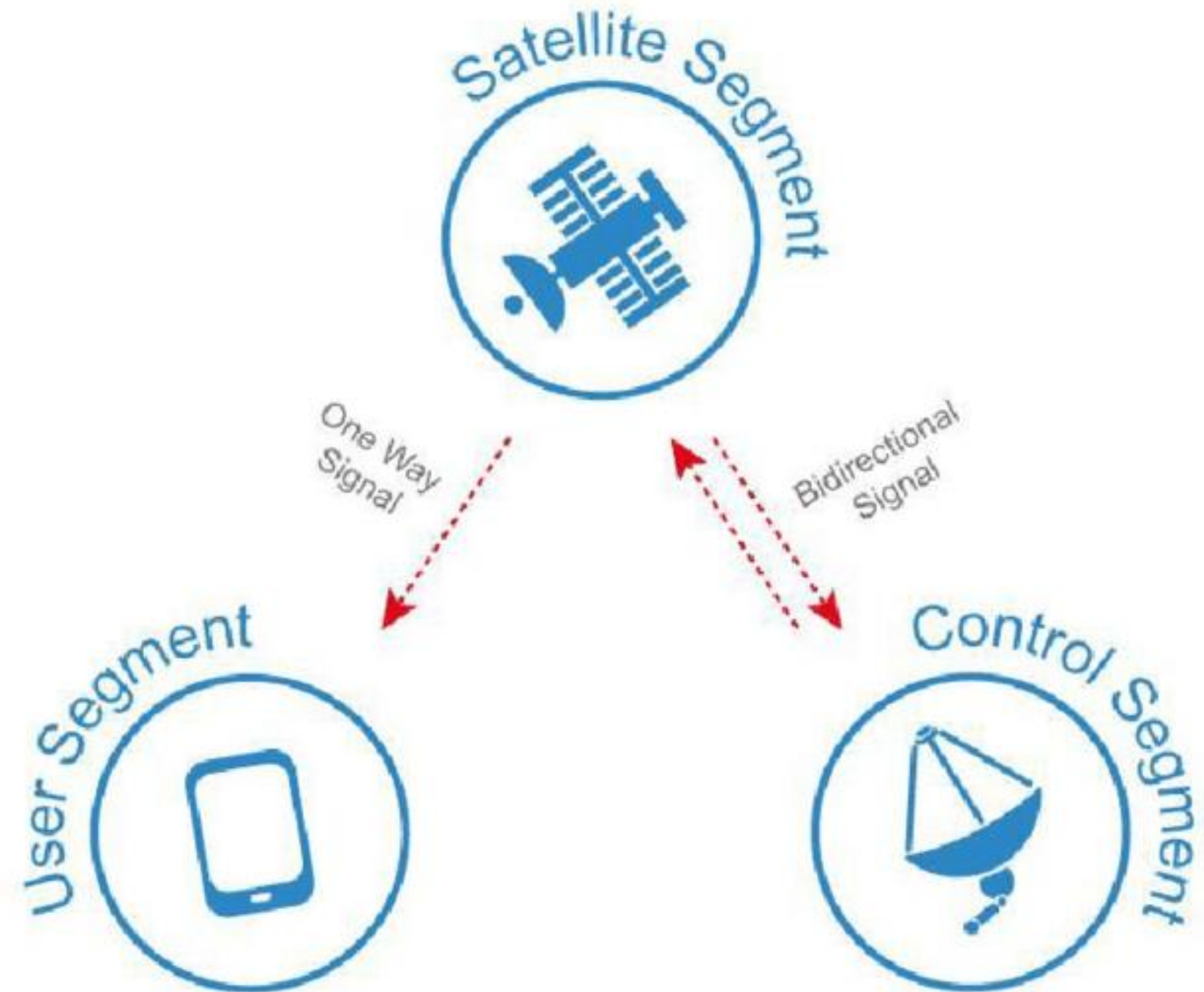


Global Positioning Systems (GPS)

