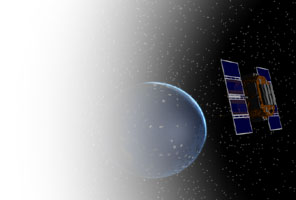
**GPS**

**What is GPS?**



The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but 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.

**How it works**

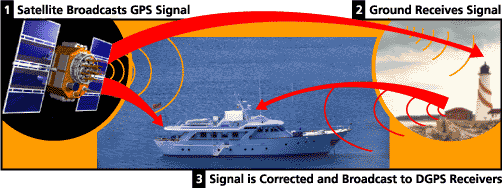
GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map.

[](http://www8.garmin.com/products/spIII/)

A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). 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.

**How accurate is GPS?**

Today's GPS receivers are extremely accurate, thanks to their parallel multi-channel design. Garmin's 12 parallel channel receivers are quick to lock onto satellites when first turned on and they maintain strong locks, even in dense foliage or urban settings with tall buildings. Certain atmospheric factors and other sources of error can affect the accuracy of GPS receivers. Garmin® GPS receivers are accurate to within 15 meters on average.



Newer Garmin GPS receivers with [WAAS](http://www8.garmin.com/aboutGPS/waas.html) (Wide Area Augmentation System) capability can improve accuracy to less than three meters on average. No additional equipment or fees are required to take advantage of WAAS. Users can also get better accuracy with Differential GPS (DGPS), which corrects GPS signals to within an average of three to five meters. The U.S. Coast Guard operates the most common DGPS correction service. This system consists of a network of towers that receive GPS signals and transmit a corrected signal by beacon transmitters. In order to get the corrected signal, users must have a differential beacon receiver and beacon antenna in addition to their GPS.



**The GPS satellite system**

The 24 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 travelling 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.
* 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.

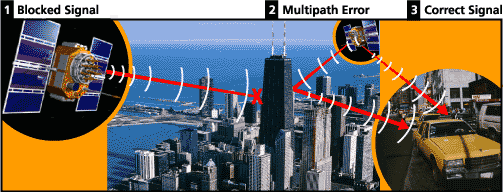
**What's the signal?**

GPS satellites transmit two low power radio signals, designated L1 and L2. Civilian GPS uses the L1 frequency of 1575.42 MHz in the UHF band. The signals travel by line of sight, meaning they will pass through clouds, glass and plastic but will not go through most solid objects such as buildings and mountains.

A GPS signal contains three different bits of information - a pseudorandom code, ephemeris data and almanac data. The pseudorandom code is simply an I.D. code that identifies which satellite is transmitting information. You can view this number on your Garmin GPS unit's satellite page, as it identifies which satellites it's receiving.

Ephemeris data, which is constantly transmitted by each satellite, contains important information about the status of the satellite (healthy or unhealthy), current date and time. This part of the signal is essential for determining a position.

The almanac data tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite transmits almanac data showing the orbital information for that satellite and for every other satellite in the system.



**Sources of GPS signal errors**

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

* Ionosphere and troposphere delays - The 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 exists 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.

## Applications

While originally a military project, GPS is considered a *dual-use* technology, meaning it has significant military and civilian applications.

GPS has become a widely deployed and useful tool for commerce, scientific uses, tracking, and surveillance. GPS's accurate time facilitates everyday activities such as banking, mobile phone operations, and even the control of power grids by allowing well synchronized hand-off switching. Farmers, surveyors, geologists, and countless others perform their work more efficiently, safely, economically, and accurately.[[25]](http://en.wikipedia.org/wiki/Global_Positioning_System#cite_note-gps.gov-24)

## Communication

The navigational signals transmitted by GPS satellites encode a variety of information including satellite positions, the state of the internal clocks, and the health of the network. These signals are transmitted on two separate carrier frequencies that are common to all satellites in the network. Two different encodings are used, a public encoding that enables lower resolution navigation, and an encrypted encoding used by the U.S. military.

### Message format

|  |  |
| --- | --- |
| GPS message format | |
| **Sub frames** | **Description** |
| 1 | Satellite clock, GPS time relationship |
| 2–3 | Ephemeris (precise satellite orbit) |
| 4–5 | Almanac component (satellite network synopsys, error correction) |

Each GPS satellite continuously broadcasts a *navigation message* at a rate of 50 bits per second (see [bitrate](http://en.wikipedia.org/wiki/Bitrate)). Each complete message is composed of 30-second [frames](http://en.wikipedia.org/wiki/Frame_%28networking%29), distinct groupings of 1,500 bits of information. Each frame is further subdivided into 5 sub frames of length 6 seconds and with 300 bits each. Each sub frame contains 10 words of 30 bits with length 0.6 seconds each. Each 30 second frame begins precisely on the minute or half minute as indicated by the atomic clock on each satellite.[[55]](http://en.wikipedia.org/wiki/Global_Positioning_System#cite_note-54)

