OPCUG Share How GPS Receivers work

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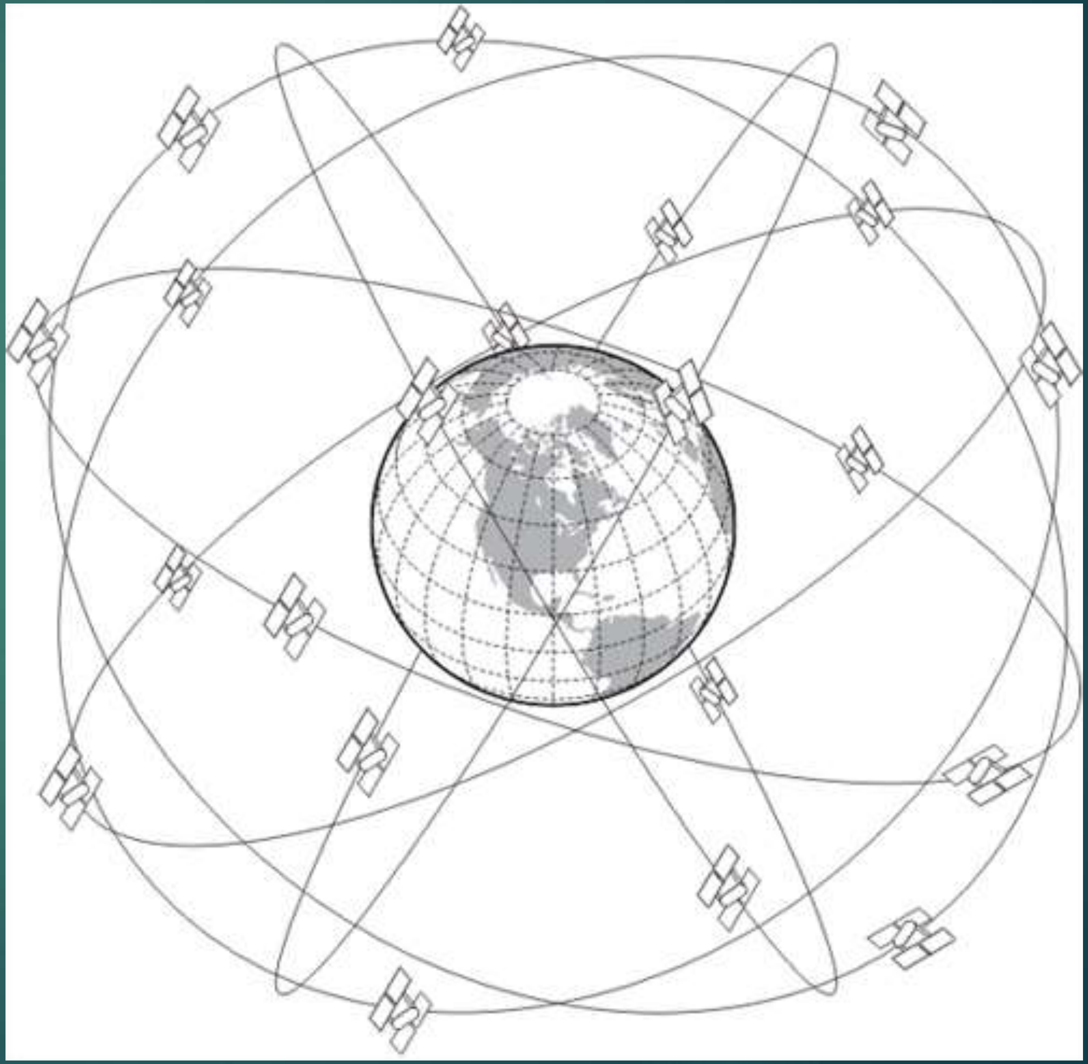
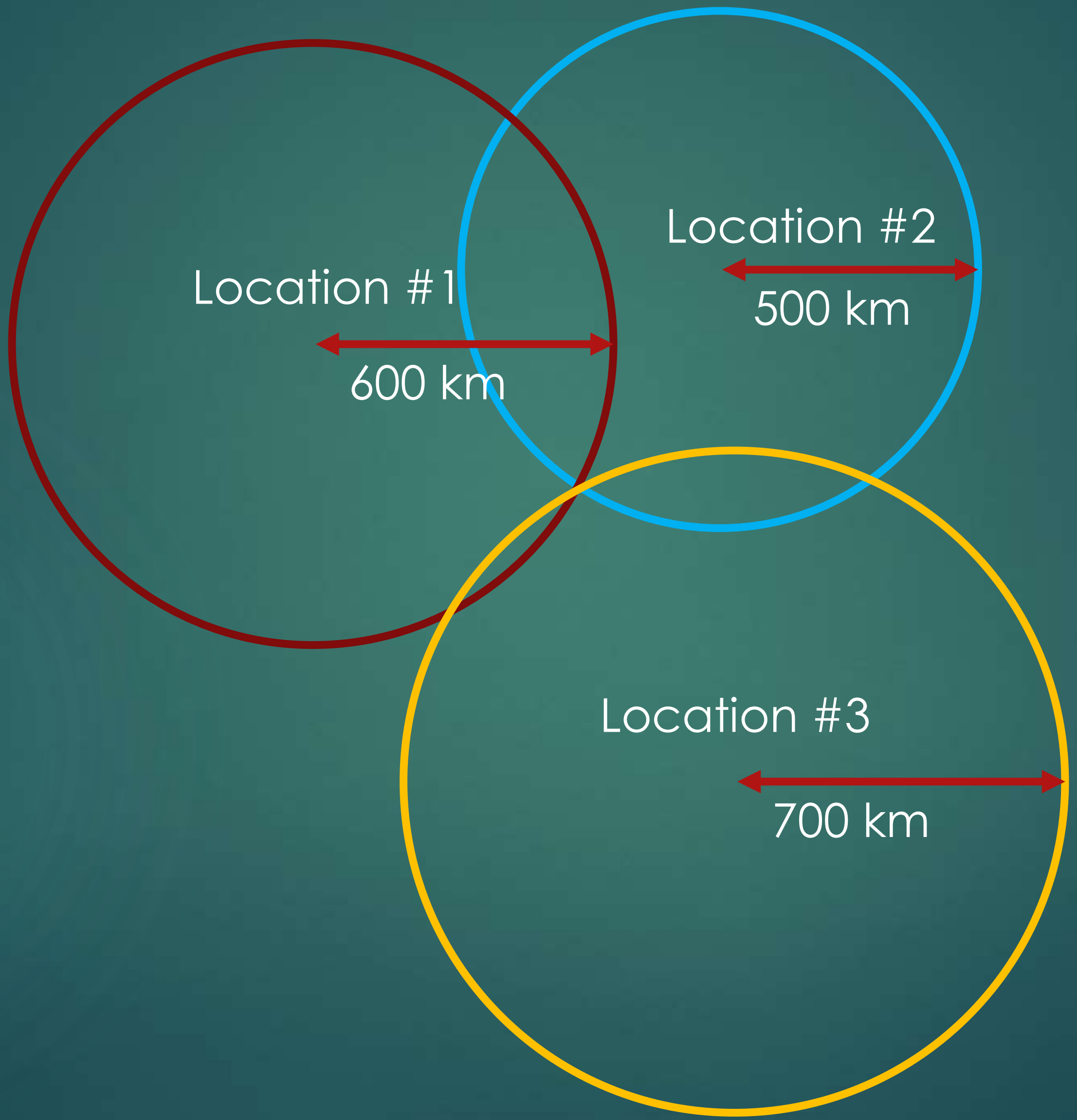
Global Positioning System (GPS) Constellation