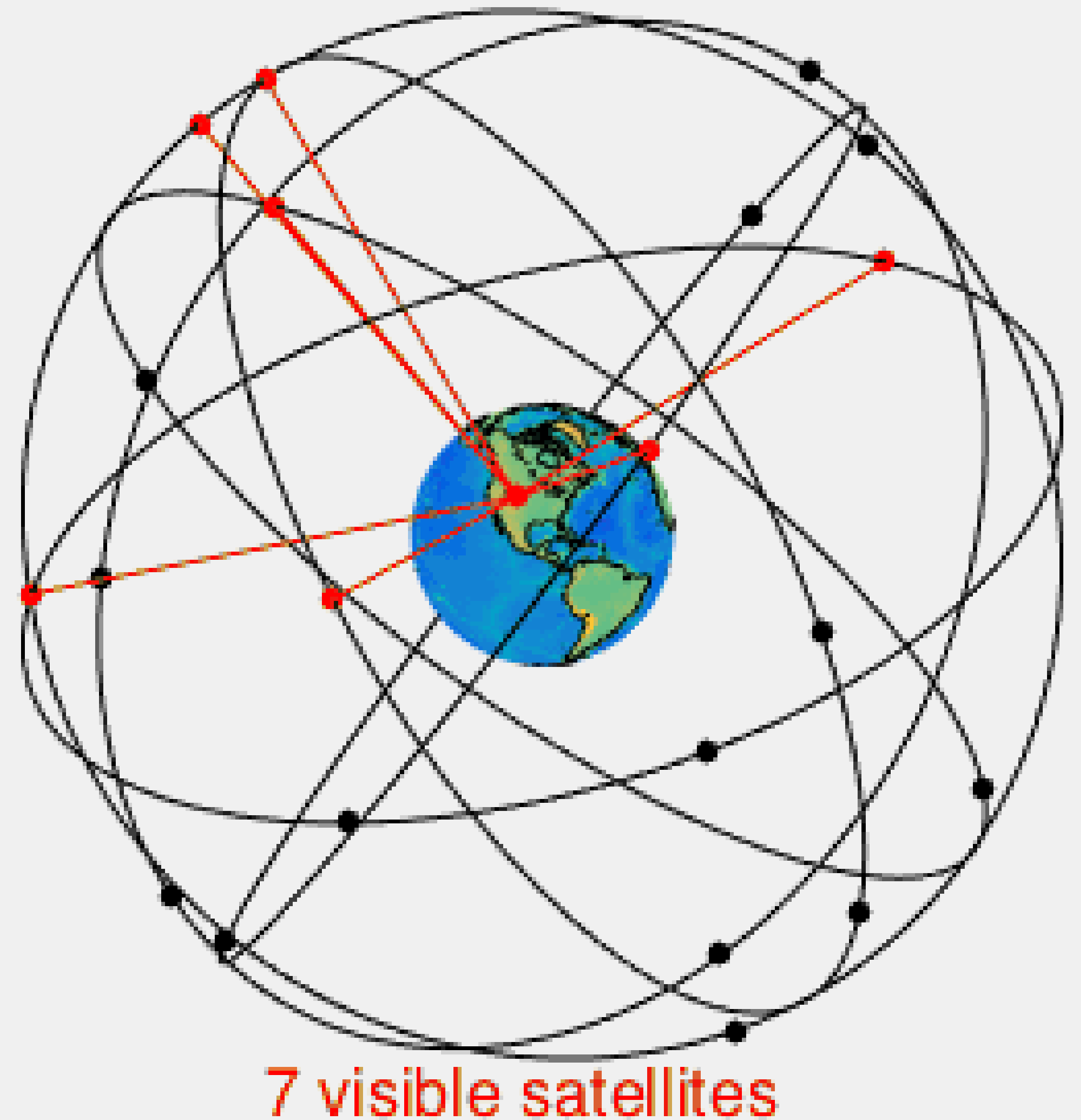
Satellite Navigation System

- GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time.
- GPS is composed of three segments



