GPS

GPS ??

- GPS is the shortened form of NAVSTAR GPS. This is an acronym for NAVigation System with Time And Ranging Global Positioning System.
- GPS, which stands for **Global Positioning System,** is one of the satellite systems currently in use. It is able to show you your exact position on the surface of earth anytime, in any weather, anywhere.

What does it do..?

- GPS is a solution for one of man's longest problems.

Where on earth am I .. ?

- One can say, "you can easily locate yourself by looking at objects that surround you and position yourself relative to them".
- But what if you have no objects around you ?

What if you are :

- In the middle of a desert

or

- In the middle of an ocean ?

Then GPS comes to your rescue

Origin of GPS:

- First idea came after the launch of Russian Satellite Sputnik in 1957
  - Two Scientists at *Johns Hopkins University* (JHU) realized they could pinpoint the location of the satellite by analyzing the radio signals.

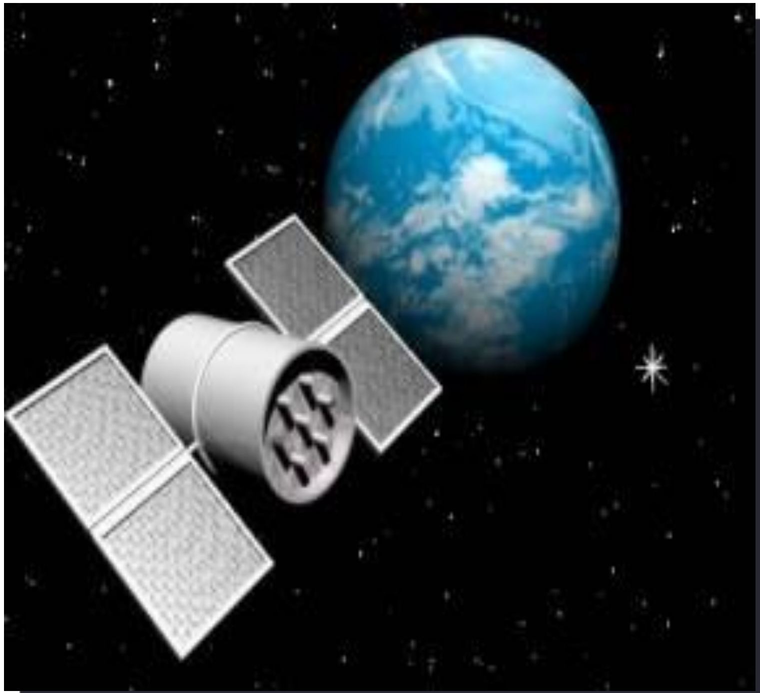
  - Frank McClure, then went a step further by suggesting that if the satellite's position were known and predictable, then we can also locate a receiver on Earth; in other words, one could navigate by satellite.

Satellites:

- There are quite a number of satellites out there in space.
- They are used for a wide range of purposes e.g:

1. Communication satellite
2. Imaging satellites
3. Global Navigation Satellite Systems etc.

- How ever at present we are referring to the third category.



GPS Segments:

Basically there are three segments of GPS.

- **The Space Segment:** Satellites orbiting the earth.
- **The Control Segment:** Stations positioned on the earth's equator to control the satellites.
- **The User Segment:** Anybody that receives and uses the GPS signal.

GPS Segments

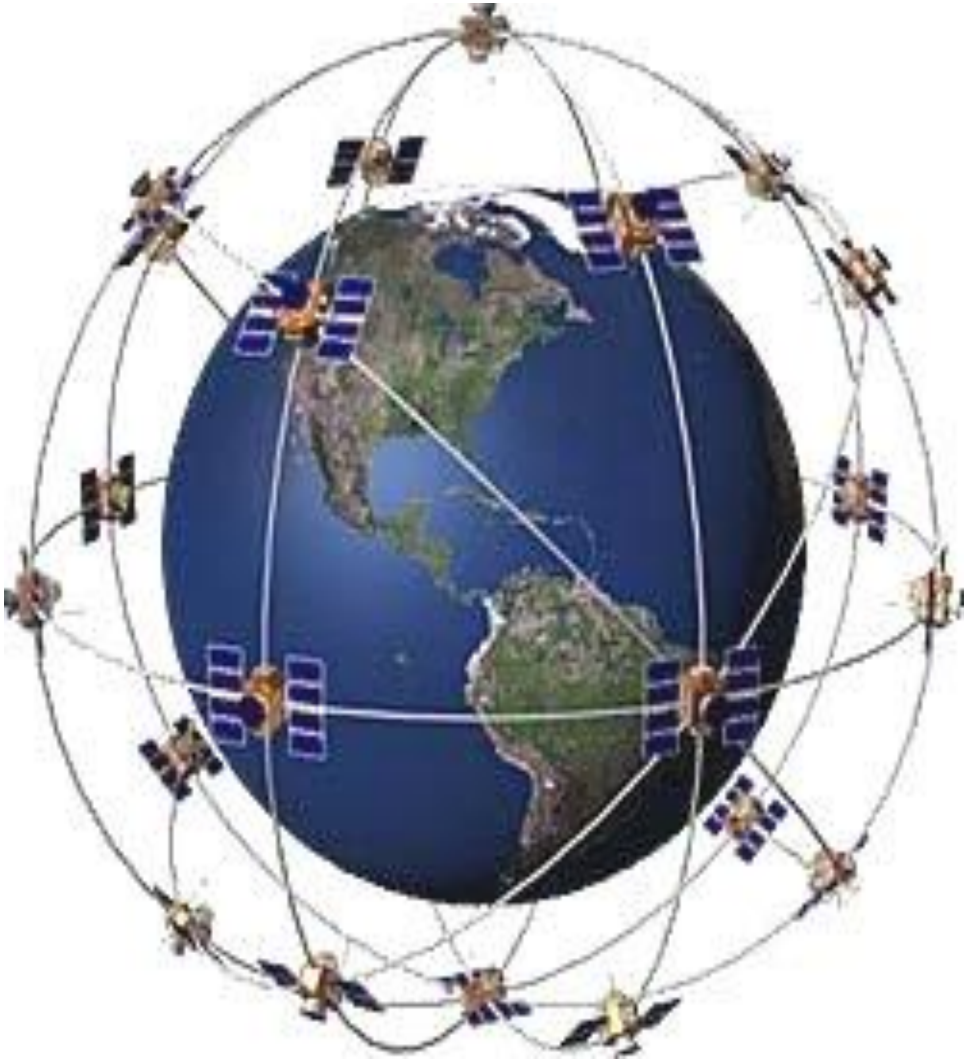
- The current GPS consists of three major segments. These are the space segment (SS), a control segment (CS), and a user segment (US).

- The U.S. Air Force develops, maintains, and operates the space and control segments.

- GPS satellites broadcast signals from space, and each GPS receiver uses these signals to calculate its three-dimensional location (latitude, longitude, and altitude) and the current time.

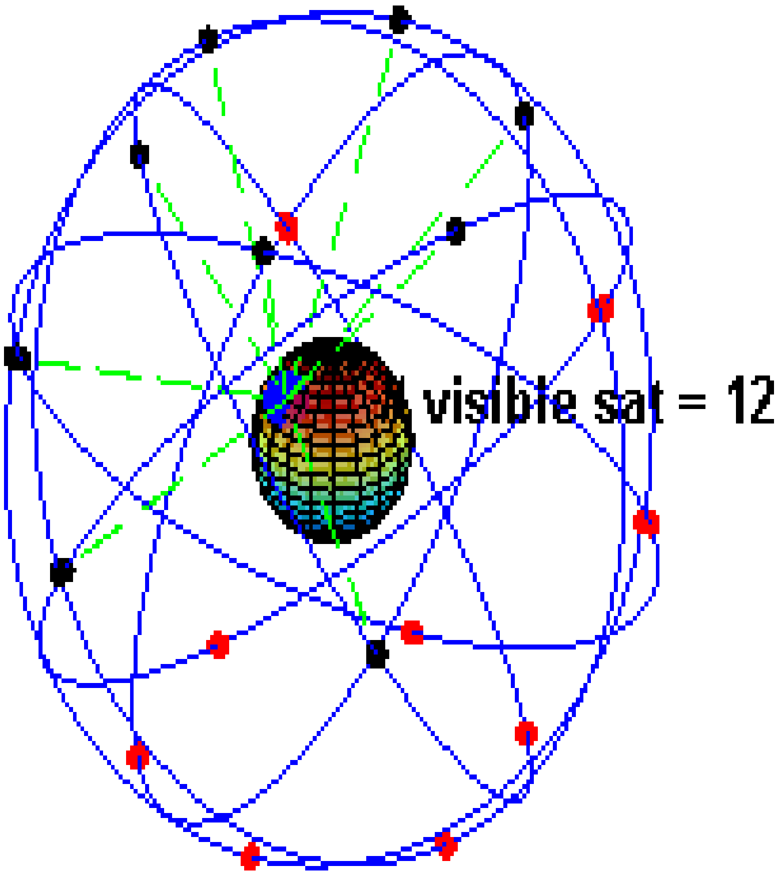
1. Space Segment:

- The GPS Operational Constellation consists of 24 satellites that orbit the Earth in very precise orbits twice a day. GPS satellites emit continuous navigation signals.



