Introduction to GPS

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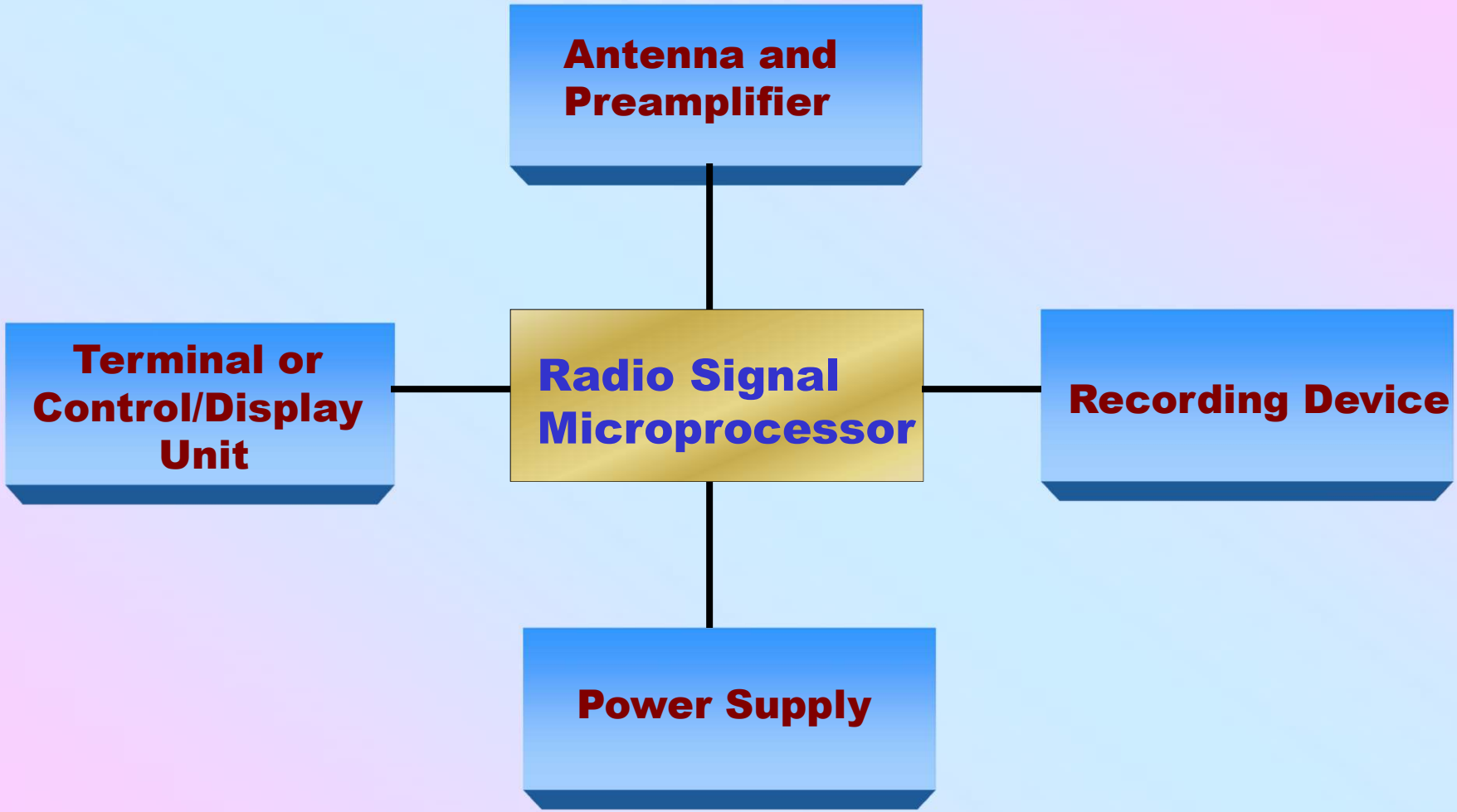
Course: Geographic Information System

