Advanced Electronic Communication Systems

Lecture 6

GPS

(Global Positioning System)

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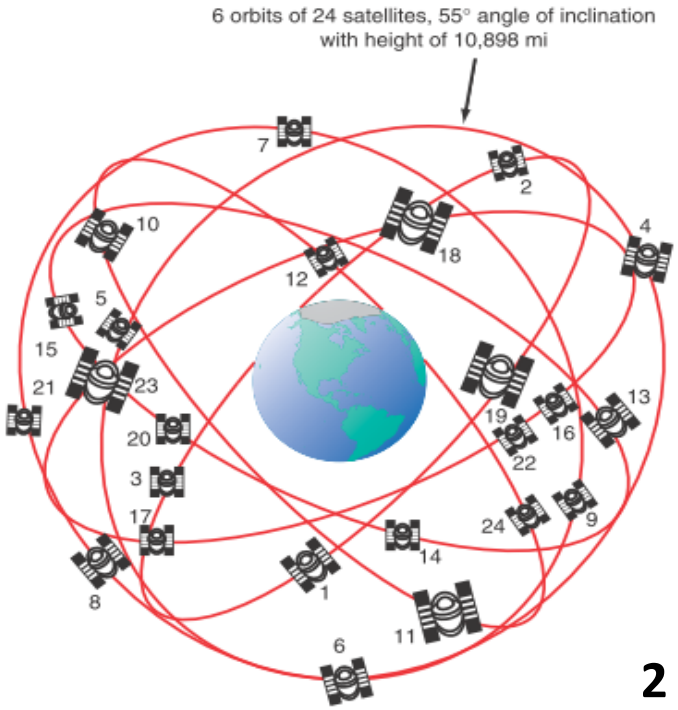
GPS (Global Positioning System)

- Global Navigation Satellite System (GNSS) refers to the multiple satellite systems used for worldwide navigation.
- The original GNSS was the U.S.'s Global Positioning System (GPS) and still is the most widely used across the globe.
- GPS, also known as NAVSTAR (Navigation System with Time and Ranging), is a satellite-based navigation system that can be used by anyone with an appropriate receiver to pinpoint his location on earth.

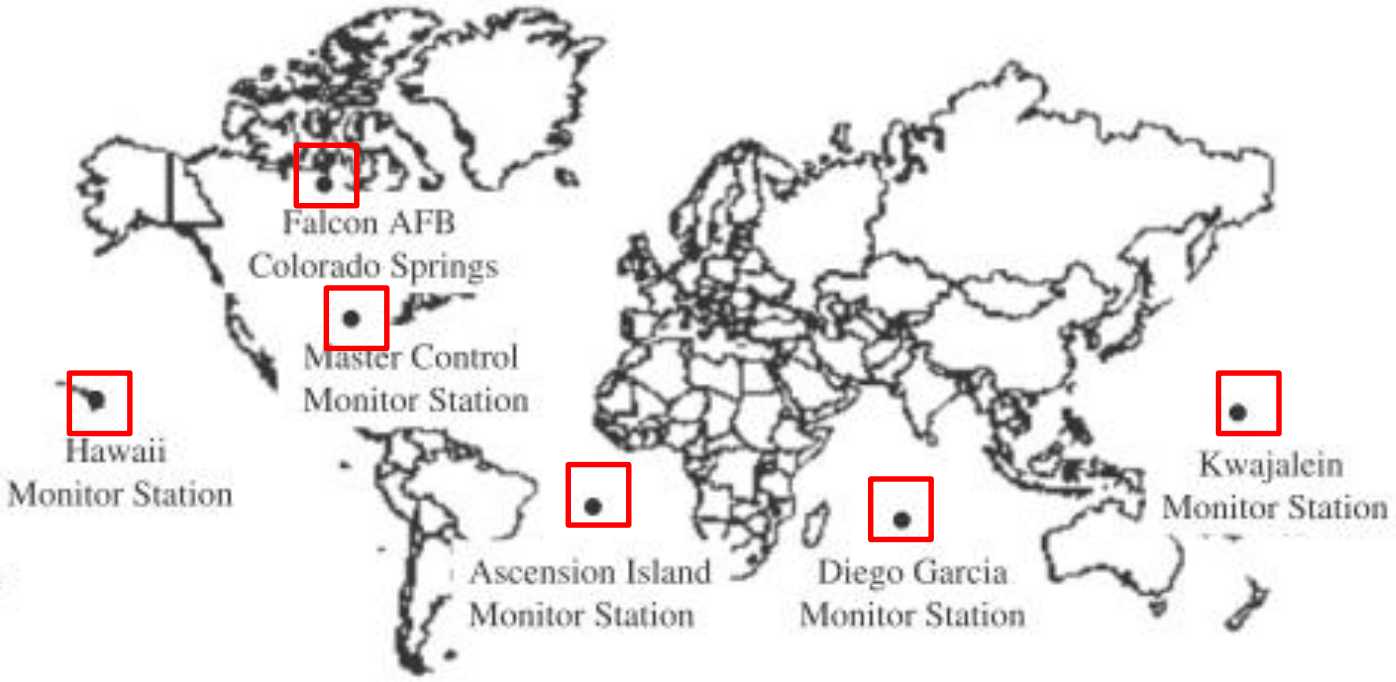
- A GPS system consists of a network of 24 orbiting satellites covering the entire earth under their signal beams
- Satellites are placed in space in six different orbital paths with four satellites in each orbital plane
- The orbital period of these satellites is 12 hours.
- The spacing of the satellites is arranged such that a minimum of five satellites are in view from every point on the globe.



