# Introduction to GNSS

# Text Books

El-Rabbany, A. (2002). Introduction to GPS: The Global Positioning System, Artech house publishers, Boston

Hofmann-Wellenhof, B., Lichtenegger, H. and Wale, E. (2008). GNSS- Global Navigation Satellite Systems: GPS, GLONASS, Galileo & more, New York: Springer-Wein.

Humans
have
always
been
Interested
in knowing
where
Things
are……..


Where to go ?

## Early Solutions:

- Marking trails with piles of stones
  (problems when snow falls…or on ocean)

- Navigating by stars
(requires clear nights and careful measurements)

## Modern Ideas:

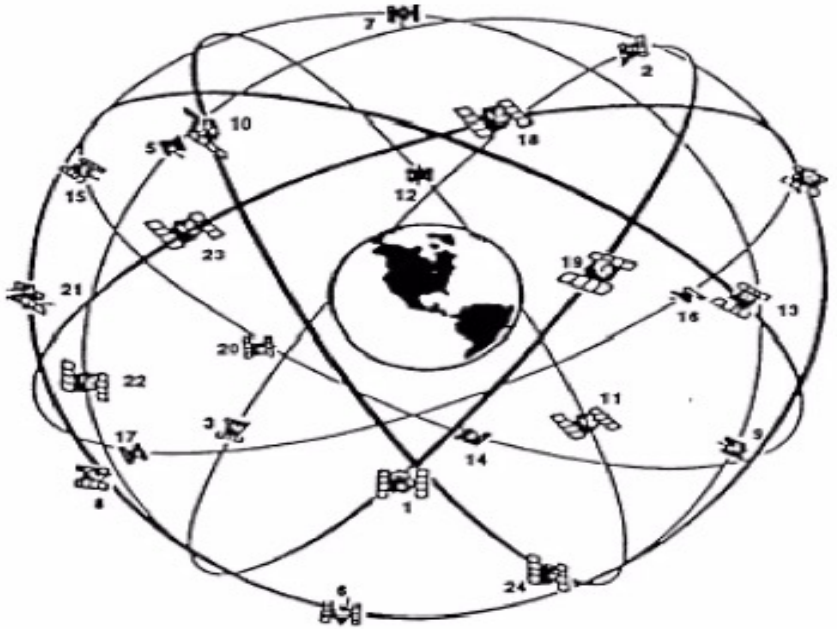
- RADAR
- GNSS

# Global Navigation Satellite Systems

GPS

GLONASS

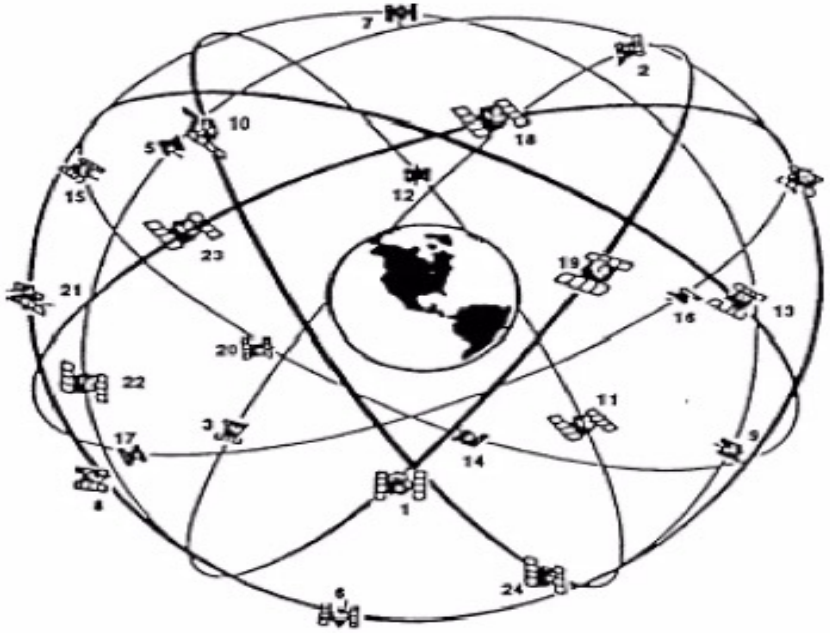
GALILEO



# Regional Navigation Satellite Systems

COMPASS

IRNSS



QZSS

# GLOBAL POSITIONING SYSTEM (GPS) USA

# History of the GPS


- Developed by US Department of Defense
- 1969-Defense Navigation Satellite System (DNSS) formed
- 1973-NAVSTAR Global Positioning System developed
- 1978-first 4 satellites launched