The first part of the message encodes the week number and the time within the week,[[56]](http://en.wikipedia.org/wiki/Global_Positioning_System#cite_note-55) as well as the data about the health of the satellite. The second part of the message, the [*ephemeris*](http://en.wikipedia.org/wiki/Ephemeris), provides the precise orbit for the satellite. The last part of the message, the *almanac*, contains coarse orbit and status information for all satellites in the network as well as data related to error correction.[[57]](http://en.wikipedia.org/wiki/Global_Positioning_System#cite_note-56)

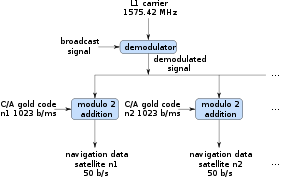
All satellites broadcast at the same frequencies. Signals are encoded using [code division multiple access](http://en.wikipedia.org/wiki/Code_division_multiple_access) (CDMA) allowing messages from individual satellites to be distinguished from each other based on unique encodings for each satellite (that the receiver must be aware of). Two distinct types of CDMA encodings are used: the coarse/acquisition (C/A) code, which is accessible by the general public, and the precise (P) code, that is encrypted so that only the U.S. military can access it.

The ephemeris is updated every 2 hours and is generally valid for 4 hours, with provisions for updates every 6 hours or longer in non-nominal conditions. The almanac is updated typically every 24 hours. Additionally data for a few weeks following is uploaded in case of transmission updates that delay data upload.

### Satellite frequencies

All satellites broadcast at the same two frequencies, 1.57542 GHz (L1 signal) and 1.2276 GHz (L2 signal). The satellite network uses a CDMA spread-spectrum technique where the low-bitrate message data is encoded with a high-rate [pseudo-random](http://en.wikipedia.org/wiki/Pseudorandom_number_generator) (PRN) sequence that is different for each satellite. The receiver must be aware of the PRN codes for each satellite to reconstruct the actual message data. The C/A code, for civilian use, transmits data at 1.023 million [chips](http://en.wikipedia.org/wiki/Chip_%28CDMA%29) per second, whereas the P code, for U.S. military use, transmits at 10.23 million chips per second. The L1 carrier is modulated by both the C/A and P codes, while the L2 carrier is only modulated by the P code.[[58]](http://en.wikipedia.org/wiki/Global_Positioning_System#cite_note-57) The P code can be encrypted as a so-called P(Y) code that is only available to military equipment with a proper decryption key. Both the C/A and P(Y) codes impart the precise time-of-day to the user. GPS Modernization added a third frequency, 1.17645 GHZ (L5 signal). The L5 consists of two carrier components that are in phase quadrature with each other. Each carrier component is bi-phase shift key (BPSK) modulated by a separate bit train.

#### Demodulation and decoding

[](http://en.wikipedia.org/wiki/File:Gps_ca_gold.svg)

[http://bits.wikimedia.org/skins-1.5/common/images/magnify-clip.png](http://en.wikipedia.org/wiki/File:Gps_ca_gold.svg)

**Demodulating and Decoding GPS Satellite Signals using the Coarse/Acquisition** [**Gold code**](http://en.wikipedia.org/wiki/Gold_code)**.**

Because all of the satellite signals are modulated onto the same L1 carrier frequency, the signals must be separated after demodulation. This is done by assigning each satellite a unique binary [sequence](http://en.wikipedia.org/wiki/Sequence) known as a [Gold code](http://en.wikipedia.org/wiki/Gold_code). The signals are decoded after demodulation using addition of the Gold codes corresponding to the satellites monitored by the receiver.[[59]](http://en.wikipedia.org/wiki/Global_Positioning_System#cite_note-58)[[60]](http://en.wikipedia.org/wiki/Global_Positioning_System#cite_note-59)

If the almanac information has previously been acquired, the receiver picks the satellites to listen for by their PRNs, unique numbers in the range 1 through 32. If the almanac information is not in memory, the receiver enters a search mode until a lock is obtained on one of the satellites. To obtain a lock, it is necessary that there be an unobstructed line of sight from the receiver to the satellite. The receiver can then acquire the almanac and determine the satellites it should listen for. As it detects each satellite's signal, it identifies it by its distinct C/A code pattern. There can be a delay of up to 30 seconds before the first estimate of position because of the need to read the ephemeris data.

Processing of the navigation message enables the determination of the time of transmission and the satellite position at this time. For more information see [Demodulation and Decoding, Advanced](http://en.wikipedia.org/wiki/GPS_signals#Demodulation_and_decoding).