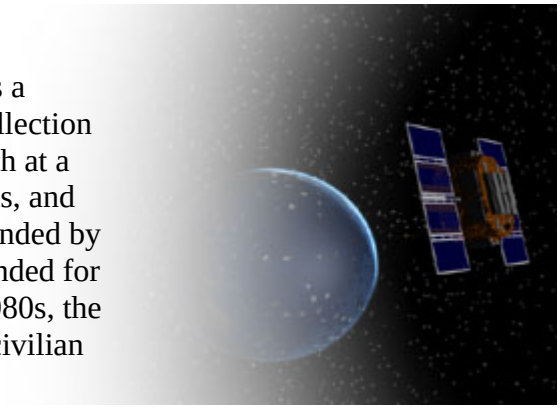
Global Positioning Systems

Introduction



The Global Positioning System (GPS) is a satellite-based navigation system with a collection of 27 NAVSTAR satellites orbiting the Earth at a height of 12,500 miles, 5 monitoring stations, and individual receivers. GPS was originally funded by the US Department of Defense and intended for military applications. However in the 1980s, the government made the system available for civilian use.

GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS.

(Source: http://www.garmin.com/aboutGPS/)

GPS Satellite System

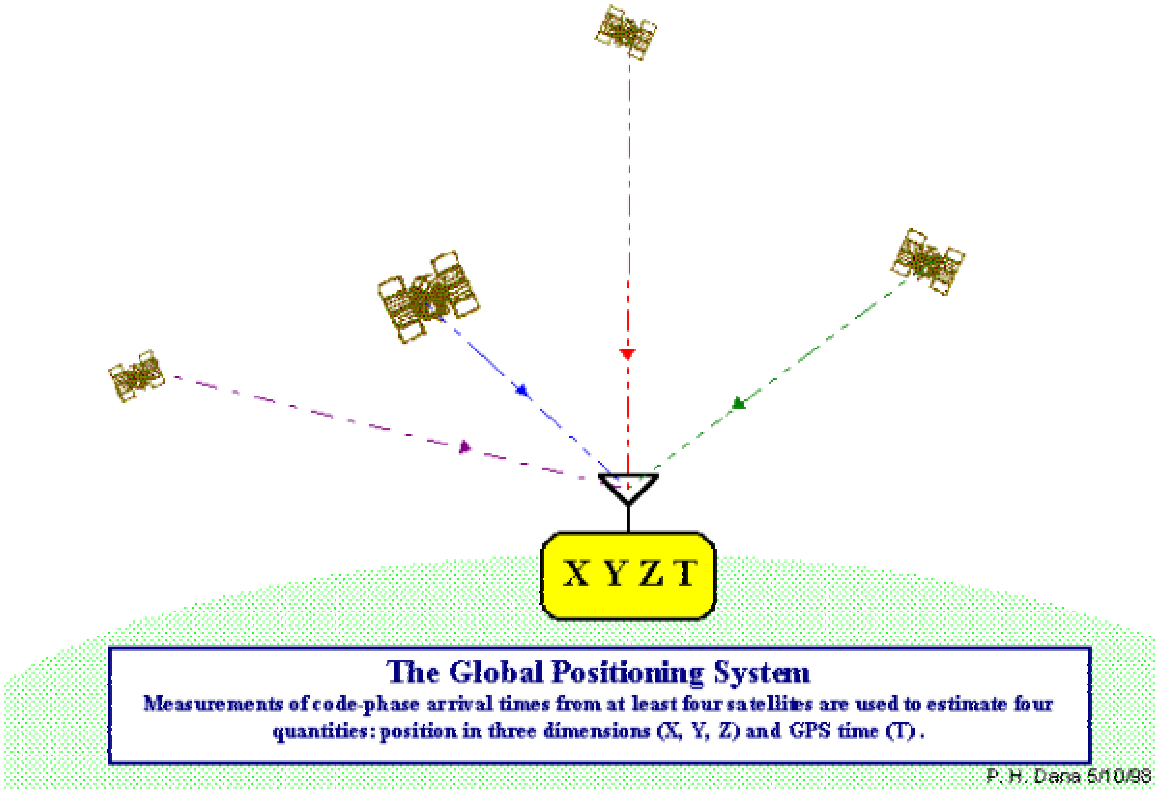
The 27 satellites that make up the GPS space segment are orbiting the earth about 12,000 miles above us. They are constantly moving, making two complete orbits in less than 24 hours. These satellites are traveling at speeds of roughly 7,000 miles an hour. GPS satellites are powered by solar energy. They have backup batteries onboard to keep them running in the event of a solar eclipse, when there's no solar power. Small rocket boosters on each satellite keep them flying in the correct path. Here are some other interesting facts about the GPS satellites (also called NAVSTAR, the official U.S. Department of Defense name for GPS):

- The first GPS satellite was launched in 1978 with a full constellation of 24 satellites was achieved in 1994.
- Each satellite is built to last about 10 years.
- Replacements are constantly being built and launched into orbit.
- A GPS satellite weighs approximately 2,000 pounds and is about 17 feet across with the solar panels extended.
- Transmitter power is only 50 watts or less.

