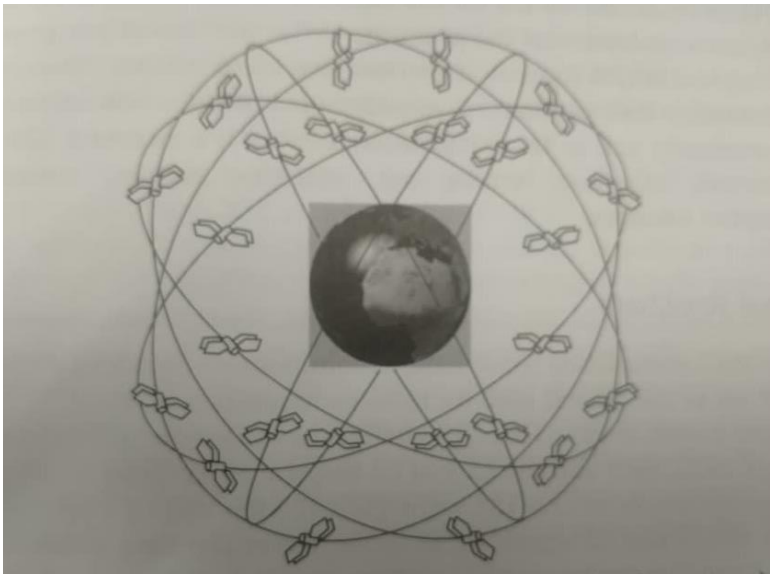
GPS Segments

Each GNSS consist of three segments, called the space segment (the satellites orbiting the Earth), the control segment (stations positioned around the Earth to control the satellites) and the user segment (anybody that receives and uses a GNSS signal). The segments of GPS are described in this section.

The space segment of GPS consists of a minimum of 24 satellites, all of which are in orbits 20,200 km above the Earth with an orbital period of 12 sidereal hours. Because the sidereal day is slightly longer than the solar day, it appears to an observer on the Earth that the satellites return to the same positions four minutes earlier each day.

This has practical implications, as a good satellite configuration for observations on one day may change to a less favourable one of the following and subsequent days. Great care was taken when designing the GPS satellite constellation, as it is necessary to have the optimum satellite coverage on the Earth from the minimum number of satellites.

To achieve the best coverage, the satellites are located in six orbital planes spaced equally around the plane of the equator, but inclined at 55 ° to the equator.



GPS satellite constellation (Courtesy Leica Geosystems)

Various generations (blocks) of GPS satellites have been launched. There are no operational Block I satellites today, and most currently in use are Block IIA, IIR and IIR-M satellites, where the R stands for replenishment. The generation of GPS satellites currently being launched are known as Block IIF satellites where the F stands for follow on. A further generation known as Block III satellites are also being deployed.

As the accurate measurement of time is essential in GPS, each satellite is fitted with up to four atomic clocks. Block IIA satellites have caesium or rubidium clocks on board with extremely high accuracies of up to 1 in 10^12 whereas the later satellites use highly stable hydrogen maser clock with an even better accuracy of 1 in 10^14.

A number of tracking stations at fixed locations around the world form the control segment of GPS. The master Control Station (MCS) is located in the consolidated Space Operations Centre (CSOC) at Schriever Air Force Base near Colorado Springs in the United States. An alternative MCS is located at Vandenberg Air Force Base in California.

To be able to position accurately with GPS, the exact position of each satellite has to be known at all times (remember that the satellites are in effect the GPS control points). This relies on very accurate orbital data and very accurate timing so that a receiver can calculate the position of a satellite at a given time. As they orbit the Earth, the satellites are subjected to the varying gravitational attraction of the Earth, the attractions of the Sun and Moon and solar radiation pressure.

All of these cause the satellite orbits to change with time, and these have to be measured and predicted by some means. Despite their phenomenal accuracy, the satellite clocks drift and they must be kept synchronised with GPS time as defined at the CSOC. To ensure that accurate orbital data is used, a network of tracking stations around the Earth continuously monitors all of the GPS satellites in view at all times and this orbital data is relayed to the MCS, where it is used to predict future orbits for the satellites.

As well as corrections to be computed in order to keep the satellite clocks in step with GPS time. The predicted satellite orbital positions (which are known as ephemeris predictions) and satellite clock correction computed at the MCS are sent to ground antennae at the tracking stations, where this information is uploaded to the satellites every two hours and then broadcast via the GPS satellites to users of the system.

This enables each GPS receiver to determine their positions of the satellites at any given time.

The user segment of GPS consists of anyone, civilian or military, who uses a GPS receiver to determine their position. As already noted, there is now an extensive civilian GPS community and as far as construction work is concerned, GPS is used for control surveys, mapping, setting out, machine control, monitoring and measurement of volumes.

Reference: Surveying for Engineers, 5th edition (John Uren and Bill Price)