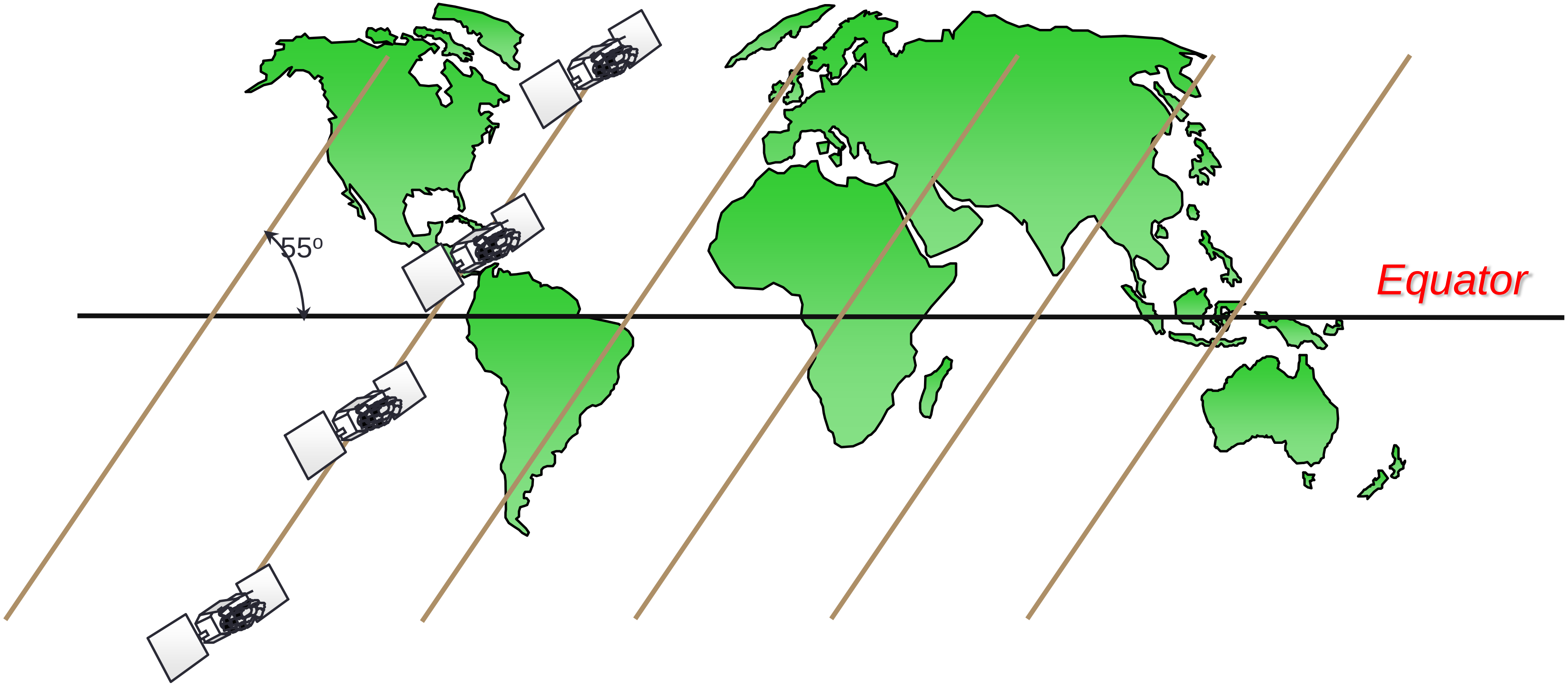
Space Segment

- The space segment is so designed that there will be a minimum of 4 satellites visible above a 15° cut-off angle at any point of the earth surface at any one time.



Space Segment

- 24 Operational Satellites
- 4 satellites in 6 orbital planes inclined at 55°
- 20,200 km above the Earth



Space Segment

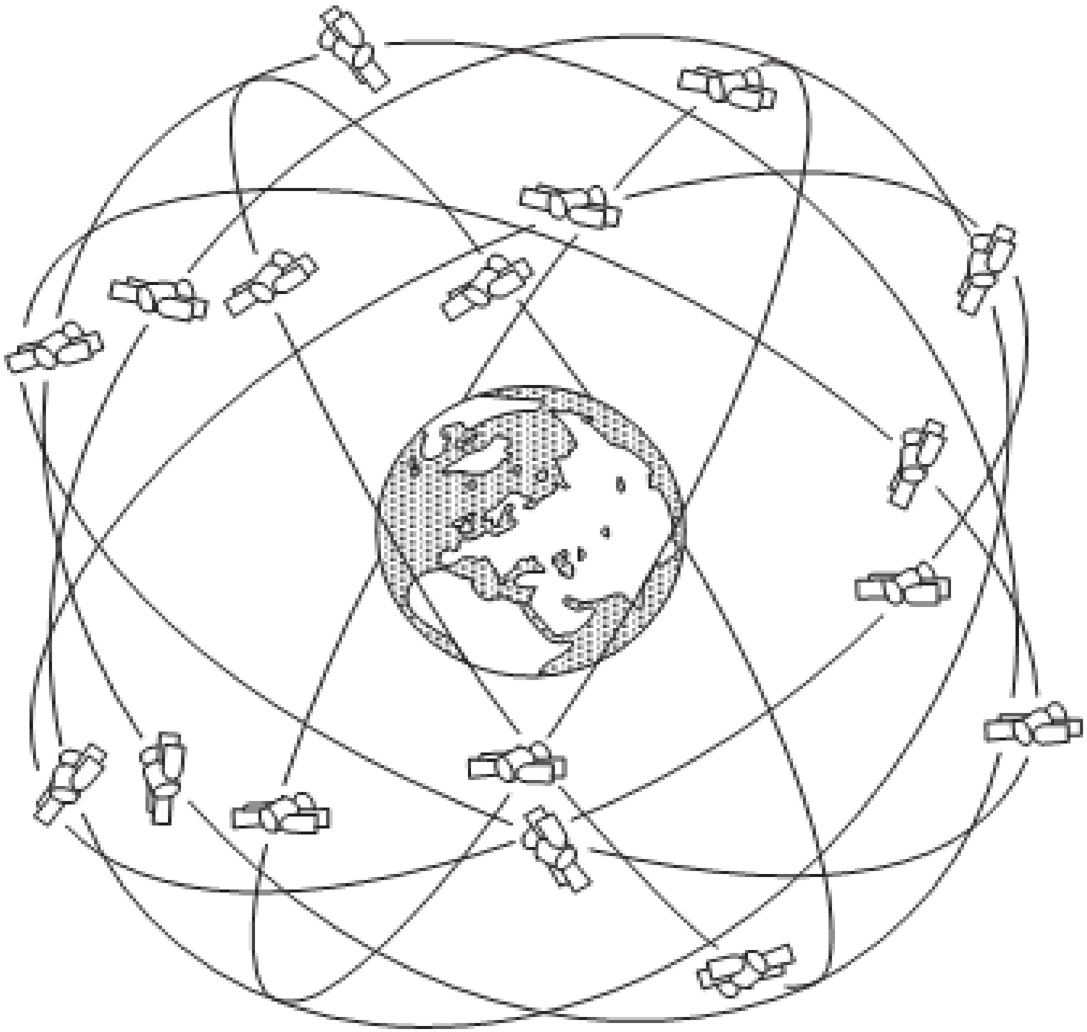
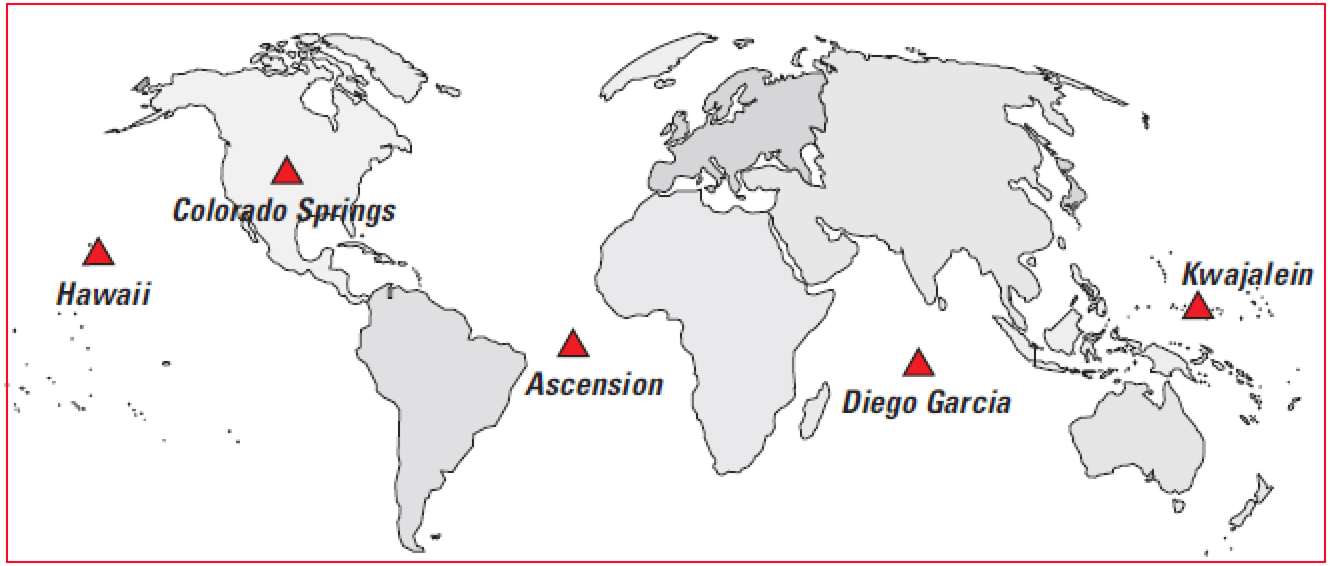