Lecture 6

User Segment

- GPS Receivers
- Antennas
- Computers (Hardware)
- Processors (Software)
- Land, Sea, and Airborne Operators

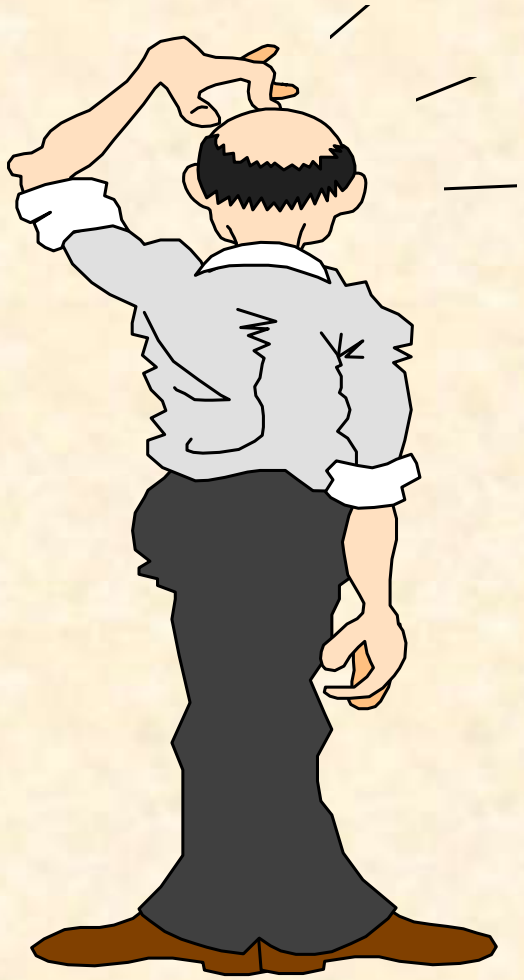
GPS Receiver



GPS Navigation

- Four Satellite Ranges
  - Latitude
  - Longitude
  - Altitude
  - Time
- User Equipment
  - Track Satellites (Identity of satellite)
  - Compute Position
  - Precise Positioning Service (P-code)
  - Standard Positioning Service (C/A-code)

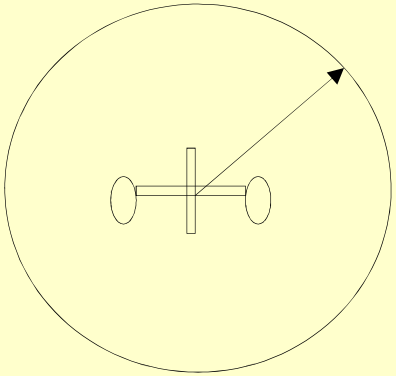
How GPS works?



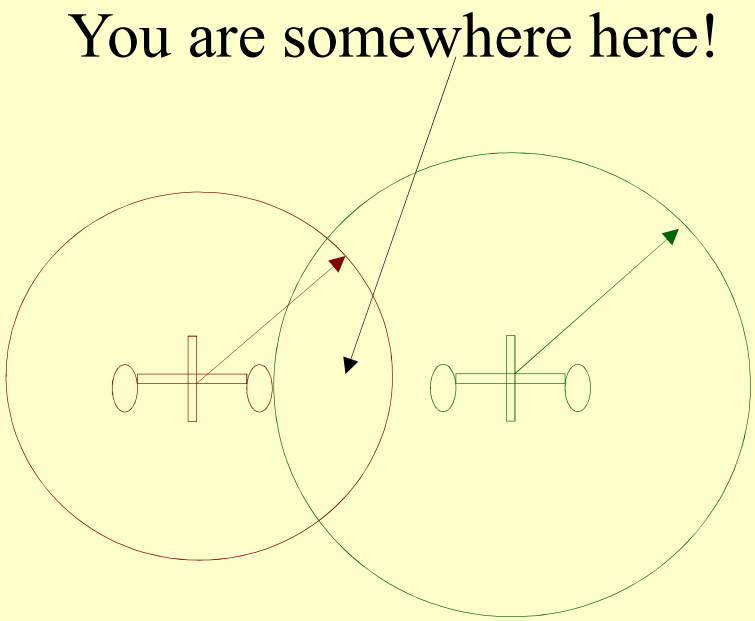
How GPS works?