(Source: http://www.garmin.com/aboutGPS/)

How it works

GPS satellites constantly transmit a coded radio signal that indi cates their exact position in space and time. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially, the GPS receiver measures how long it takes the signal to travel from the satellites. By measurin g the distance from 3 or more satellites, the location of the receiver can be obtained by triangulation. If a signal can be obtained from a 4th satellites, then the elevation of the receiver can also be determined.



Source: Geographer's Craft (http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html)

Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more.

What makes up a GPS?

GPS unit
PC to download data and check satellite position prior to going out (PFINDER)
Antenna (optional)
Data logger (optional)
Notebook

Sources of Error

Although standard GPS receivers can provide locations at accuracies of 5-10m, it is important to understand that there are several possible sources of error inherent in these locations. Some of the errors are random in nature, while others are systematic and can therefore be corrected.

Factors that can degrade the GPS signal and thus affect accuracy include the following:

- Ionosphere and troposphere delays — Satellite signal slows as it passes through the atmosphere. The GPS system uses a built-in model that calculates an average amount of delay to partially correct for this type of error.
- Signal multipath — This occurs when the GPS signal is reflected off objects such as tall buildings or large rock surfaces before it reaches the receiver. This increases the travel time of the signal, thereby causing errors.
- Receiver clock errors — A receiver's built-in clock is not as accurate as the atomic clocks onboard the GPS satellites. Therefore, it may have very slight timing errors.
- Orbital errors — Also known as ephemeris errors, these are inaccuracies of the satellite's reported location.
- Number of satellites visible — The more satellites a GPS receiver can "see," the better the accuracy. Buildings, terrain, electronic interference, or sometimes even dense foliage can block signal reception, causing position errors or possibly no position reading at all. GPS units typically will not work indoors, underwater or underground.
- Satellite geometry/shading — This refers to the relative position of the satellites at any given time. Ideal satellite geometry exits when the satellites are located at wide angles relative to each other. Poor geometry results when the satellites are located in a line or in a tight grouping.
- Intentional degradation of the satellite signal — **Selective Availability (SA)** is an intentional degradation of the signal once imposed by the U.S. Department of Defense. SA was intended to prevent military adversaries from using the highly accurate GPS signals. The government turned off SA in May 2000, which significantly improved the accuracy of civilian GPS receivers.

Accuracy of measurements can be improved by using ***Differential Correction***. This technique uses 2 receivers. One is fixed and the other is used to collect measurements. If the location of the fixed (base) receiver is known accurately, comparing the exact location with the location reported by GPS will provide an estimate of error. This error can be used to correct measurements obtained from the roving receiver provided that it is within 300km. Differential GPS can improve accuracy to allow locations to be determined to better than 1 meter.

Useful Resources

Geographer's Craft - GPS

GPS Documentation

How to Use the GIS

Step 1: Turn on the GPS unit.

Press and hold on button (usually a black button)

Step 2: Check the GPS Status

When you turn on the GeoExplorer, it automatically begins to track visible satellites and to calculate its current position. Use the Satellite icon (GeoExplorer 3) or GPS Status option (GeoExplorer 2) to check if GPS is computing positions. The GPS provides information on the geometry of the satellites being used to compute GPS positions.

SNR – Current signal-to-Noise ratio of each satellite. The signal strength of a satellite is a measure of the information content of the signal, relate to the signal's noise. The typical SNR of a satellite at 30° elevation is between 10.0 and 15.0. The quality of a GPS position is degraded

The accuracy of a position computed by a GPS receiver is a function of the geometry of the GPS satellites visible at that moment in time. When the visible satellites are well separated in the sky, the GPS receiver can compute accurate positions. If two or more satellites are close together at the time of the position is recorded, the small errors inherent in measuring their signals compound, reducing the accuracy of computed positions. The best overall indicator of satellites geometry is Position Dilution of Precision (PDOP) which is a measure of positional accuracy. PDOP values are categorized:

PDOP level	Quality
1 – 4	Excellent
4-6	Good
6-8	Fair
8-12	Poor
12-100	Very poor
>100	Unusable

GeoExplorer already has a PDOP mask set and uses it as an upper bound on PDOP values for collecting data.

Step 3: Create a New File

Before you start collecting data you need to create a new file.

GeoExplorer 3 – Press Data tab. You can enter a name in the File field. Then, press Enter. Select New feature as Point.

GeoExplorer 2 – Return to the Main menu (hit Esc). Use arrow keys to locate “Capture Data”. Open a Rover file.

Step 4: Collect Features

Begin collecting features by pressing the Enter tab.

GeoExplorer 3 starts logging GPS positions when the logging icon appears at the bottom of the status bar (lower right). Number above the icon indicates how many positions have been logged.