Fig. 7.2 *The GPS satellite constellation: 24 satellites, 6 orbital planes, 55° inclination, 20 200 km altitude 12-hour orbits. (Courtesy Wild Heerbrugg)*

2. Control Segment:

- The Control Segment consists of one master control station, monitor stations and 4 ground antennas distributed amongst 5 locations roughly on the earth's equator. The Control Segment tracks the GPS satellites, updates their orbiting position & time.
- A further important function is to determine the orbit of each satellite and predict it's path for the following 24 hours.

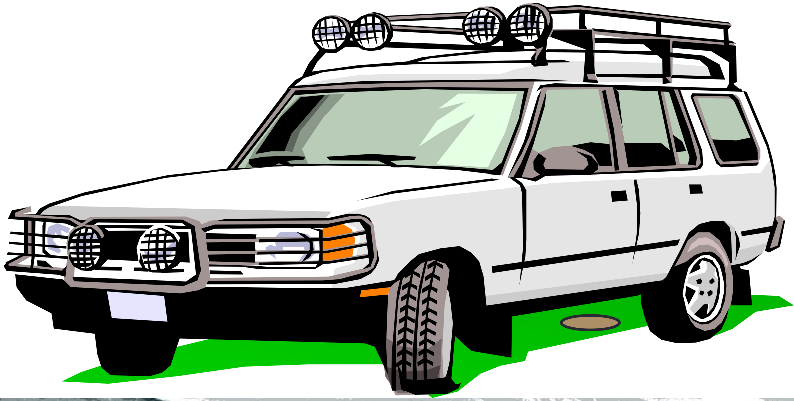


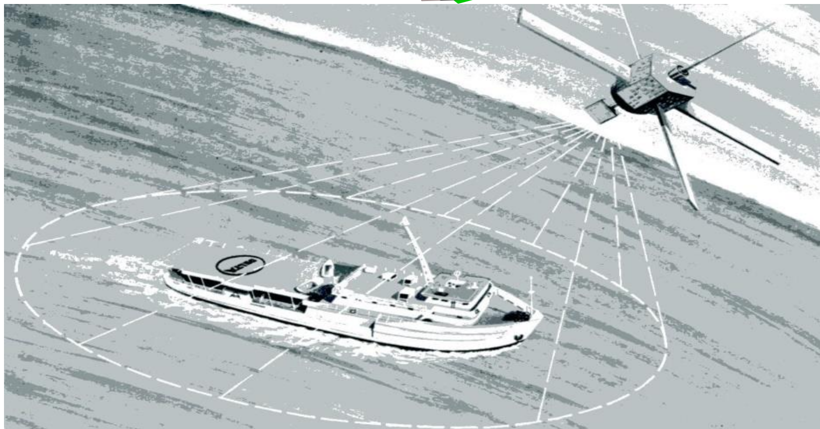
Control Segment Station Locations

3. User Segment:

- The User Segment comprises of anyone using a GPS receiver to receive the GPS signal and determine their position and or time.

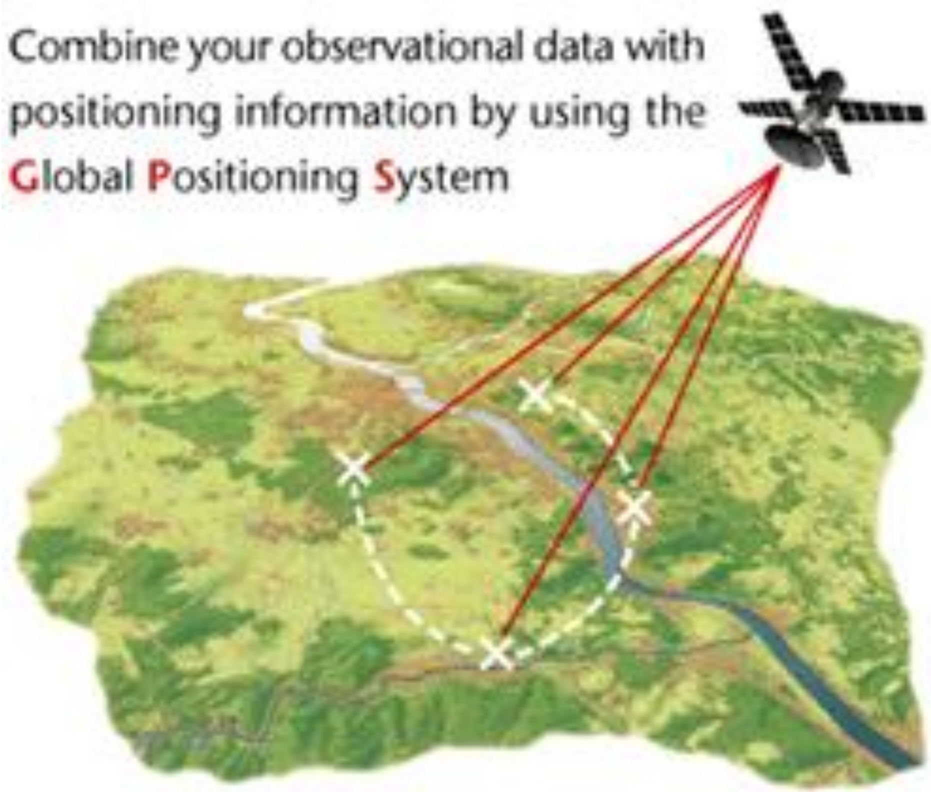
- Typical applications within the user segment are land navigation for hikers, vehicle location, surveying, marine navigation, aerial navigation, etc.





GPS Receivers:

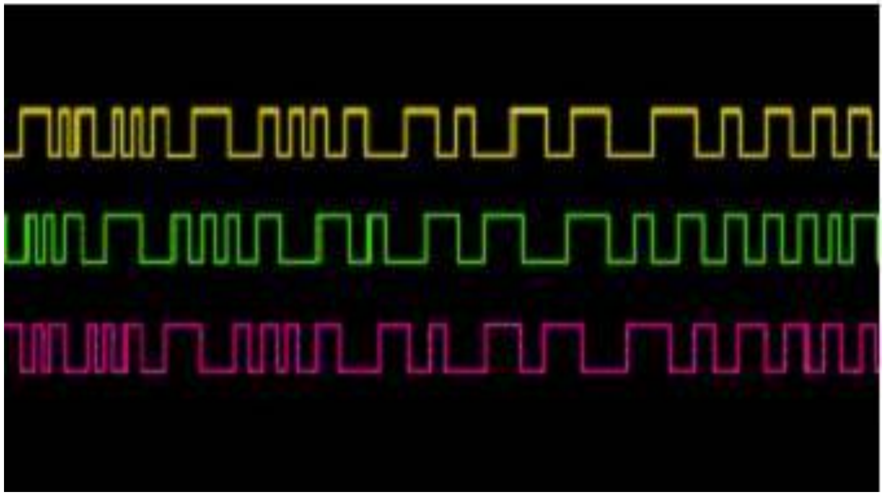
- GPS units are made to communicate with GPS satellites (which have a much better view of the Earth) to find out exactly where they are on the global scale of things.