- Triangulation from satellite is the basis of the system
- A GPS receiver measures the distance using the travel time of a radio signals
- GPS needs very accurate clock to measure travel time
- Once the distance to satellite are known, then we need to know exactly where the satellites are in space
- Satellites and receivers generate same code and keeps same time
- As the GPS signal travels through the atmosphere, the signal is delayed (time difference is calculated).

Triangulation

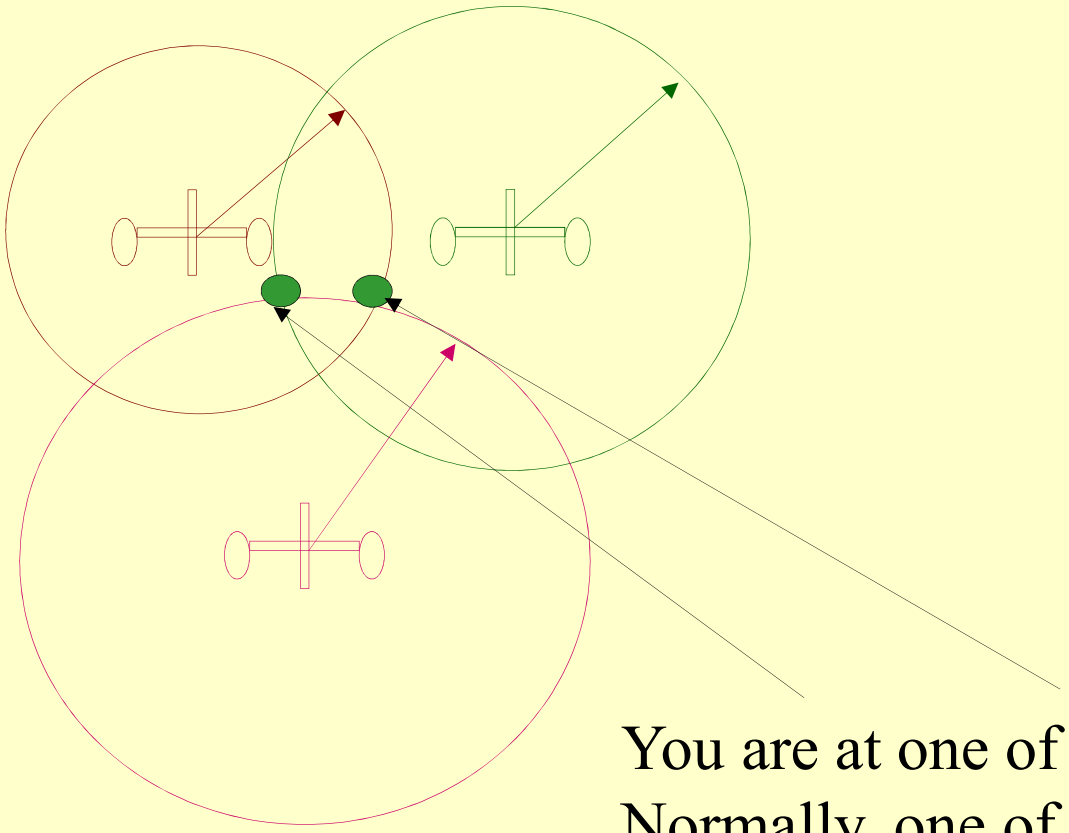


11,000 miles from satellite-1



11000 miles from satellite -1 and
12000 miles from satellite -2

Position is calculated from distance measurements (ranges) to satellites
Three ranges are enough if we reject ridiculous answers or use another tricks
Mathematically we need 4 satellites ranges to determine location



You are at one of the Green SPOTS
Normally, one of the spots is not on the earth
Another measurement is required for technical reasons.

