Chapter 4. Global Positioning System (GPS)

4.1. 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 Defence. 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.

4.2. 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.

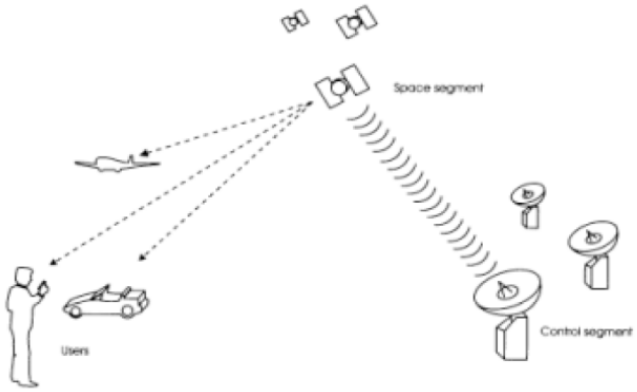
4.3. Introduction to the System Components

System Design Considerations

Development work on GPS commenced within the U.S. Department of Defence in 1973, the motivation being to develop an all-weather, 24-hour, global positioning system to support the positioning requirements for the armed forces of the U.S. and its allies. The system was therefore designed to replace the large variety of navigational systems already in use, and great emphasis was placed on the system's reliability and survivability.

The GPS system consists of three segments.

- **The Space Segment**: comprising the satellites and the transmitted signals.
- **The Control Segment**: the ground facilities carrying out the task of satellite tracking, orbit computations, telemetry and supervision necessary for the daily control of the space segment.
- **The User Segment**: the entire spectrum of applications equipment and computational techniques that are available to the users.



4.4. 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 Defence. 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.