GPS Signals:

- Each GPS satellite transmits data that indicates its location and the current time.

- All GPS satellites synchronize operations so that these repeating signals are transmitted at the same instant.



Physically the signal is just a complicated digital code, or in other words, a complicated sequence of “on” and “off” pulses.

How GPS Works?

Simple Navigation:

- This is the most simple technique employed by GPS receivers to instantaneously give a position and height and/ or accurate time to a user.

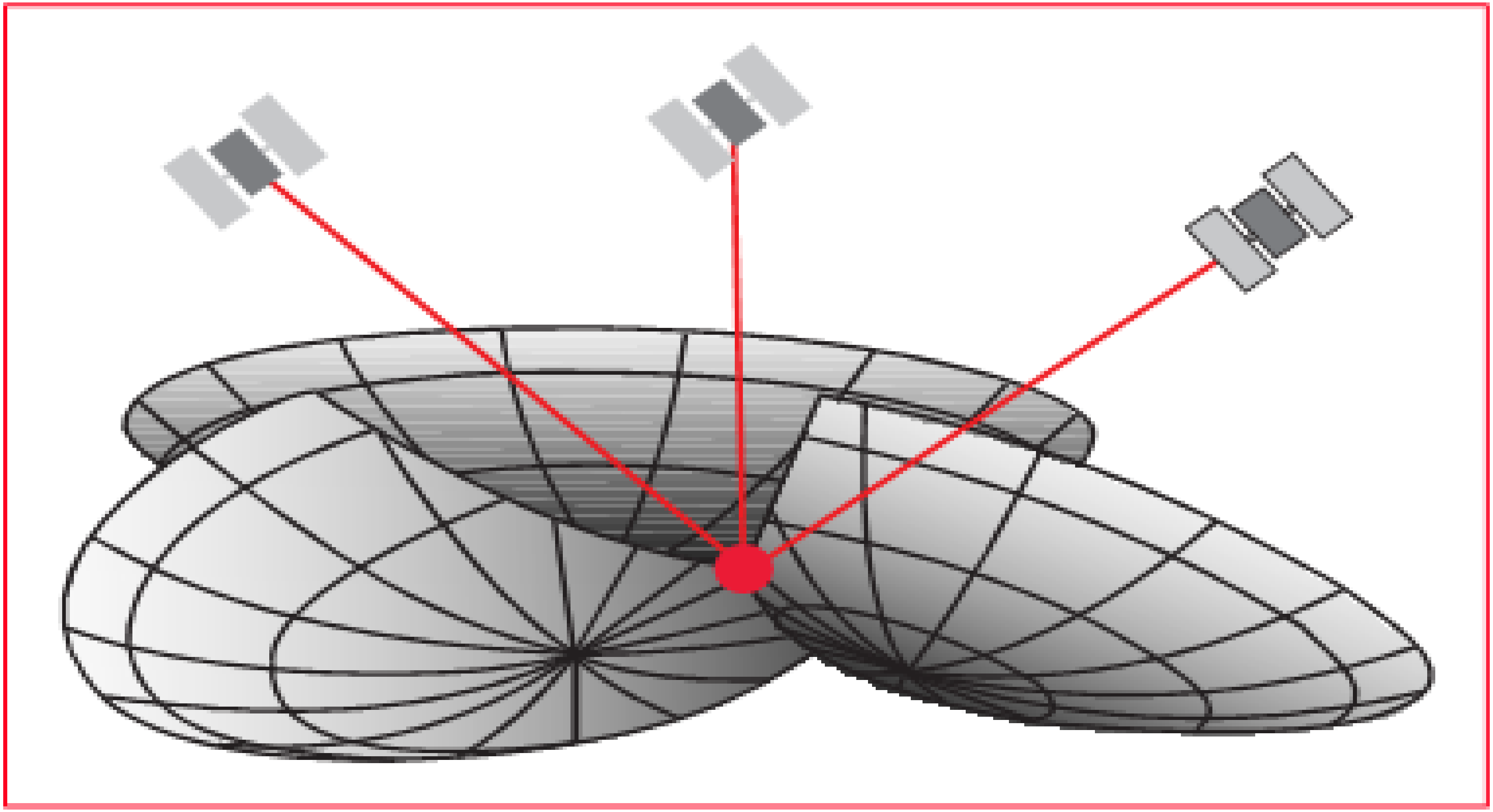
A Handheld GPS Receiver

Satellite Ranging:

- All GPS positions are based on measuring the distance from the satellites to the GPS receiver on the earth. This distance to each satellite can be determined by the GPS receiver.

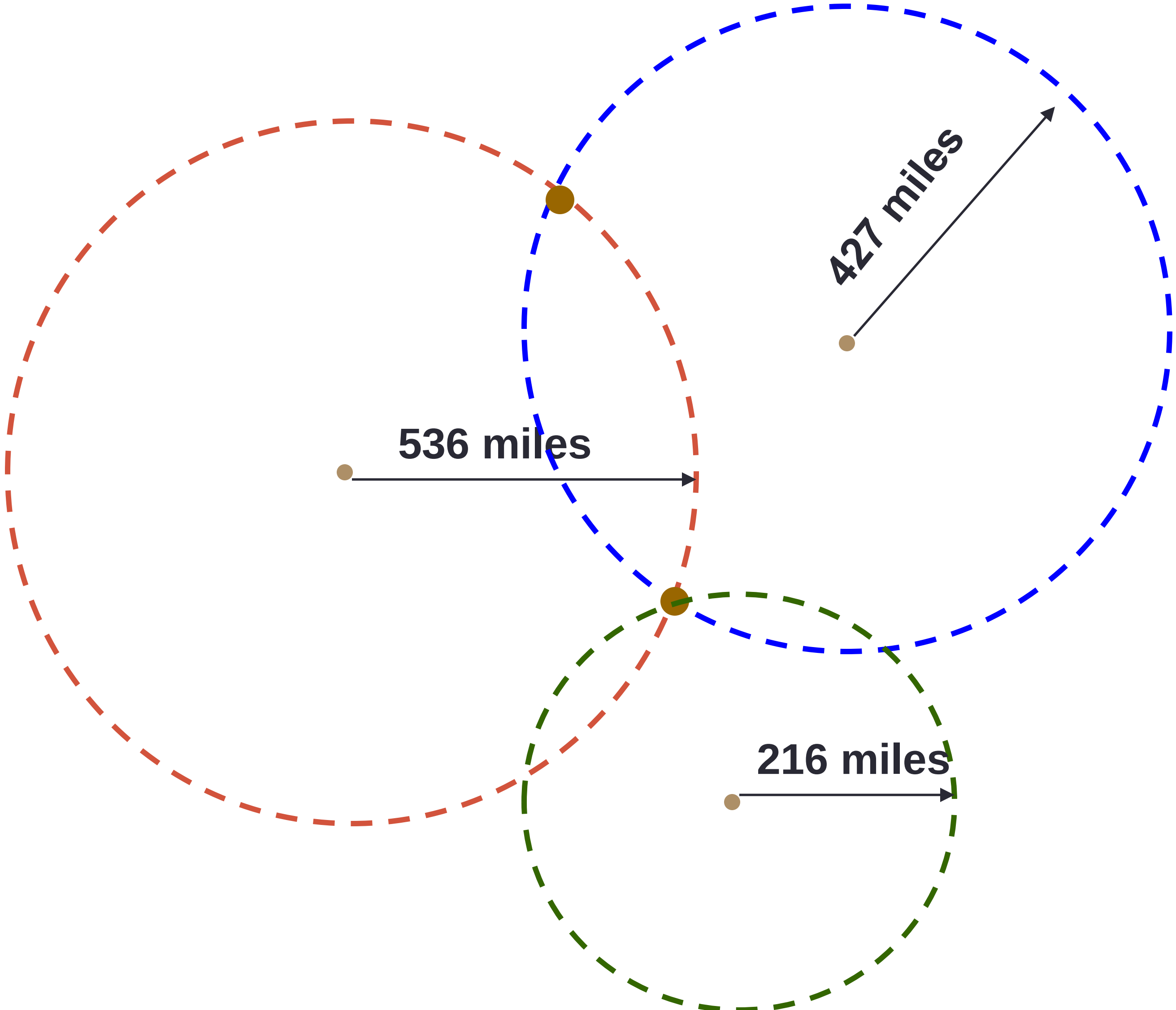
- From the distance to one satellite we know that the position of the receiver must be at some point on the surface of an imaginary sphere which has it's origin at the satellite. By intersecting three imaginary spheres the receiver position can be determined.