# History of the GPS

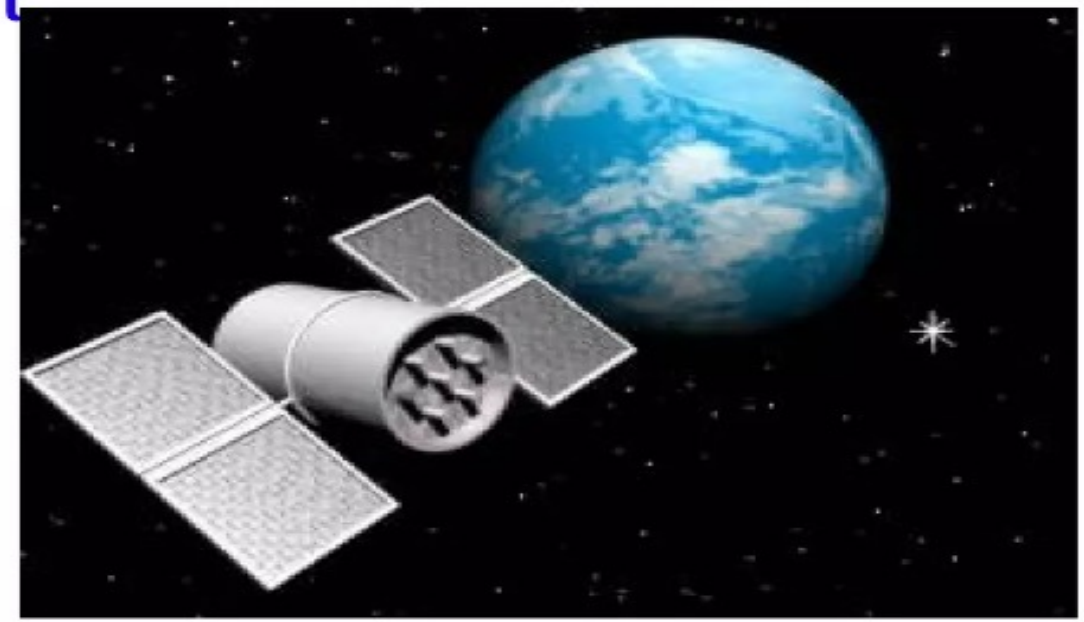

- 1993-24th satellite launched; initial operational capability
- 1995-full operational capability
- May 2000-Military accuracy available to all users

# What is GPS and how it works?

GPS, which stands for Global Positioning System, is the system today able to show you your exact position on the Earth anytime, in any weather, anywhere

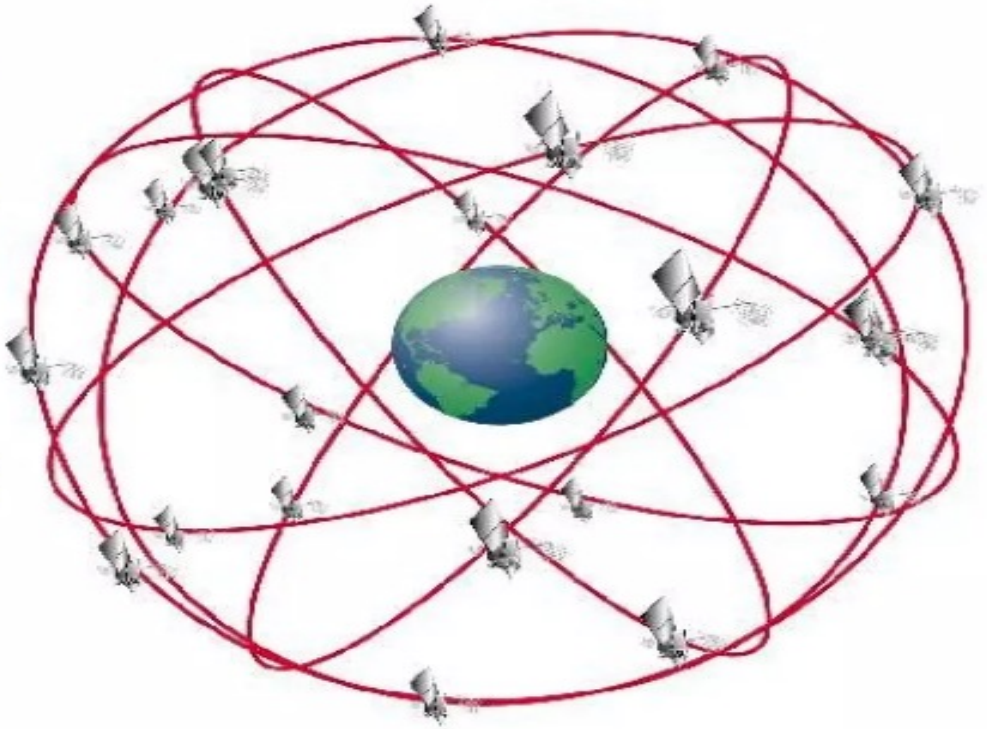
# Satellites

There are quite a number of satellites out there in space. They are used for a wide range of purposes: satellite TV, cellular phones, military purposes and etc. Satellites can also be used by GPS receivers.