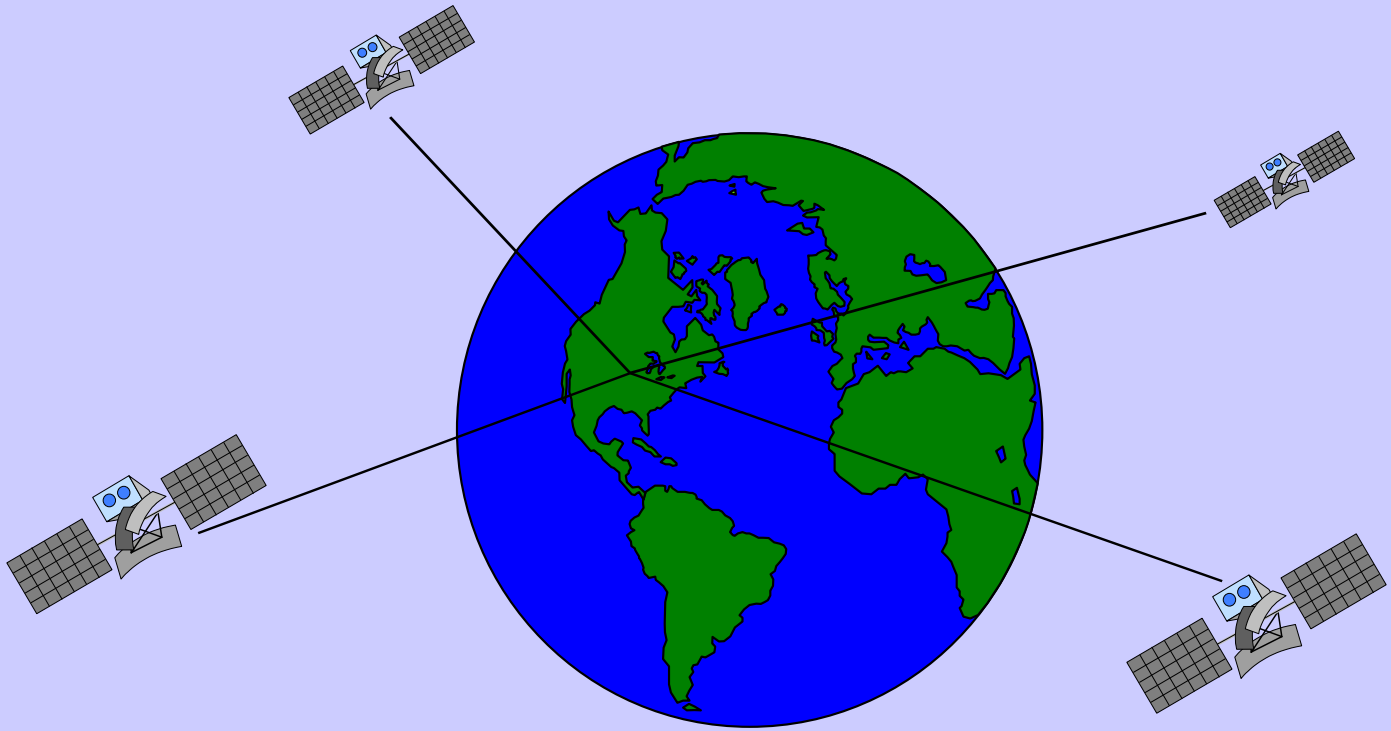
11000 miles from satellite -1 and 12000 miles from satellite - 2 and 13000 miles from satellite - 3