GeoExplorer 2 works similar with points being logged appearing in the upper right corner.

Step 5: Close File

When your are finished collecting data:

GeoExplorer 3 - press Close until the File tab appears and then you can start a new file or turn off the GeoExplorer 3 which automatically closes the data file.

GeoExplorer 2 - Choose Close option under the Capture Data menu.

Selected Availability turned off in May 1, 2000

STATEMENT BY THE PRESIDENT REGARDING THE UNITED STATES

DECISION TO STOP DEGRADING GLOBAL POSITIONING SYSTEM ACCURACY

THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release May 1, 2000

STATEMENT BY THE PRESIDENT REGARDING

THE UNITED STATES DECISION TO STOP DEGRADING GLOBAL POSITIONING SYSTEM ACCURACY

Today, I am pleased to announce that the United States will stop the intentional degradation of the Global Positioning System (GPS) signals available to the public beginning at midnight tonight. We call this degradation feature Selective Availability (SA). This will mean that civilian users of GPS will be able to pinpoint locations up to ten times more accurately than they do now. GPS is a dual-use, satellite-based system that provides accurate location and timing data to users worldwide. My March 1996 Presidential Decision Directive included in the goals for GPS to: "encourage acceptance and integration of GPS into peaceful civil, commercial and scientific applications worldwide; and to encourage private sector investment in and use of U.S. GPS technologies and services." To meet these goals, I committed the U.S. to discontinuing the use of SA by 2006 with an annual assessment of its continued use beginning this year.

The decision to discontinue SA is the latest measure in an on-going effort to make GPS more responsive to civil and commercial users worldwide. Last year, Vice President Gore announced our plans to modernize GPS by adding two new civilian signals to enhance the civil and commercial service. This initiative is on-track and the budget further advances modernization by incorporating some of the new features on up to 18 additional satellites that are already awaiting launch or are in production. We will continue to provide all of these capabilities to worldwide users free of charge.

My decision to discontinue SA was based upon a recommendation by the Secretary of Defense in coordination with the Departments of State, Transportation, Commerce, the Director of Central Intelligence, and other Executive Branch Departments and Agencies. They realized that worldwide transportation safety, scientific, and commercial interests could best be served by discontinuation of SA. Along with our commitment to enhance GPS for peaceful applications, my administration is committed to preserving fully the military utility of GPS. The decision to discontinue SA is coupled with our continuing efforts to upgrade the military utility of our systems that use GPS, and is supported by threat assessments which conclude that setting SA to zero at this time would have minimal impact on national security. Additionally, we have demonstrated the capability to selectively deny GPS signals on a regional basis when our national security is threatened. This regional approach to denying navigation services is consistent with the 1996 plan to discontinue the degradation of civil and commercial GPS service globally through the SA technique.

Originally developed by the Department of Defense as a military system, GPS has become a global utility. It benefits users around the world in many different applications, including air, road, marine, and rail navigation, telecommunications, emergency response, oil exploration, mining, and many

more. Civilian users will realize a dramatic improvement in GPS accuracy with the discontinuation of SA. For example, emergency teams responding to a cry for help can now determine what side of the highway they must respond to, thereby saving precious minutes. This increase in accuracy will allow new GPS applications to emerge and continue to enhance the lives of people around the world.

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From: www.whitehouse.gov/library

More about this topic:
http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html

SO do we need to differentially correct anymore?

It depends on your use? take the use of your data into consideration. If you are doing very precise measurements--- meaning safety-critical or surveyor you may. However, if your precision only need be >20m, then you do not need it. From: http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html
Interesting facts about GPS.

From: www.garmin.com

Each satellite weighs 2,000 pounds and is 17ft across when the solar panels (for power) are extended
The transmitter requires less than or equal to 50 watts of power
Each satellite lasts approximately 10 years and replacements are constantly being built and launched (the program is funded until 2006)
It works anywhere in the world
It works in all weather conditions

What companies make GPS and what are the costs?

Companies: Garmin, Trimble, Sony, Magellan, NavTrak, Alpine, Silva, MLR, and others.

Costs:

Handhed : $100-600
Automotive (some attach to pc?s in the car) : $150-$2,000
Aviation: $300-$1,500
Fixed Mount (can be used for auto, but usually for marine):$270 -$370
Wristwatch(!?!): $400

from: http://www.cnde.iastate.edu/staff/swormley/gps/gps.html

For more information/tutorials:

Trimble?s tutorial: http://www.trimble.com/gps/fsections/aa_f0.htm

Garmin?s tutorial: http://www.garmin.com/aboutGPS/

GPS World Online: http://www.gpsworld.com/

Geographer?s Craft:
http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html
(excellent--- very detailed)

Lab Reference:

Hurn, Jeff, 1989. GPS: A Guide to the Next Utility. Published by Trimble Navigation.

Selective Availability Turned Off

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