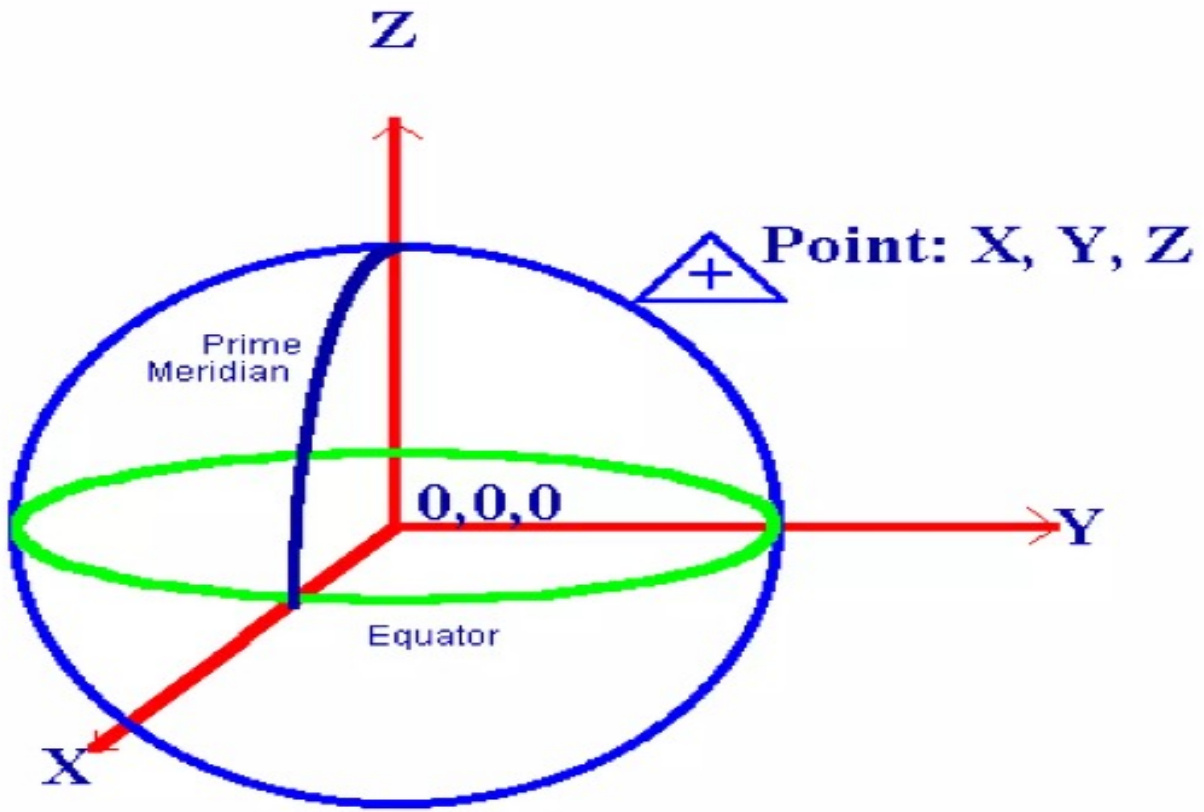


# GPS Satellites

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.



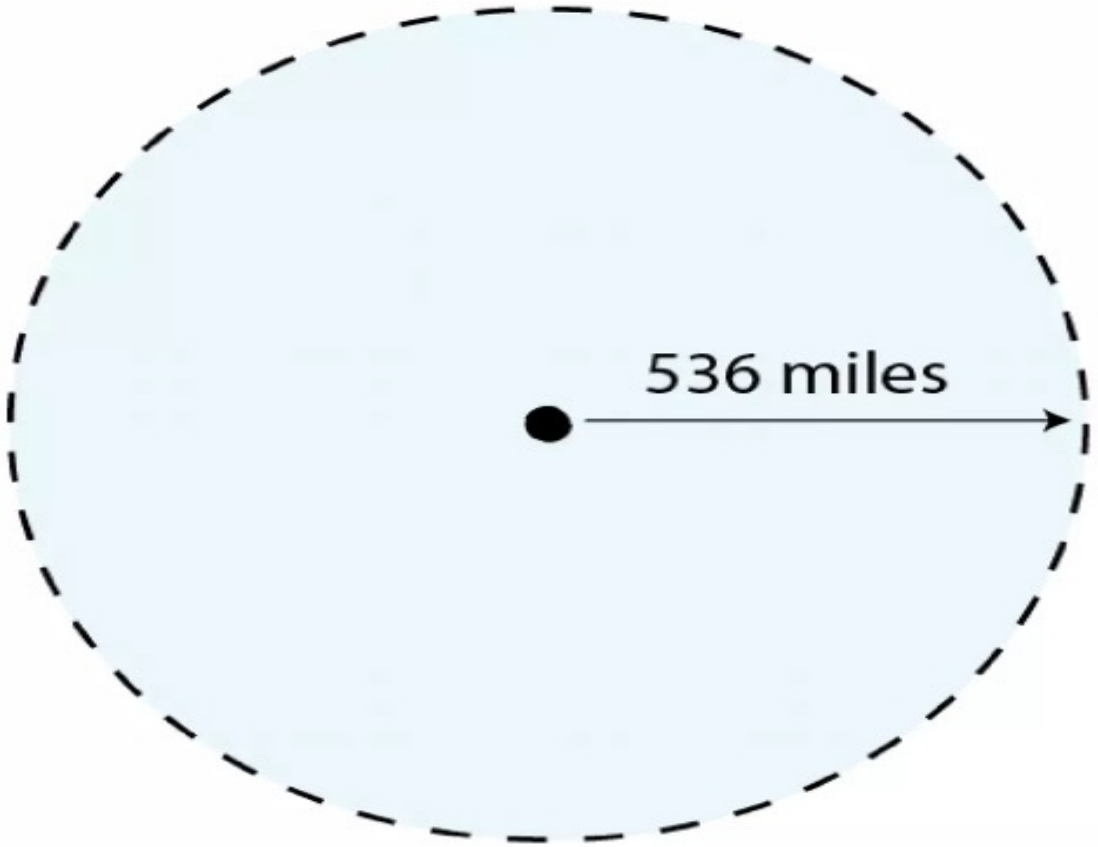
# GPS determines locations on Earth



# Triangulation

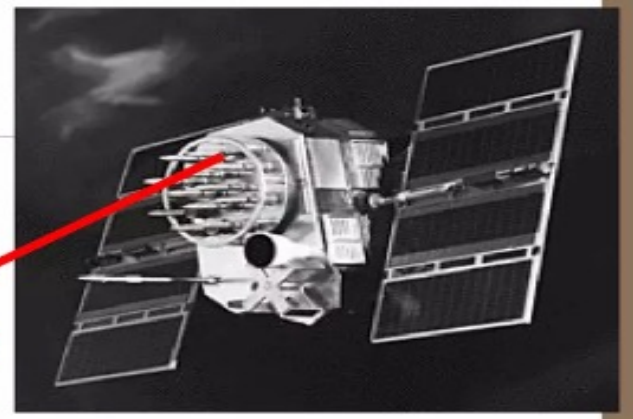
## Geometric Principle:

You can find one location if you know its distance from other, already-known locations.