Knowing where a satellite in a space

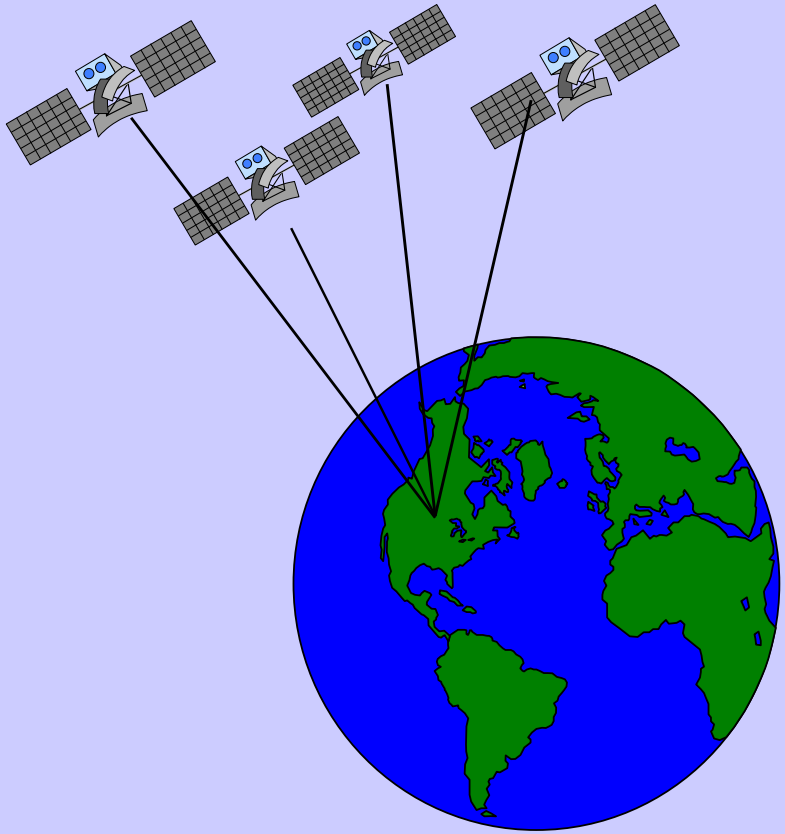
Monitor and relay the updated exact position to satellite by DOD. Then satellite transmits corrected position information in the timing signals its broadcasting. Therefore, GPS signal is more than pseudo-random code. It also includes ephemeris information as well.

PDOP (Positional Dilution of Precision)
GDOP(Geometric Dilution of precision)

