

THE GLOBAL POSITIONING SYSTEM

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The Global Positioning System (GPS) is a global navigation satellite system (GNSS) developed by the United States Department of Defense and managed by the United States Air Force 50th Space Wing. It is the only fully functional GNSS in the world, can be used freely, and is often used by civilians for navigation purposes. It uses a constellation of between 24 and 32 Medium Earth Orbit satellites that transmit precise microwave signals, which allow GPS receivers to determine their current location, the time, and their velocity. Its official name is NAVSTAR GPS. Although NAVSTAR is not an acronym, a few backronyms have been created for it.

Since it became fully operational in 1993, GPS has become a widely used aid to navigation worldwide, and a useful tool for map-making, land surveying, commerce, scientific uses, and hobbies such as geocaching. Also, the precise time reference is used in many applications including the scientific study of earthquakes. GPS is also a required key synchronization resource of cellular networks, such as the Qualcomm CDMA air interface used by many wireless carriers in a multitude of countries.

The first satellite navigation system, Transit, used by the United States Navy, was first successfully tested in 1960. Using a constellation of five satellites, it could provide a navigational fix approximately once per hour. In 1967, the U.S. Navy developed the Timation satellite which proved the ability to place accurate clocks in space, a technology that GPS relies upon. In the 1970s, the ground-based Omega Navigation System, based on signal phase comparison, became the first worldwide radio navigation system.

The design of GPS is based partly on similar ground-based radio navigation systems, such as LORAN and the Decca Navigator developed in the early 1940s, and used during World War II. Additional inspiration for the GPS came when the Soviet Union launched the first Sputnik in 1957. A team of U.S. scientists led by Dr. Richard B. Kershner were monitoring Sputnik's radio transmissions. They discovered that, because of the Doppler effect, the frequency of the signal being transmitted by Sputnik was higher as the satellite approached, and lower as it continued away from them. They realized that since they knew their exact location on the globe, they could pinpoint where the satellite was along its orbit by measuring the Doppler distortion.

After Korean Air Lines Flight 007 was shot down in 1983 after straying into the USSR's prohibited airspace, President Ronald Reagan issued a directive making GPS freely available for civilian use as a common good. The satellites were launched between 1989 and 1993.

Initially the highest quality signal was reserved for military use, while the signal available for civilian use was intentionally degraded ("Selective Availability", SA). Selective Availability was ended in 2000, improving the precision of civilian GPS from about 100m to about 20m.

Of crucial importance for the function of GPS is the placement of atomic clocks in the satellites, first proposed by Friedwardt Winterberg in 1955. Only then can the required position accuracy be reached.

A GPS receiver calculates its position by precisely timing the signals sent by the GPS satellites high above the Earth. Each satellite continually transmits messages containing the time the message was sent, precise orbital information (the ephemeris), and the general system health and rough orbits of all GPS satellites (the almanac). The receiver measures the transit time of each message and computes the distance to each satellite. Geometric trilateration is used to combine these distances with the location of the satellites to determine the receiver's location. The position is displayed, perhaps with a moving map display or latitude and longitude; elevation information may be included. Many GPS units also show derived information such as direction and speed, calculated from position changes.

It might seem three satellites are enough to solve for position, since space has three dimensions. However a very small clock error multiplied by the very large speed of light—the speed at which satellite signals propagate—results in a large positional error. The receiver uses a fourth satellite to solve for x , y , z , and t which is used to correct the receiver's clock.