# Velocity x Time = Distance

**Signal leaves satellite at time "T"**



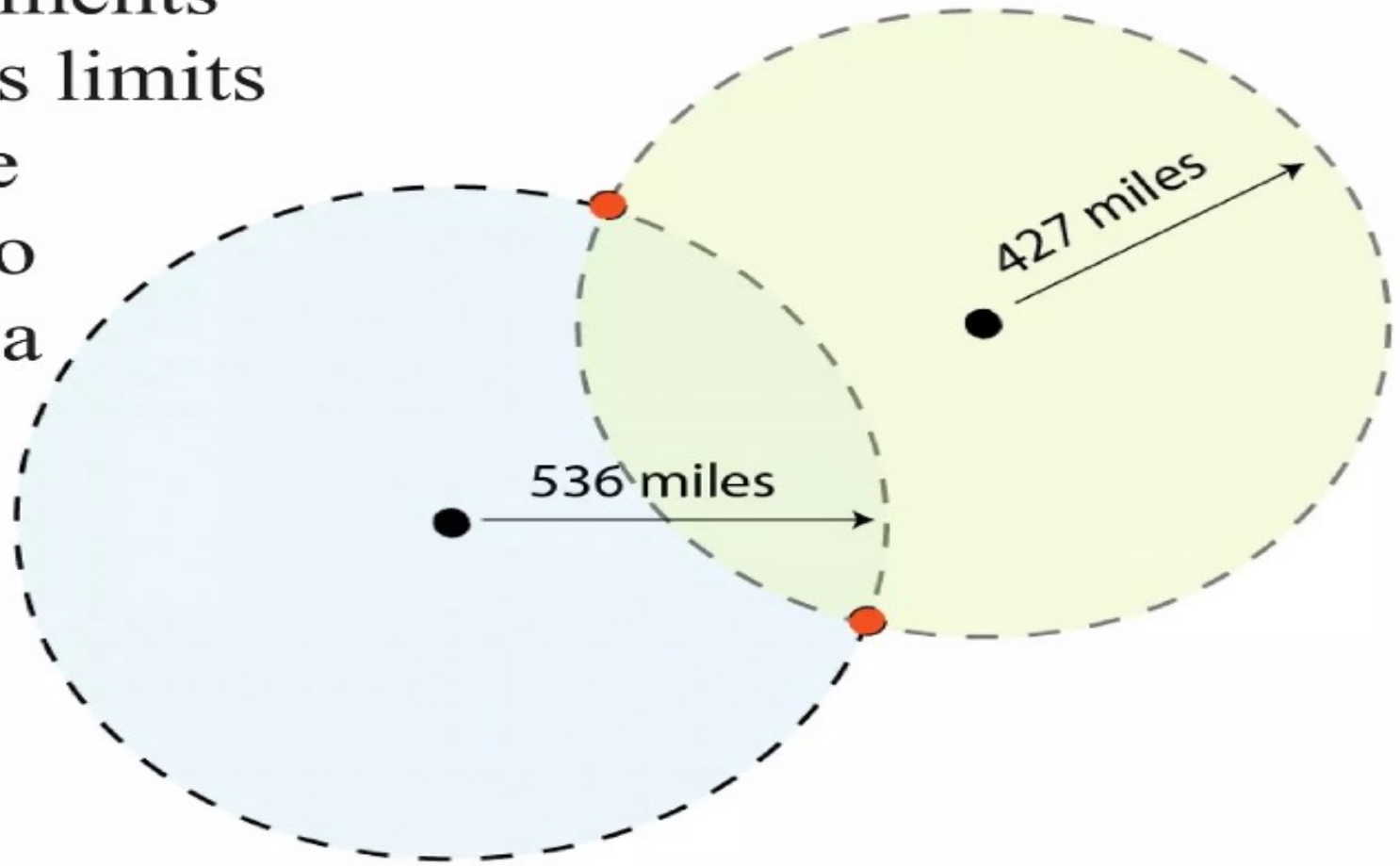
**T**

**Distance =Velocity x Time**


*Distance between satellite and receiver

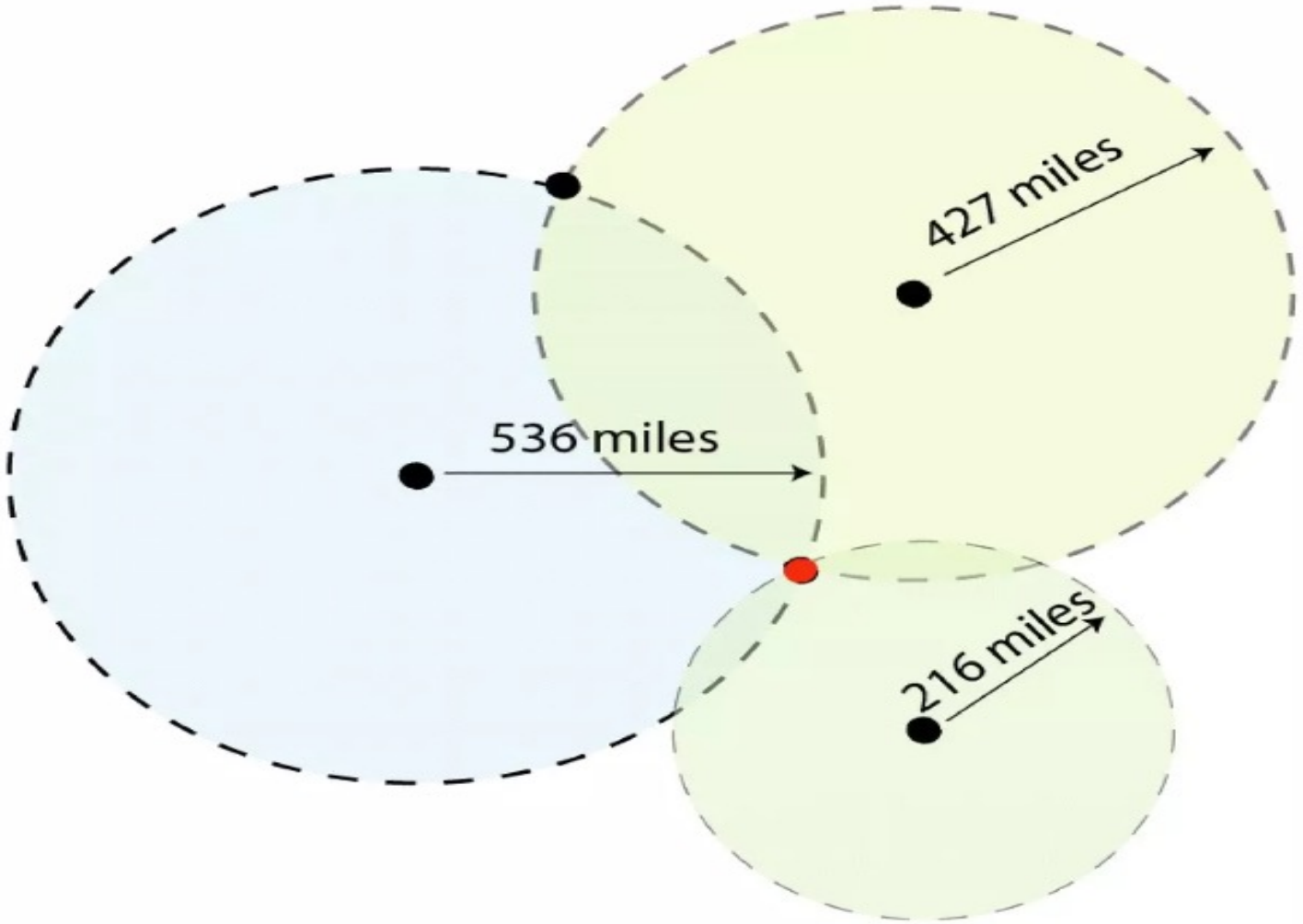