Low PDOP

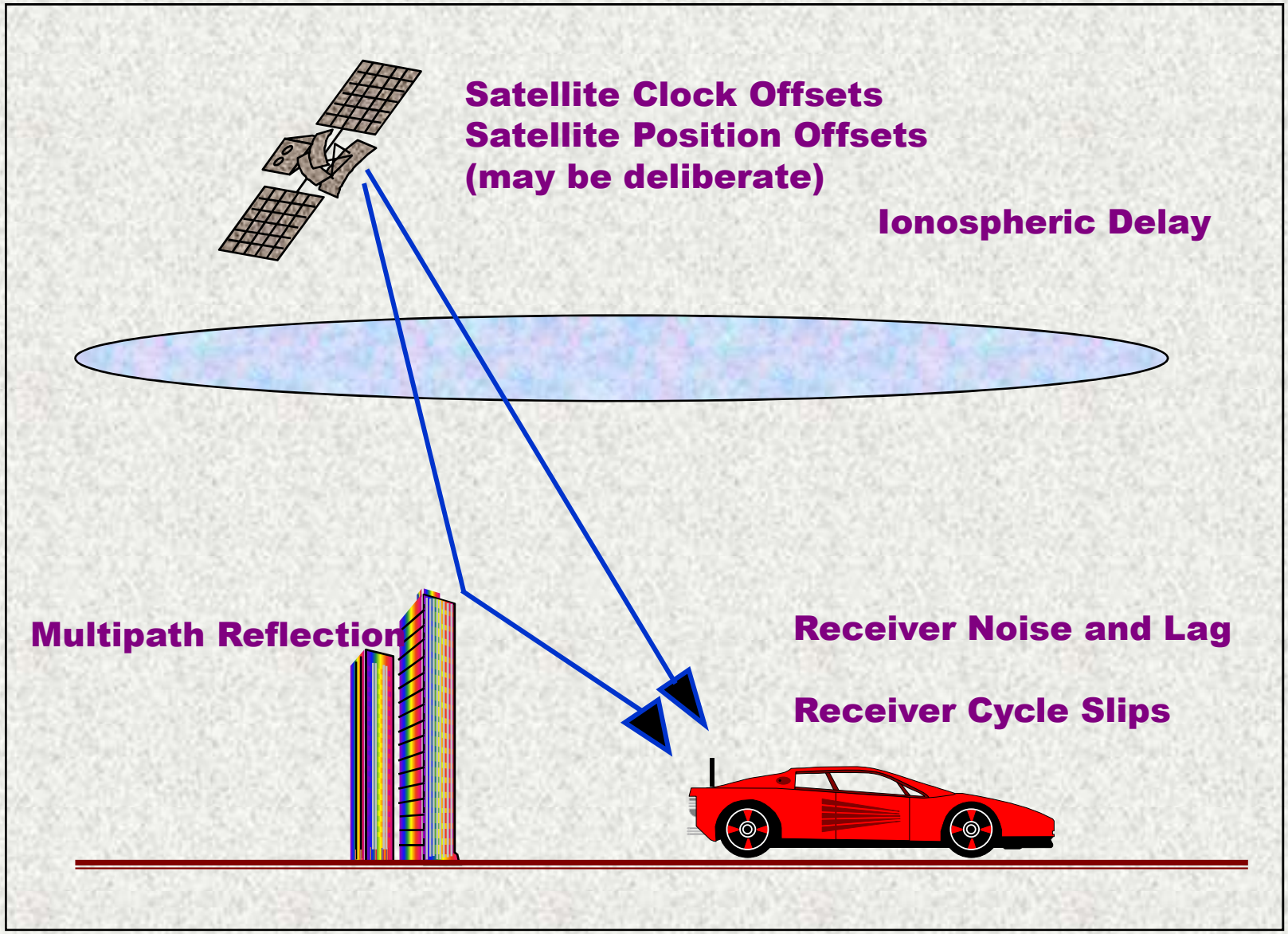


High PDOP



Errors & Biases in GPS

- **Errors**
  - **Atmospheric delays (Ionospheric particles, Tropospheric clouds)**
  - **Satellite Clocks**
  - **Orbital (Ephemeris, Cycle slip)**
  - **Multipath (reflections)**
  - **Receiver measurement noise**
- **Biases** (Intentional Errors)
  - **Selective Availability (SA)**


Satellite Clock Offsets
Satellite Position Offsets
(may be deliberate)
Ionospheric Delay
Multipath Reflection
Receiver Noise and Lag
Receiver Cycle Slips

Summary of GPS Error

Typical Error Budget

Per Satellite Accuracy	Standard GPS	DGPS
Satellite clock	1.5	0
Orbit error	2.5	0
Ionosphere	5.0	0.4
Troposphere	0.5	0.2
Receiver noise	0.3	0.3
Multipath	0.6	0.6
SA	30.0	0