- GPS space segment consists of a constellation of 24 operational satellites in 6 orbital planes moving at 3.9 km/s (14,040 km/h)
- GPS satellites fly in medium Earth orbit (MEO) at an altitude of approximately 20,200 km
- Each satellite circles the Earth twice a day
- Each satellite has an atomic clock - precise within three nanoseconds or three-billionths of a second



2-D Trilateration



3-D Trilateration

- Instead of circle, dealing with sphere
- Two spheres intersect in a perfect circle
- Three spheres intersect in two points
- Four spheres intersect in a single point
- The Earth itself can act as a fourth sphere -- only one of the two possible points will actually be on the surface of the planet, so the receiver can eliminate the one in space
- Receivers generally look to four or more satellites to improve accuracy and provide precise altitude information

GPS receiver calculation

- GPS receiver has to know two things:
  - The location of at least three satellites above the receiver
  - The distance between the receiver and each of those satellites
- GPS satellites move but they broadcast:
  - navigation messages which include ephemeris data used to calculate the position of each satellite in orbit
  - ranging signals which are used to measure the distance to the satellite
- At a particular time:
  - the satellite begins transmitting a long, digital pattern
  - the receiver begins running the same digital pattern
- When the satellite's signal reaches the receiver, its transmission of the pattern will lag a bit behind the receiver's playing of the pattern
- The length of the delay is equal to the signal's travel time. The receiver multiplies this time by the speed of light (300,000 km/s) to determine how far the signal traveled

Clock precision

- In order to make this measurement, the receiver and satellite both need clocks that can be synchronized down to the nanosecond
- To make a satellite positioning system using only synchronized clocks, you would need to have atomic clocks not only on all the satellites, but also in the receiver itself
- The Global Positioning System has a clever, effective solution to this problem - the receiver itself uses an ordinary quartz clock, which is constantly adjusted
- The correct time value will cause all of the signals that the receiver is receiving to align at a single point in space – the receiver location
- The GPS receiver gets atomic clock accuracy "for free“ which many computer servers use to synchronize their system clock

Differential GPS

- Inaccuracies do occur due to:
  - Calculation assume constant propagation speed which is not correct in the ionosphere and troposphere
  - Radio signals bounce off large objects, such as skyscrapers, giving a receiver the impression that a satellite is farther away than it actually is
  - Satellites sometimes just send out bad ephemeris data, misreporting their own position
- Differential GPS (DGPS) helps correct these errors:
  - The basic idea is to gauge GPS inaccuracy at a stationary receiver station with a known location
  - The station then broadcasts a radio signal to all DGPS-equipped receivers in the area, providing signal correction information for that area