# Triangulation

Distance measurements from two satellites limits our location to the intersection of two spheres, which is a circle.



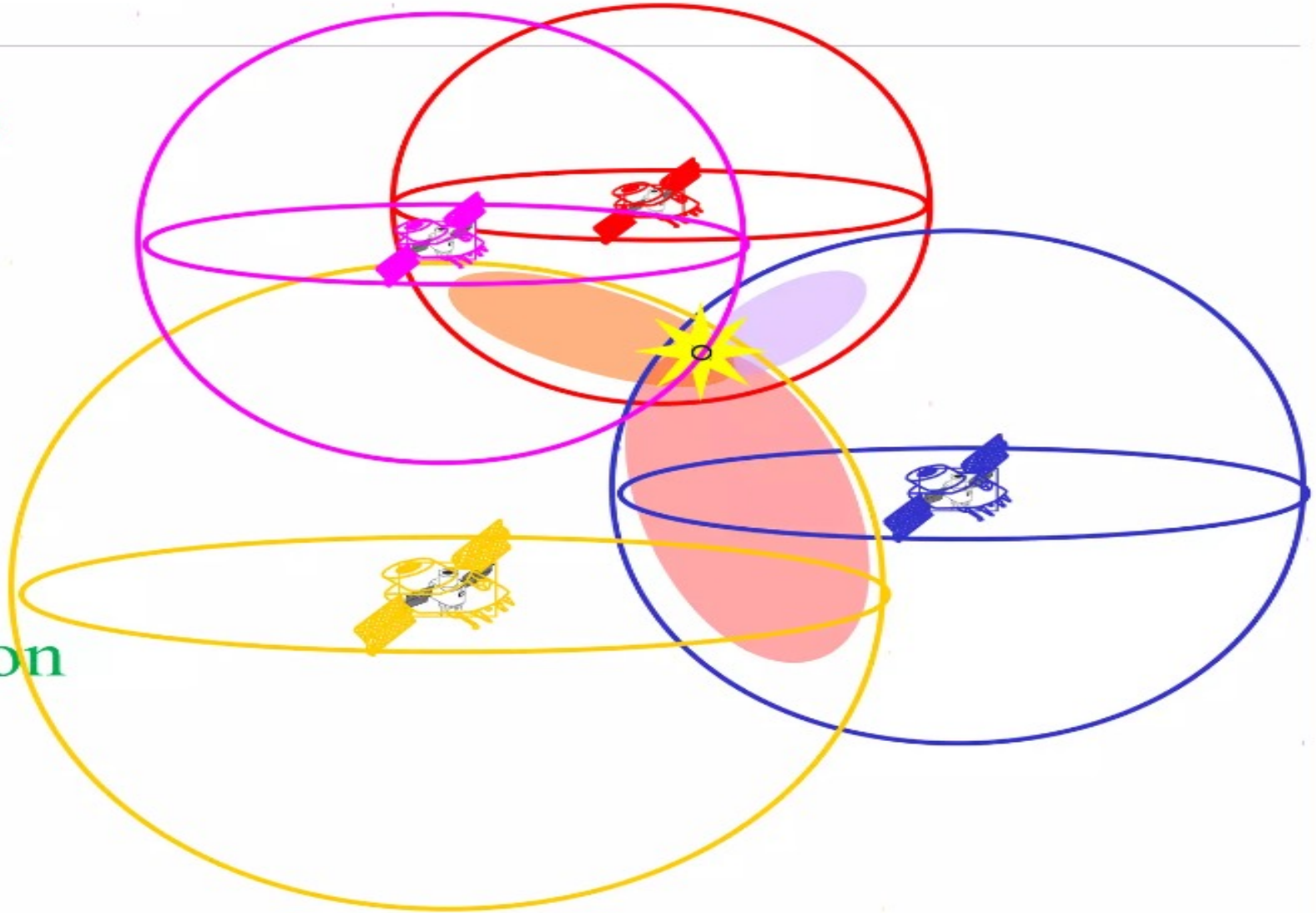
# Triangulation

A third measurement narrows our location to just two points.