Typical Position Accuracy

Horizontal	50	1.3
Vertical	78	2.0
3D	93	2.8

- Differential GPS can eliminate almost all error

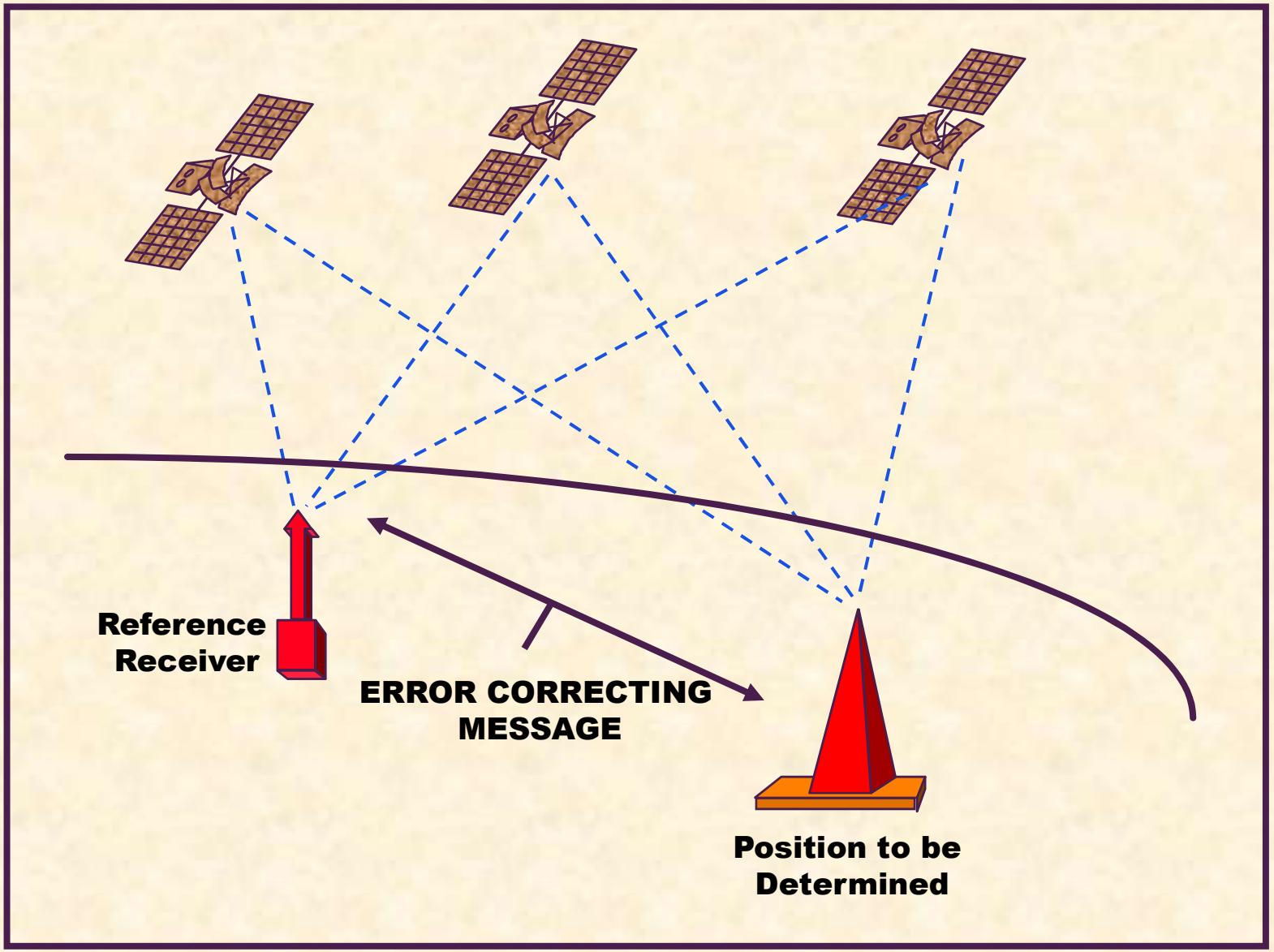

Tell me more about GPS!

Absolute GPS

- A single receiver station
- Ranging strictly between satellite and receiver
- Overall accuracy of absolute positioning ($\pm$ 50 or 100 m)
- Satellite clock error cancels
- Orbit error cancels
- Atmospheric delay errors reduced

Differential GPS

- Differential GPS measurements can be much more accurate than standard GPS measurements
- A receiver placed at a known location calculates the combined error in the satellite range data
- That correction can be applied to all other receivers in the same locale, to eliminate virtually all error in their measurements


Reference
Receiver
ERROR CORRECTING
MESSAGE
Position to be
Determined