted to the five earth-based tracking stations that constantly monitor the GPS satellite signals.

Common Terms

Waypoint—Synonymous with coordinate or landmark, a waypoint is a position location that can be entered and stored in the GPS unit at any given time. Waypoints can lead to a final destination or be placed to coordinate a route. They mark your location along a route and can be added or deleted at any time during a journey. It is possible to begin with a starting point and end point and enter waypoints along the journey that deviate from an original plan, giving you the freedom to explore and wander without getting lost. Some GPS units let you name your waypoints or identify them with symbols.

Go To—This term refers to a direct path to a location, such as a city or a specific address.

Route—A route is a stored path that tells you how to get from one waypoint to the next. It is created by the connection of waypoints entered into the GPS unit. The waypoints along the route divide the route into "legs."

Track Back—The method by which the GPS unit records your path or journey.

WAAS (Wide Area Augmentation System)—A technology necessary to pinpoint location with a precision of less than three meters. Not all GPS units have WAAS, so if you are looking for a high-level of precision, make sure that yours does.

Types of GPS Receiver Units

All GPS units are essentially compasses with multi-dimensional accuracy. They are programmed with both magnetic north and true north settings. The user can choose one or the other, but when using a GPS unit with a compass, you should choose the magnetic north setting.

The three most commonly used types of GPS units are non-mapping, base-mapping and mapping.

Non-mapping GPS units are the most basic. They generally have no map detail. The plotter screen shows your path by tracking waypoints, routes or track logs. They may also indicate time of day and latitude and longitude, as a compass would.

Base-mapping GPS units have the same tracking, plotting and route features as non-mapping units, but show the user a map to help determine location. When a map is unavailable but necessary for determining a final destination, base-mapping units are an excellent resource. Base-mapping units will typically show state, interstate and U.S. highways, major thoroughfares in metro areas, lakes, rivers, coastlines, airports and exit locations. They can determine current location, speed of travel and direction of a destination.

Mapping GPS units can capture entered information and transmit it to a computer through an RS-232 cable. Depending on the amount of memory available, a mapping unit can be personalized by uploading area maps or road maps from another digital source. Mapping units can be used for real-time applications. Because the amount of memory available varies between mapping GPS units, it is important to choose software carefully.

Getting Started With GPS

Every GPS unit requires input data before it can go to work for you. The first piece of information it needs to recognize is its own "point" (waypoint or current location). Turn the unit on and it will receive a satellite signal identifying its beginning point. From this moment on you can track or record your waypoints as you move. Some GPS receivers can store up to 700 waypoints. Tracking waypoints can create a guide along the same route for future use.

GPS technology has advanced beyond the basic navigational goals it was originally designed to meet, and improvements keep coming. New ways to use GPS for work or recreation are probably just waiting for necessity or someone's imagination to discover them. For more information regarding specific GPS units and job-specific applications, go to: www.benmeadows.com, www.garmin.com, www.ashtech.com or www.navcen.uscg.gov.

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