# Triangulation

Since satellite clocks time is variable a fourth measurement determines which point is our true location



GPS is based on satellite ranging, i.e. distance from satellites

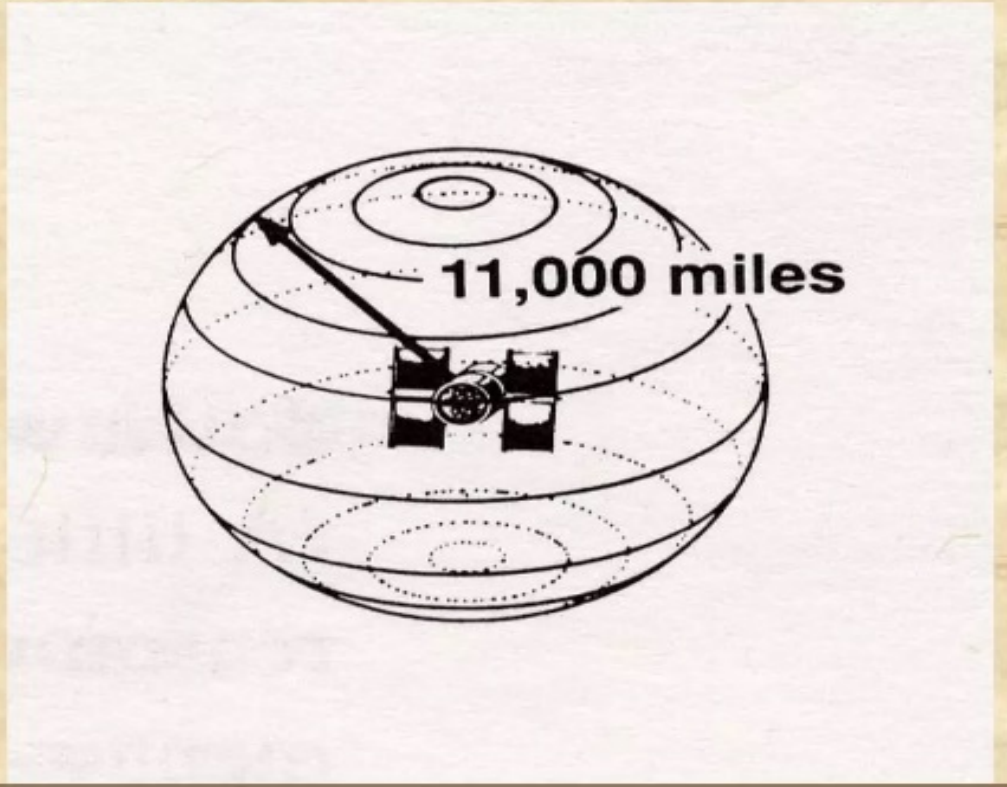
…satellites are precise reference points