Space Segment

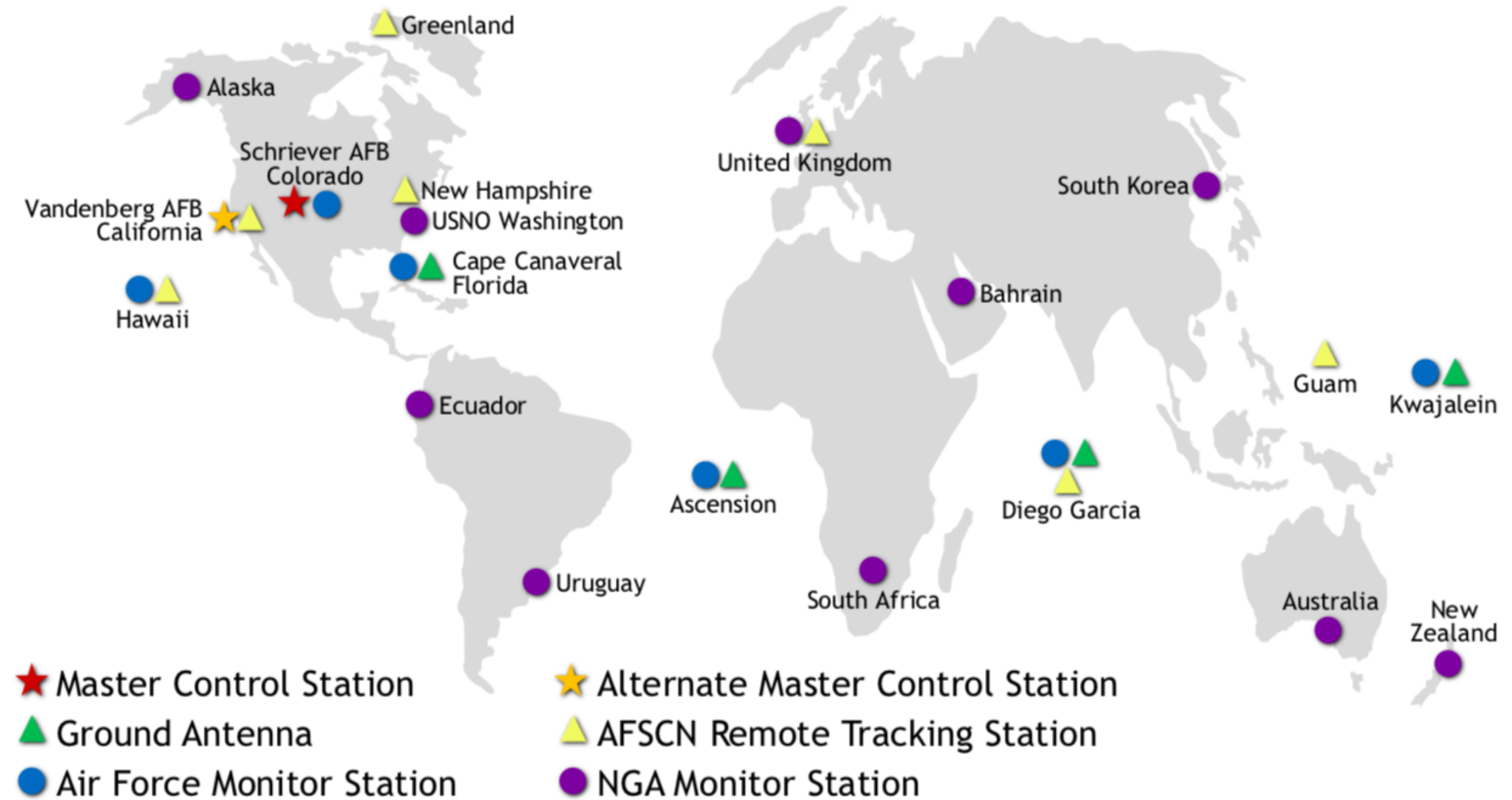
- The Space Segment of the system consists of the GPS satellites. These space vehicles (SVs) send radio signals from space.
- The nominal GPS Operational Constellation consists of 24 satellites that orbit the earth in 12 hours.
- This constellation provides the user with between five and eight SVs visible from any point on the earth.
- Four GPS satellite signals can be used to compute positions in three dimensions and the time offset in the receiver clock.



Control Segment

- The Control Segment consists of a system of tracking stations located around the world.
- These monitor stations measure signals from the SVs
- The models compute precise orbital data and SV clock for each satellite.
- The Control station uploads to the SVs.
- The SVs then send subsets of the data to GPS receivers over radio signals.