GPS (Global Positioning System)

- The GPS control, or the ground segment, consists of unmanned monitor base stations located around the world:

- The stations track and monitor the GPS satellites.



GPS (Global Positioning System)

- The GPS Navstar system is an open navigation system; i.e., anyone with a GPS receiver can use it.
- The system is designed, however, to provide a base navigation system with a horizontal accuracy to within 3 m.

- The array of GPS satellites transmits highly accurate, time-coded information that permits a receiver to calculate its exact location in terms of the latitude, longitude and altitude above sea level.

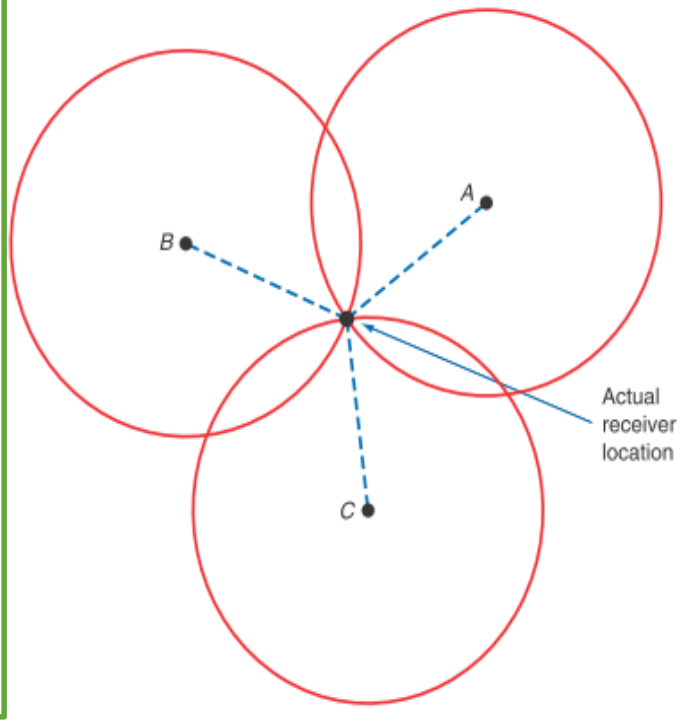
- A GPS receiver on earth is designed to pick up signals from three, four, or more satellites simultaneously.

- The receiver decodes the information and, calculates the exact position of the receiver using GPS TRIANGULATION.

GPS Triangulation

- The determination of the location of a GPS receiver is based on measuring the distance between the receiver and three satellites.
- The distance is determined by measuring the time of arrival of the satellite signals and then computing distance based on the speed of radio waves, with correction factors.

- Assume three satellites A, B, and C.
- The receiver first computes the distance from the receiver to A (on a circle that falls on a wide range of locations on earth).
- Then the receiver calculates the distance to satellite B (along another circle).
- The two circles intersect at two points. One of those is the exact location, but we don't know which until we get a third satellite reading.
- The distance from satellite C intersects with the other circles at only one point.



- Actually it is a sphere not a circle.
- Using a fourth satellite gives a fourth intersection point that enables the altitude to be determined.

Limitations of GPS

1. A major source of error arises from the fact that the speed of the radio signals is constant only in a vacuum, which means that distance measurements may vary as the values of the signal speed vary in the atmosphere.

2. Another source of error is the multiple paths that signals take between the satellite and the MS ground receivers. The effects of multipath fading and shadowing are significant due to the absence of a direct LOS path.

3. Another factor affecting the precision is satellite geometry (i.e., locations of the satellites relative to each other). If a GPS receiver is locked with four satellites and all four of these satellites are in the sky to the north and west of the receiver, satellite geometry is relatively poor. This is because all the distance measurements are from the same general direction.

4. The largest source of position error is selective availability (SA), which is an intentional degradation of civilian GPS by the U.S. Department of Defense. The idea behind intentionally induced errors due to SA is to make sure that no hostile force or terrorist group can use GPS to make accurate weapons.

Applications of GPS

User Group	Application Area
U.S. military	Maneuvering in extreme conditions and navigating planes, ships, etc.
Building the English channel tunnel	Checking positions along the way and making sure that they meet in the middle
General aviation and commercial aircraft	Navigation
Recreational boaters and commercial fishermen	Navigation
Surveyors	Reducing setup time at survey sites and offering precise measurements
Recreational users (e.g., hikers, hunters, snowmobilers, mountain bikers)	Keeping track of where they are and finding a specified location
Automobile services	Emergency roadside assistance

A-GPS

✓ Receiver-based approach,

- an MS directly contacts the constellation of GPS satellites and downloads information necessary to determine its position.
- Therefore there is a lot of delay in obtaining all the information from the satellites.
- Another problem is that when the MS is indoors, it may not be possible to contact the GPS satellites.

✓ Network-based approach

- An alternative is to use a network-based approach wherein the MS triangulates its position using information from three or more BSs.
- This approach has the disadvantage that the location information obtained may not possess the desired accuracy.

- The A-GPS is a hybrid solution to this problem whereby information from both the satellites and the network is used to accurately determine the location of a MS.

A-GPS

- Information about the satellite positions may be downloaded and calculated by powerful A-GPS servers located at the BSs, and this is fed to the MSs,
- The MSs use this information along with the encoded signals obtained from the satellites to accurately and quickly obtain its location

A-GPS also addresses the problem of weak GPS signals indoors.