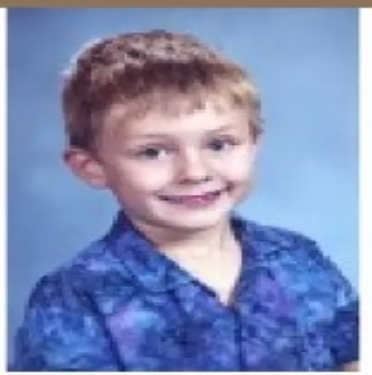
…we determine our distance from them

***we will assume for now that we know exactly where satellite is and how far away from it we are…***

**if we are lost and we know that we are 11,000 miles from satellite A…**

**we are somewhere on a sphere whose middle is satellite A and diameter is 11,000 miles**





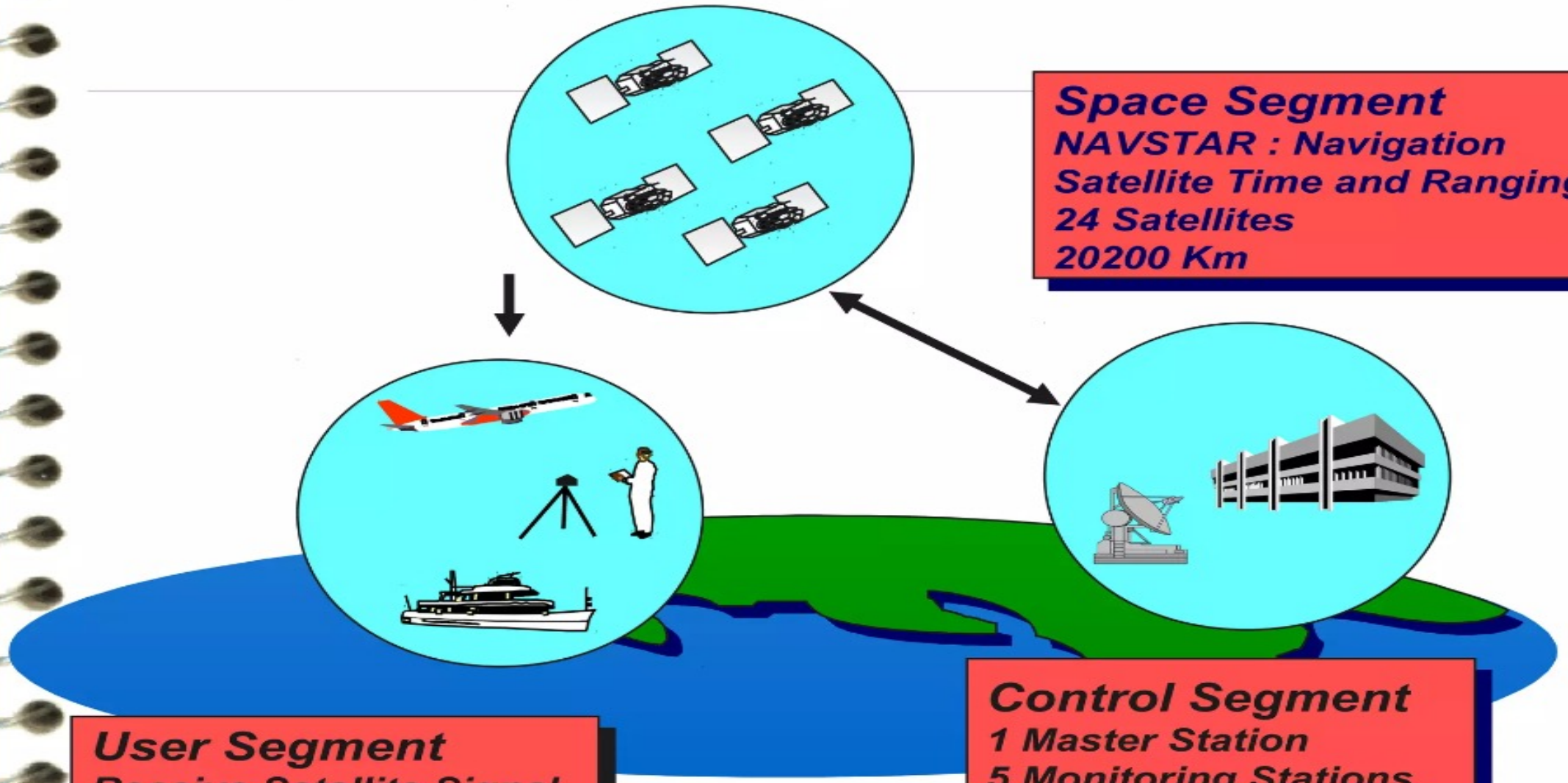
GPS

Grand Junction
Transmitter

Radon in Boulder

$$(x-a_1)^2+(y-b_1)^2+(z-c_1)^2=c^2t^2$$
$$(x-a_2)^2+(y-b_2)^2+(z-c_2)^2=c^2t^2$$
$$(x-a_3)^2+(y-b_3)^2+(z-c_3)^2=c^2t^2$$
$$(x-a_4)^2+(y-b_4)^2+(z-c_4)^2=c^2t^2$$

# GPS SEGMENTS



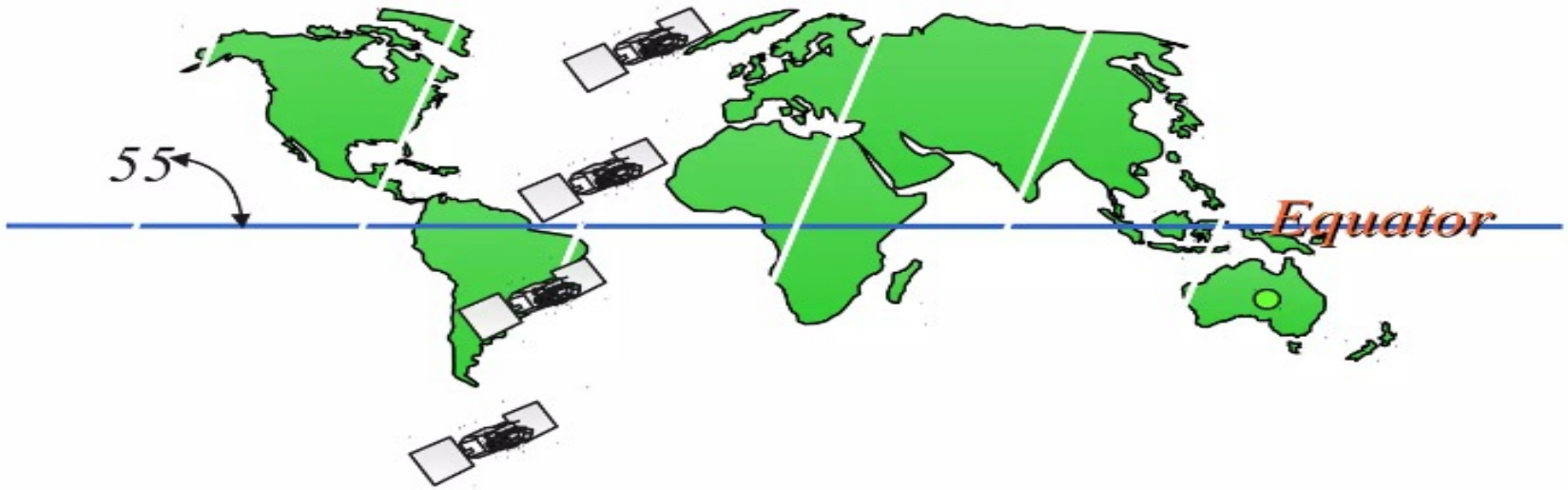
**Space Segment**
**NAVSTAR : Navigation Satellite Time and Ranging**
**24 Satellites**
**20200 Km**

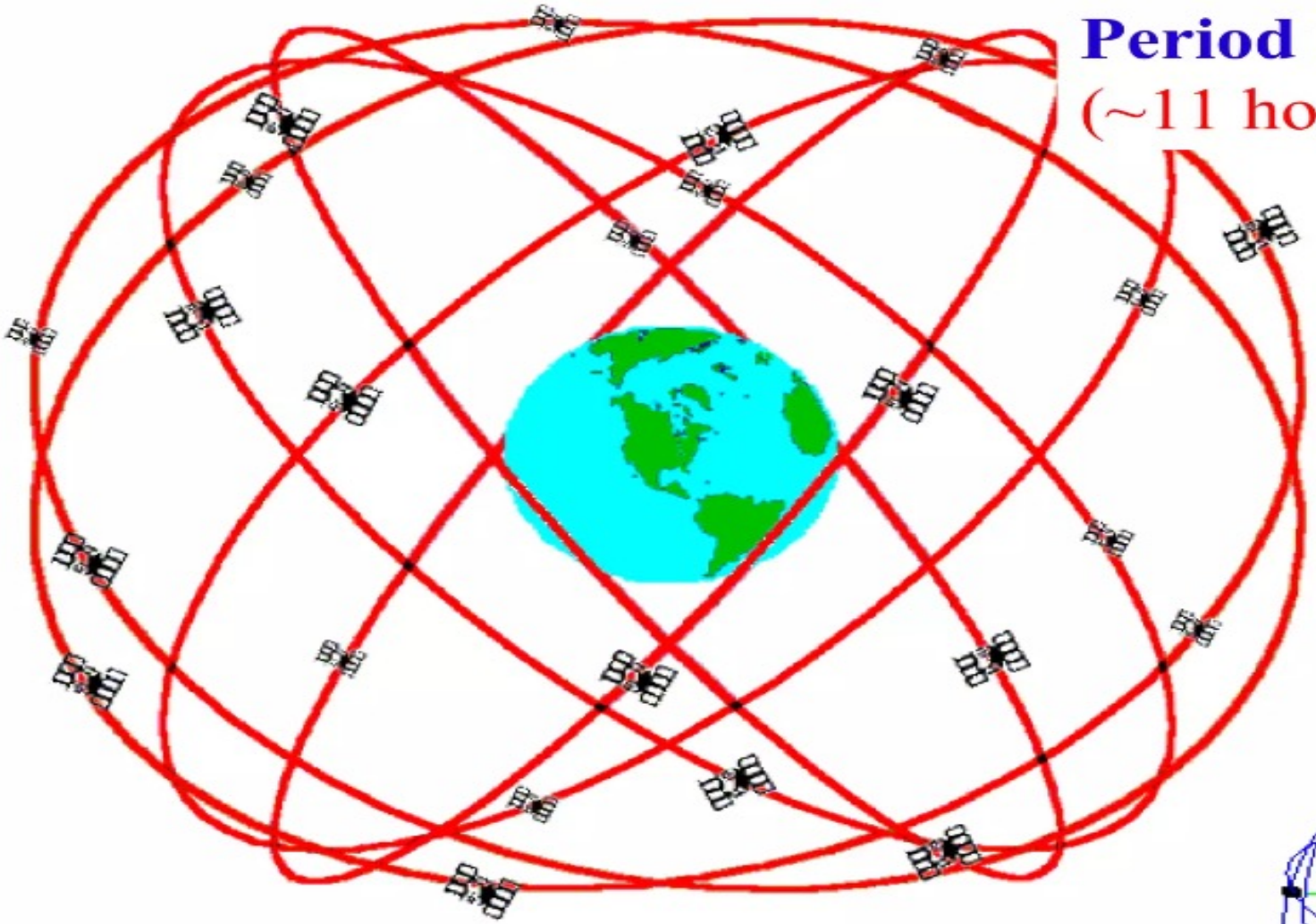
**User Segment**
**Receive Satellite Signal**