Satellite Ranging



Intersection of three imaginary spheres

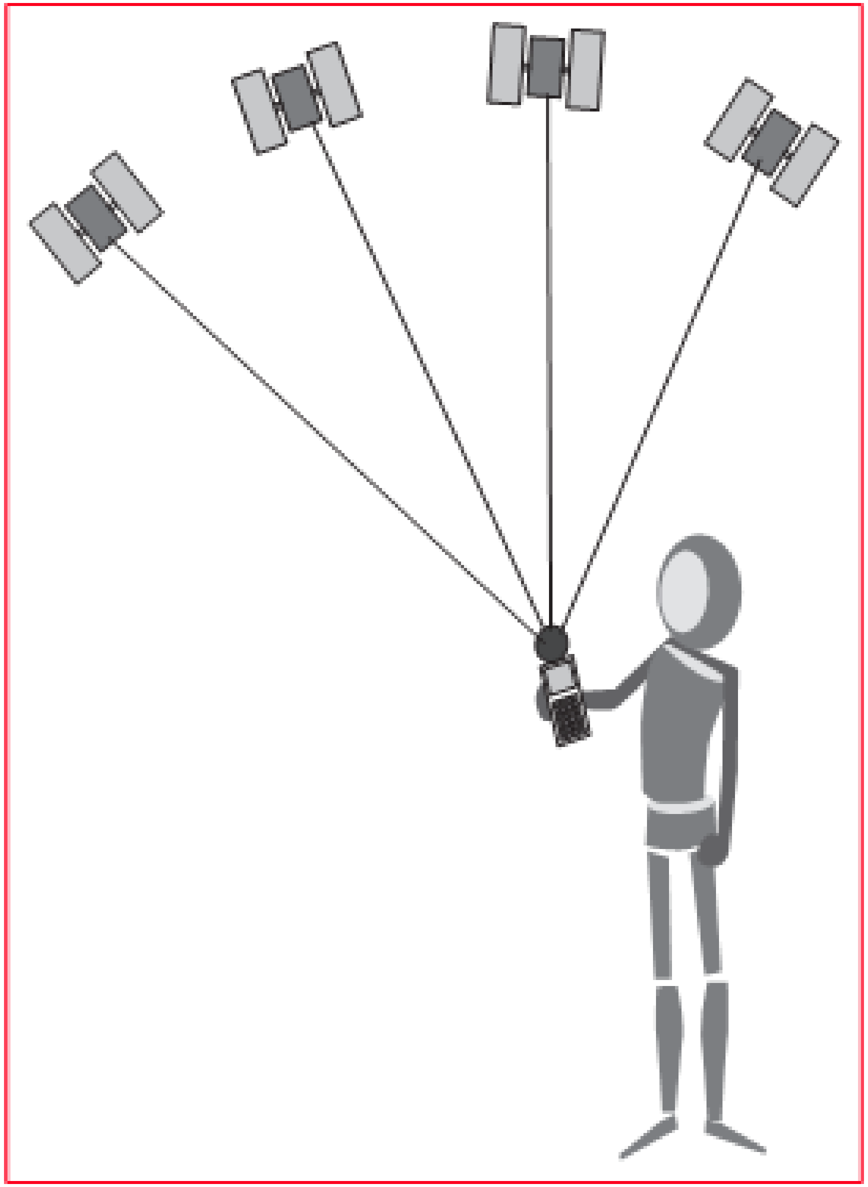
Satellite Ranging



Satellite Ranging

- Thus there are four unknowns to determine; position (X, Y, Z) and time of travel of the signal.

- Observing to four satellites produces four equations which can be solved, enabling these unknowns to be determined.

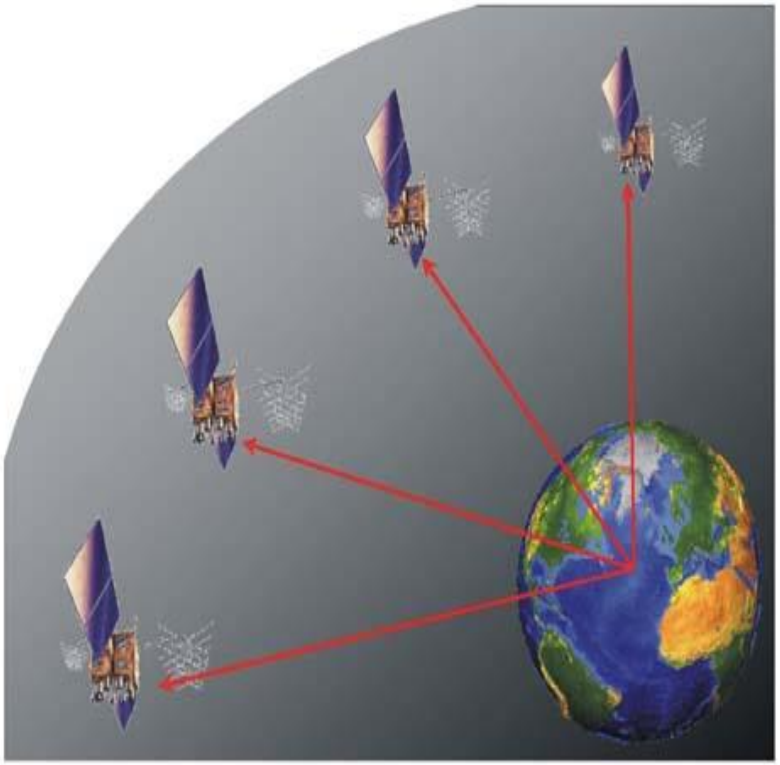


At least four satellites are required to obtain a position and time in 3 dimensions

Time Difference:

- 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.



Calculating Distance:

Velocity x Time = Distance

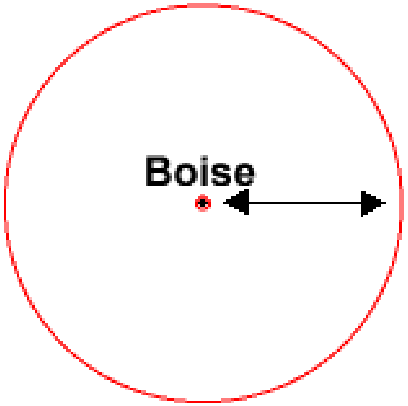
- **Radio waves travel at the speed of light, roughly 186,000 miles per second (mps)**

  If it took 0.06 seconds to receive a signal transmitted by a satellite floating directly overhead, use this formula to find your distance from the satellite.

186,000 mps **x 0.06** seconds **= 11,160 miles**

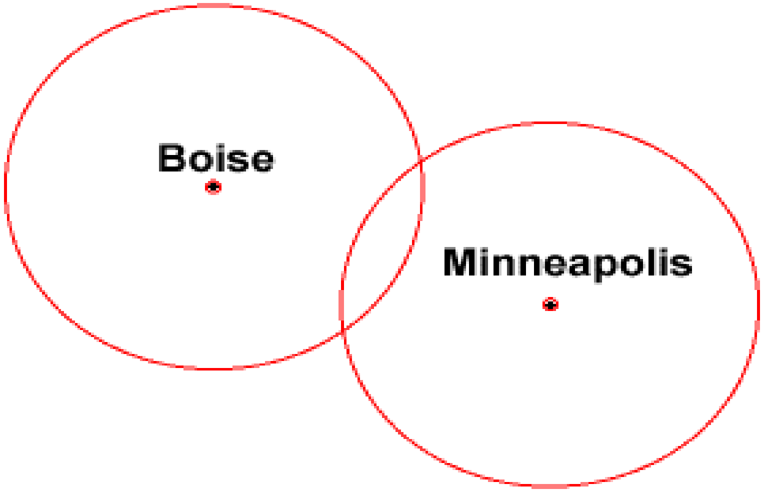
2-D Trilateration:

- Imagine you are somewhere in the United States and you are TOTALLY lost -- for whatever reason, you have absolutely no clue where you are.
- You find a friendly local and ask, "Where am I?" He says, "You are 625 miles from Boise, Idaho."
- This is a nice, hard fact, but it is not particularly useful by itself. You could be anywhere on a circle around Boise that has a radius of 625 miles, like this:



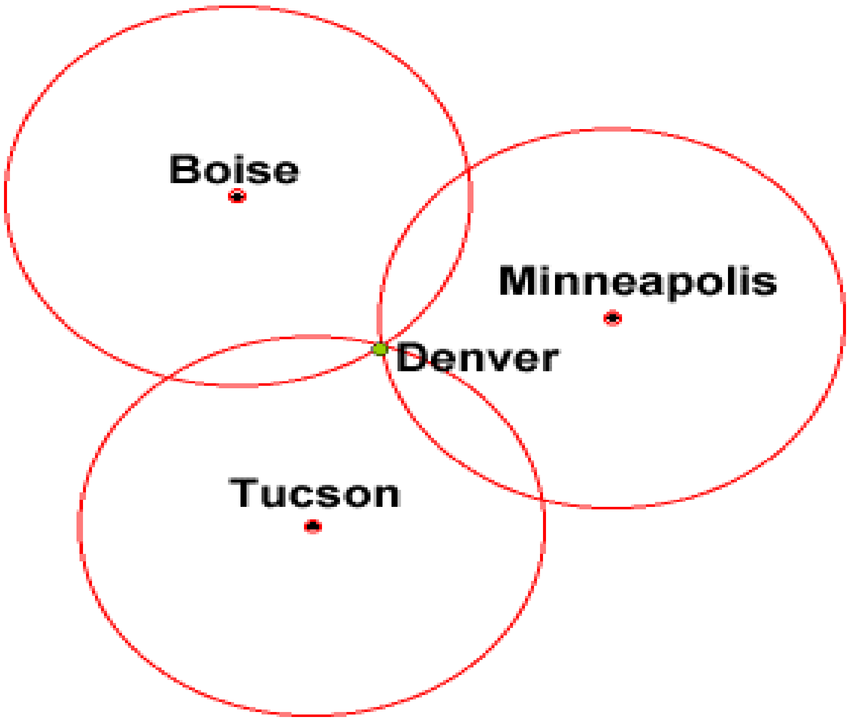
2-D Trilateration:

- You ask somebody else where you are, and he says, "You are 690 miles from Minneapolis, Minnesota."
- Now you're getting somewhere. If you combine this information with the Boise information, you have two circles that intersect.
- You now know that you must be at one of these two intersection points, if you are 625 miles from Boise and 690 miles from Minneapolis.



2-D Trilateration:

- If a third person tells you that you are 615 miles from Tucson, Arizona, you can eliminate one of the possibilities, because the third circle will only intersect with one of these points.
- You now know exactly where you are -- Denver, Colorado.



✓ This same concept works in three-dimensional space, as well, but you're dealing with **spheres** instead of circles. In the next section, we'll look at this type of trilateration.

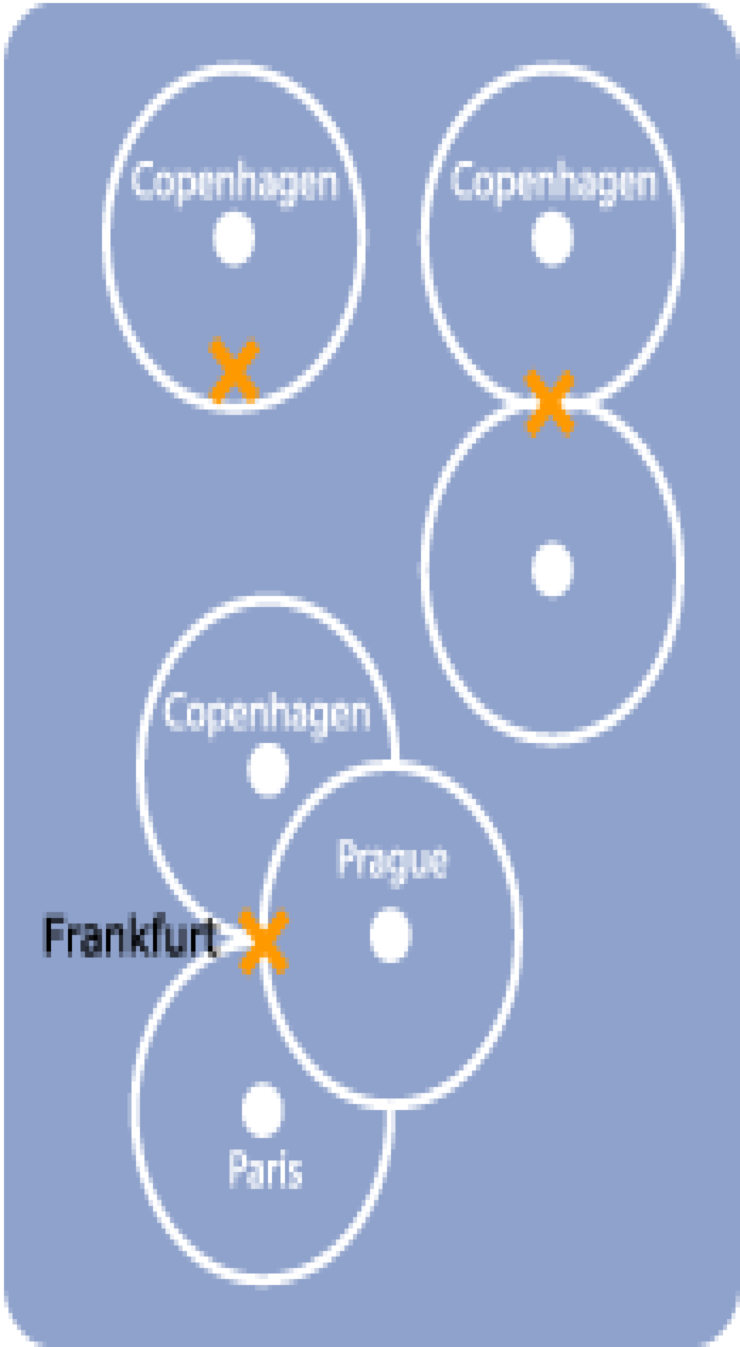
Another Example:

2-D Trilateration:

- Imagine you’re completely lost. You wake up in a strange hotel room one morning with no idea at all where you are. You go downstairs and ask the hotel receptionist, "Where am I?"
- “I can’t say” he says, “but I will tell you you’re 593 miles/ 955 kilometres from Copenhagen.”
- You now know you’re somewhere on a circle round Copenhagen with a radius of 593 miles/ 955 kilometres.
- You stroll into town and, stopping off for a coffee, ask the waitress where you are. “375 miles/ 604 kilometres from Paris" she says and walks away.
- You then notice the table napkins. As luck would have it, they are perfect detailed maps of Europe! You take one, pull out your handy compass-and-ruler accessory set and draw two circles. So:

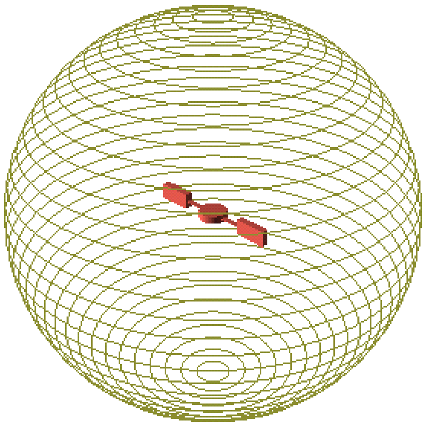
2-D Trilateration:

- You now know you must be at one of the two points where the circles intersect. The only two points both 593 miles/ 955 kilometres from Copenhagen and 375 miles/ 604 kilometres from Paris.
- Back on the street an old man calls you over. He tells you that you are 317 miles/ 510 kilometres from Prague. You whip out your napkin and compass and draw another circle.
- You now know exactly where you are: Frankfurt!

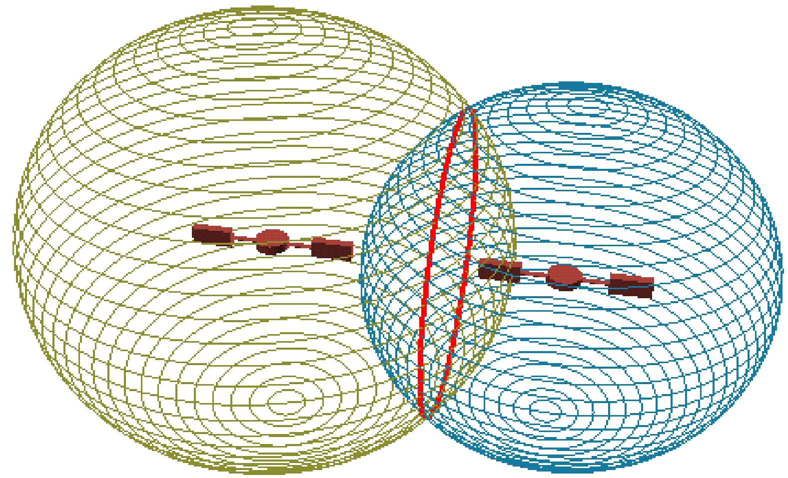


3-D Trilateration:

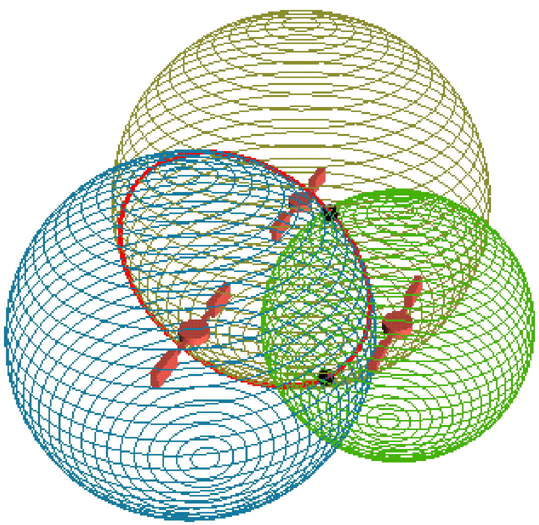
1 Satellite

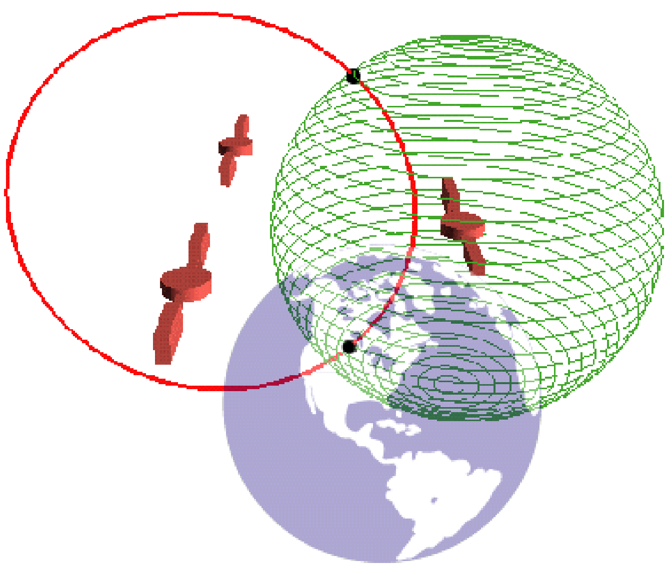


2 Satellites



3 Satellites

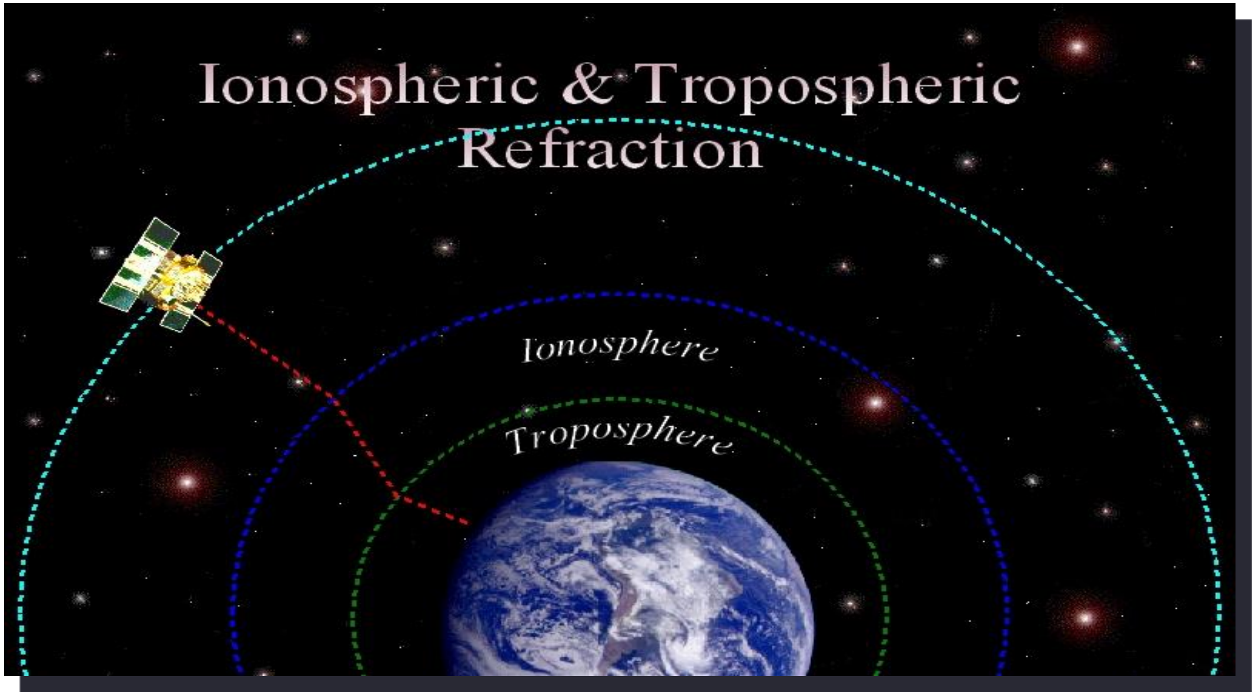




ERROR SOURCES

1. Signal Refraction:

- Signals from satellites can be like light. When they hit some interference (air patterns in the atmosphere, uneven geography, etc.) they sometimes bend a little.



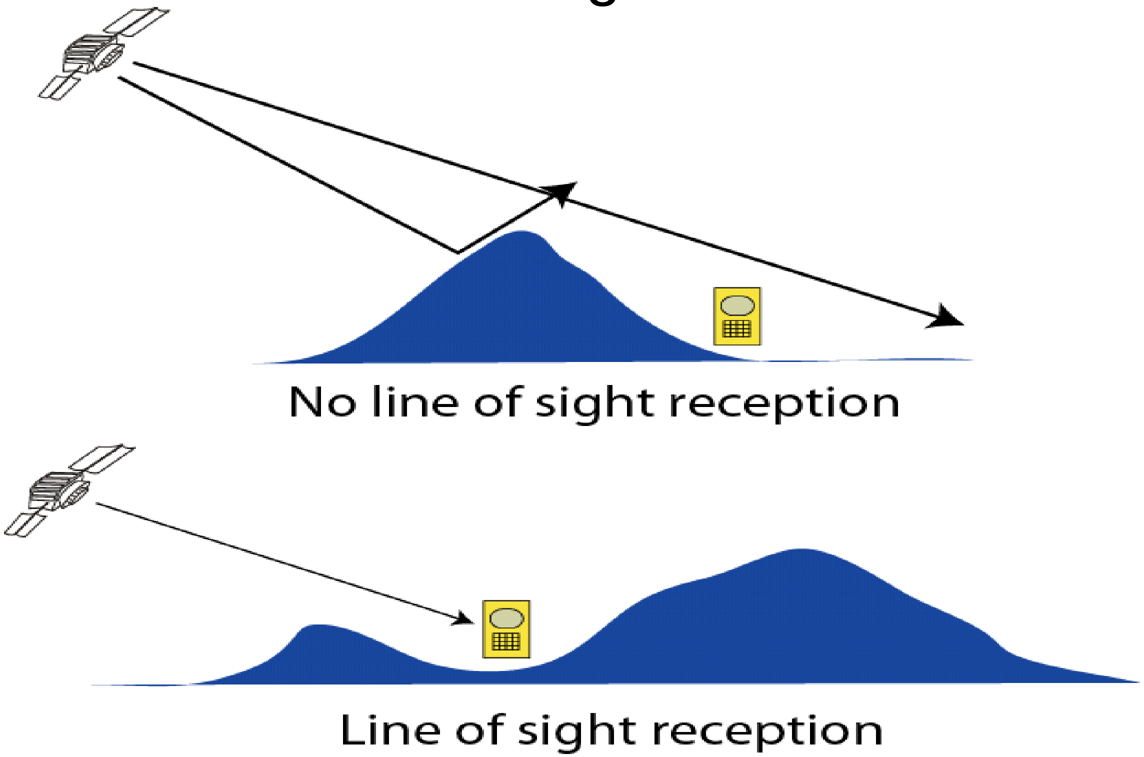
Line of Refraction:

- Sometimes the GPS signal from the satellite doesn't follow a straight line.

- Refraction is the bending of light as it travels through one media to another.