GPS Control Segment



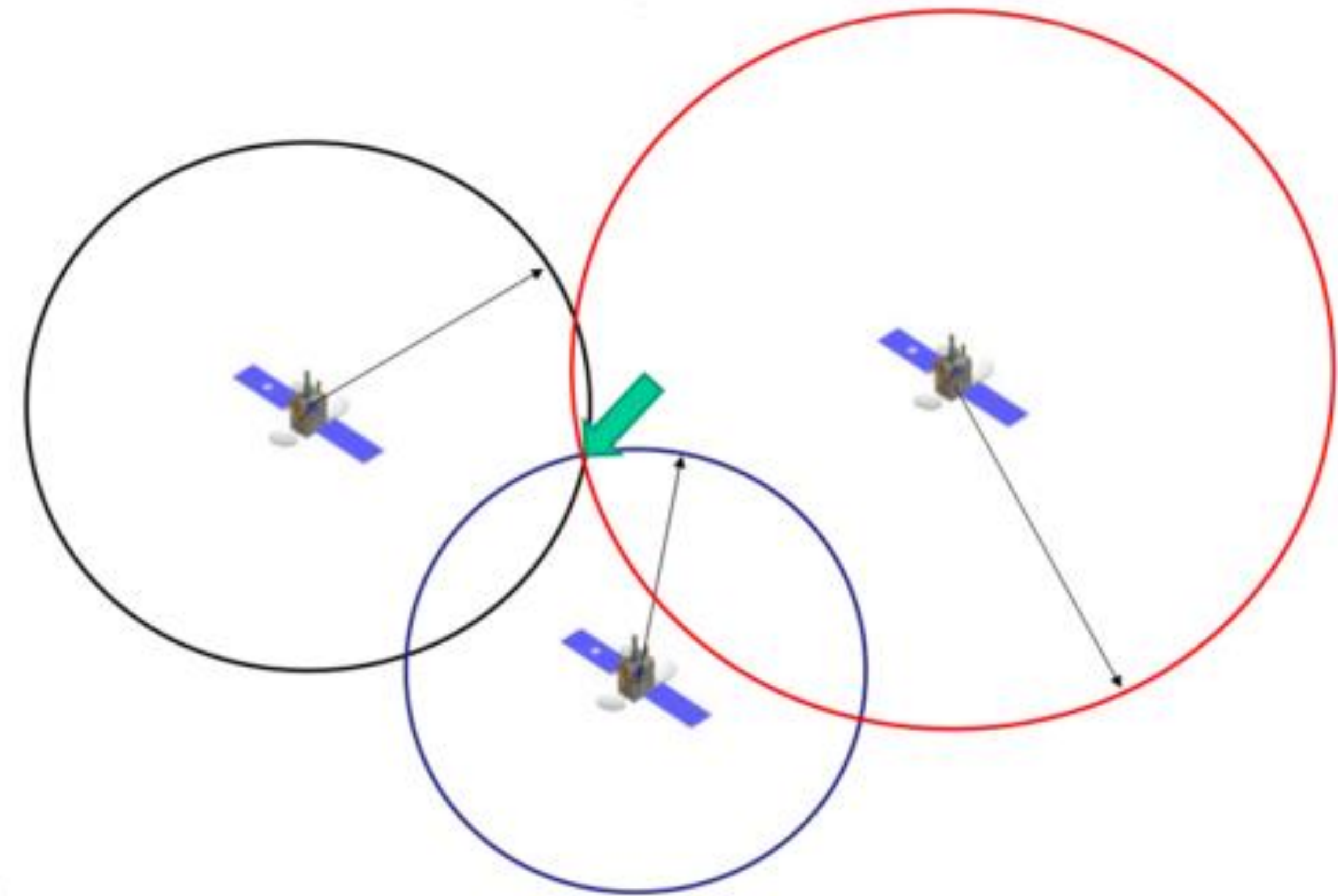
User Segment

- The GPS User Segment consists of the GPS receivers and the user community. GPS receivers convert SV signals into position, velocity, and time estimates.
- Four satellites are required to compute the four dimensions of X, Y, Z (position) and Time.