**Control Segment**
**1 Master Station**
**5 Monitoring Stations**

# Space Segment

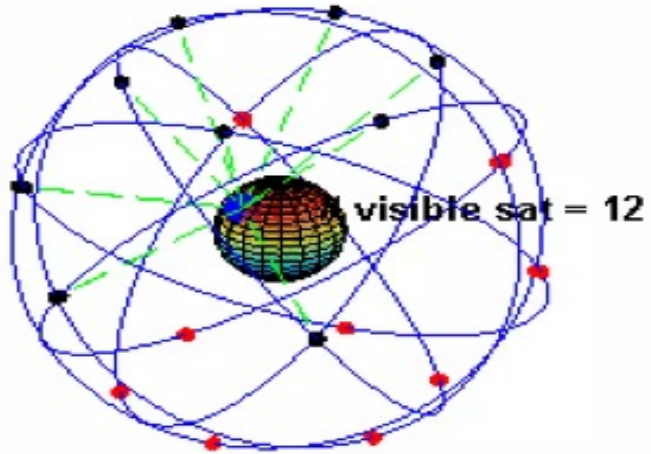
- 24 Satellites
  - 4 satellites in 6 Orbital Planes inclined at 55 Degrees
- 20200 Km above the Earth
- 12 Hourly orbits
  - In view for 4-5 hours
- Designed to last 7.5 years
- Different Classifications
  - Block 1, 2, 2A, 2R & 2 F





**Period 12 sidereal hours**
(~11 hours 58 minutes)

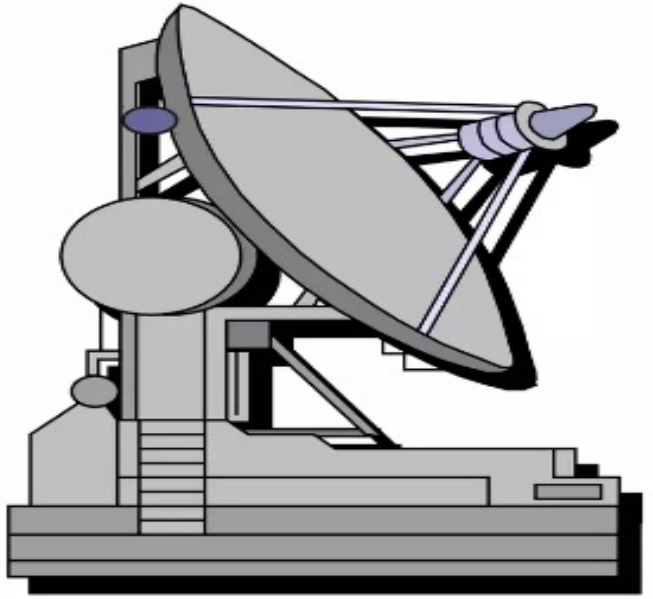
nearly circular orbit with a semi-major axis of 26 578 km




**GPS Nominal Constellation**
**24 Satellites in 6 Orbital Planes**
**4 Satellites in each Plane**
**20,200 km Altitudes, 55 Degree Inclination**

# Control Segment

- Master Control Station
  - Responsible for collecting tracking data from the monitoring stations and calculating satellite orbits and clock parameters
- 5 Monitoring Stations
  - Responsible for measuring pseudorange data. This orbital tracking network is used to determine the broadcast ephemeris and satellite clock modeling
  - Ground Control Stations
  - Responsible for upload of information to the satellites



# CONTROL SEGMENT


Global Positioning System (GPS) Master Control and Monitor Station Network

**1 Master Station** **5 Monitoring Stations**

# User Segment

- The most visible segment
- GPS receivers are found in many locations and applications

# Applications of GPS

## MILITARY

- Navigation
- Target tracking
- Search and Rescue

# Applications of GPS

CIVILIAN Purposes

- GPS for surveying
- Mapping
- Finding lost vehicles

# Applications:
# Monitoring of Fishing Fleet

- In Europe quota system Fishermen only allowed to catch certain amount of a particular species of fish on a particular fishing ground
- Trials of monitoring fleet incorporating GPS data

# Links

- https://www.youtube.com/watch?v=cHYtMSJ83hs