2. Line of Sight Transmissions:

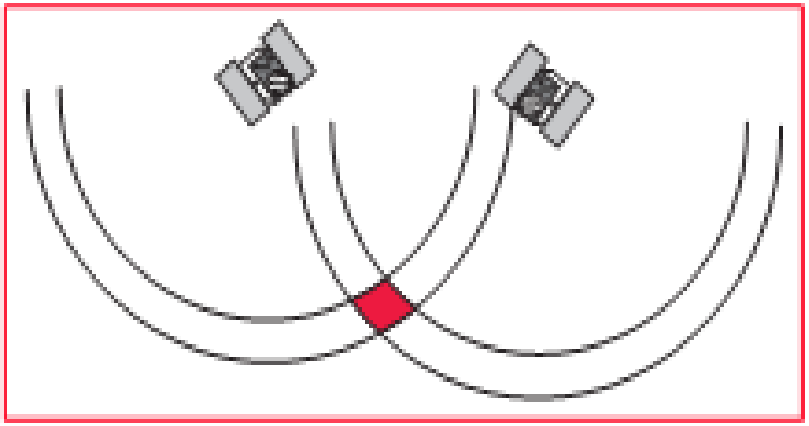
Line of sight is the ability to draw a straight line between two objects without any other objects getting in the way. GPS transmission are line-of-sight transmissions.



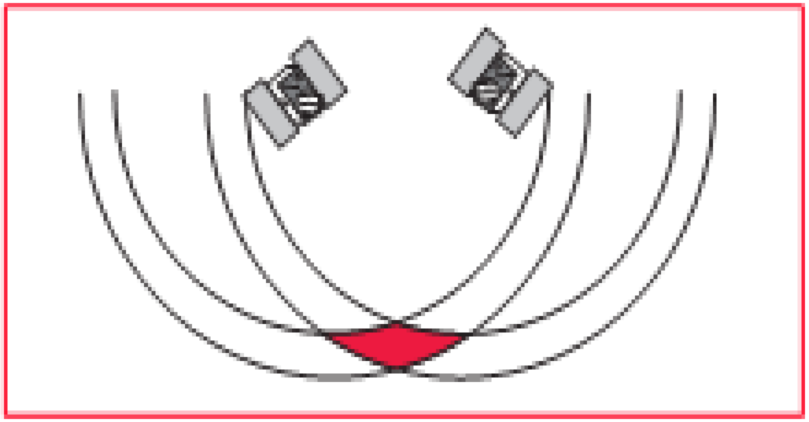
Obstructions such as trees, buildings, or natural formations may prevent clear line of sight.

3.Satellite Distribution:

- When the satellites are all in the same part of the sky, readings will be less accurate.



Well spaced satellites - low uncertainty of position

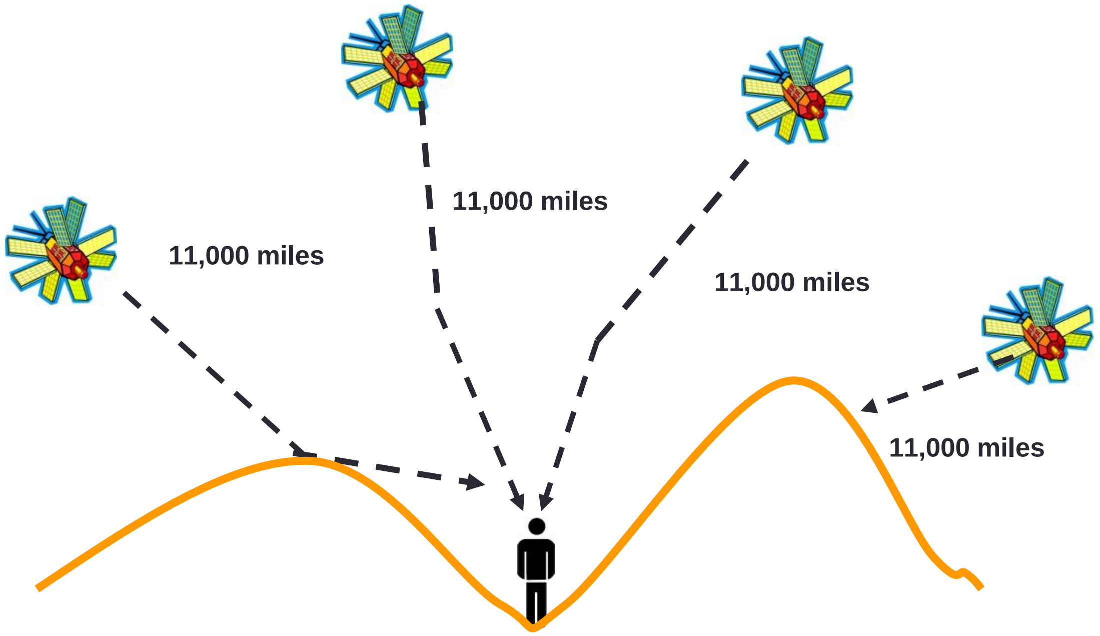


Poorly spaced satellites - high uncertainty of position

PDOP

PDOP = Positional Dilution of Precision

- All of this combines to make the signal less accurate, and gives it what we call a high "PDOP."



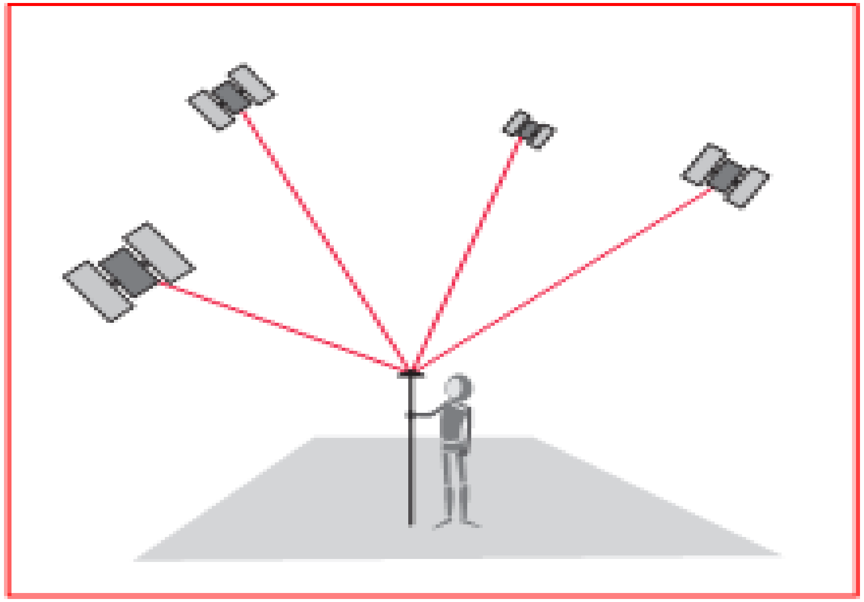
Advantages:

- GPS has numerous advantages over traditional surveying methods:

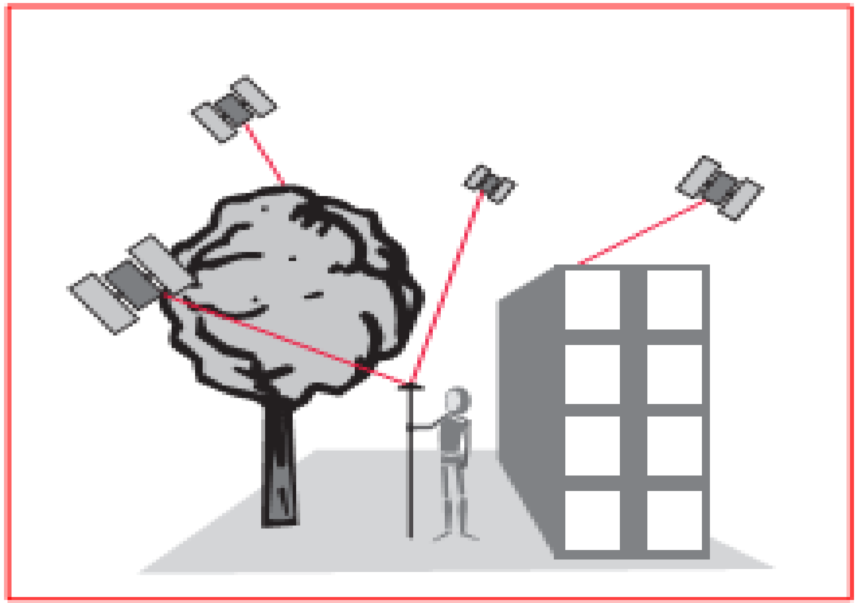
1. Intervisibility between points is not required.
2. Can be used at any time of the day or night and in any weather.
3. Produces results with very high geodetic accuracy.
4. More work can be accomplished in less time with fewer people.

Limitations:

- In order to operate with GPS it is important that the GPS Antenna has a clear view to at least 4 satellites.
- Sometimes, the satellite signals can be blocked by tall buildings, trees etc. Hence, GPS cannot be used indoors.
- It is also difficult to use GPS in town centers or woodland.



Clear view to four satellites



Large objects can block the GPS signal

Any Questions?