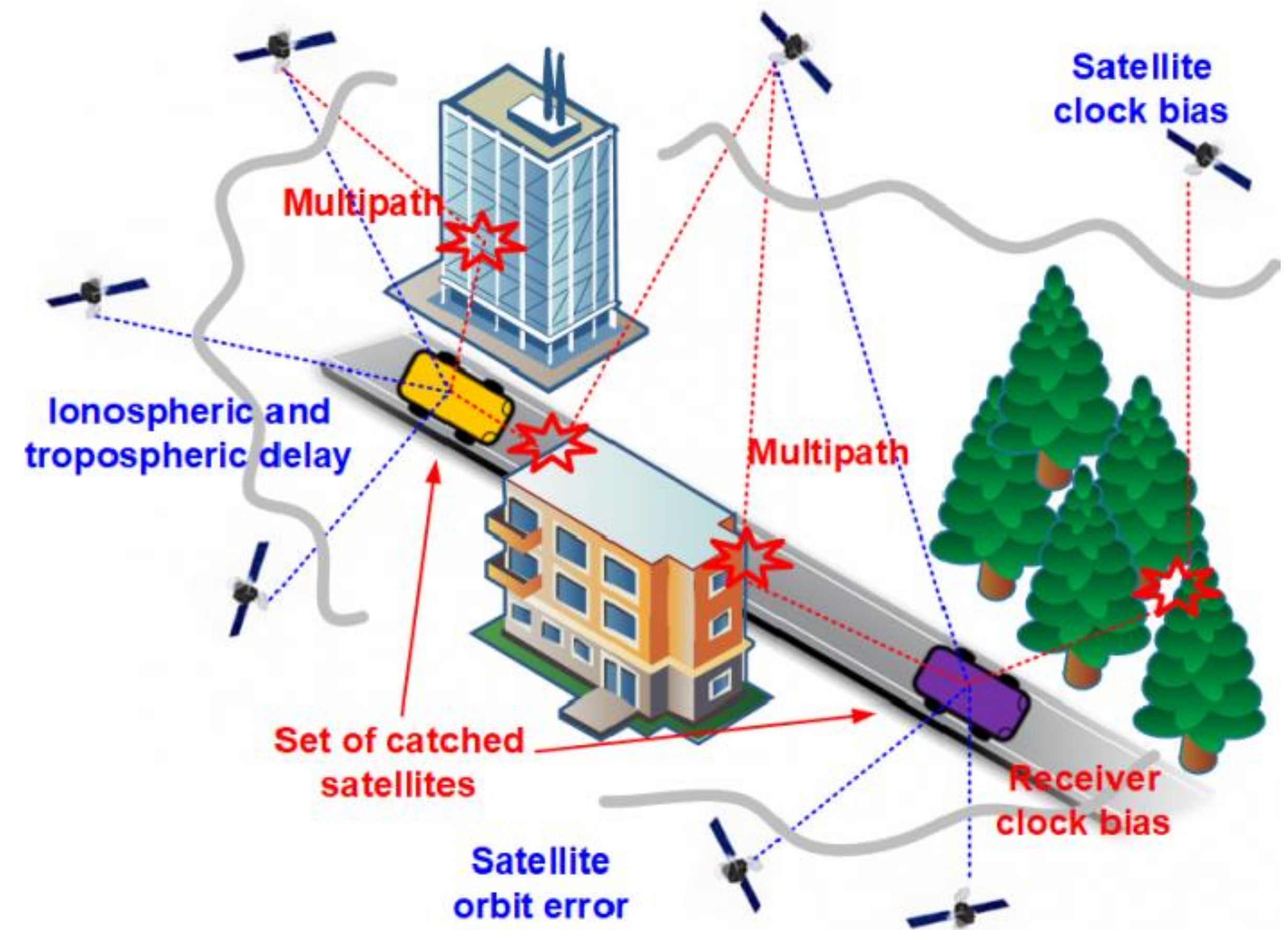
Positioning Principle

- The position of the receiver is where the pseudo-ranges from a set of SVs intersect.
- Position is determined from multiple pseudo-range measurements at a single measurement epoch. The pseudo range measurements are used together with SV position estimates based on the precise orbital elements (the ephemeris data) sent by each SV. This orbital data allows the receiver to compute the SV positions in three dimensions at the instant that they sent their respective signals.
- Receiver position is computed from the SV positions, the measured pseudo-ranges, and a receiver position estimate (usually the last computed receiver position).



GPS Error Sources

- SV clock error uncorrected by Control Segment and Receiver clock error can result in one meter error.
- Satellite data errors: 1 meter
- Tropospheric delays: 1 meter.
- Un-modeled ionosphere delays: 10 meters.
- Multipath: 0.5 meters. Multipath is caused by reflected signals from surfaces near the receiver that can interfere.



GPS Blunders

- Control segment mistakes due to computer or human error. These can cause errors from one meter to hundreds of meters.
- User mistakes, including incorrect geodetic datum selection, can cause errors from 1 to hundreds of meters.
- Receiver errors from software or hardware failures can cause blunder errors of any size.

