Global Positioning Systems

The Basics

Satellite Base Position System

- Satellite base station was developed and implemented to address Military use , some what analogously to internet early development
- But this system prove significant to civilian purposes as well e.g.
  - Suitable for all kinds of military use; Ground troops, Vehicles , Aircraft, Ships and Missiles
  - Requiring only low cost equipment with low energy consumption at receiver end.

Satellite Base Position System Cont…

- Provision of result in real time for an unlimited number of user concurrently
- Support for different level of accuracy (military vs civilian)
- Round the clock and weather availability.
- Use single geodetic system

Satellite Base Position System Cont…

- GLONASS
- GPS
- Galileo

GPS?

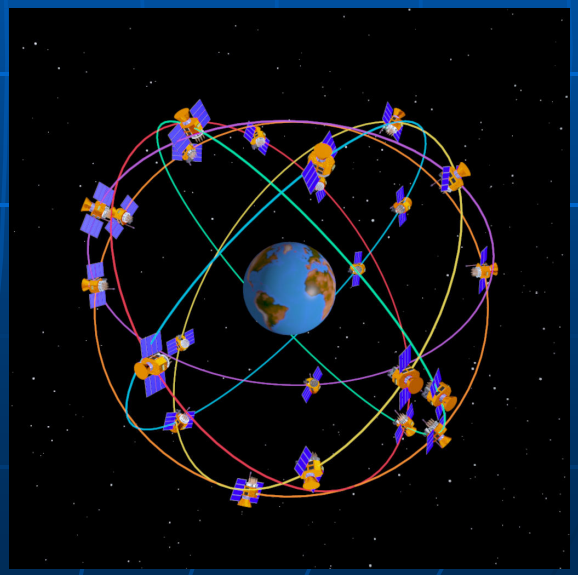
- What is GPS?
- Lineage of GPS
- HOW GPS WORKING
- MAIN PARTS OF GPS
- GPS SIGNAL AND CODES
  - L1, L2, C/A CODE, P CODE
- METHODS OF DATA CAPTURE USING GPS
- SOURCES OF ERROR
- DGPS (Differential GPS)

What is GPS?

The Global Positioning System (GPS)

is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense.

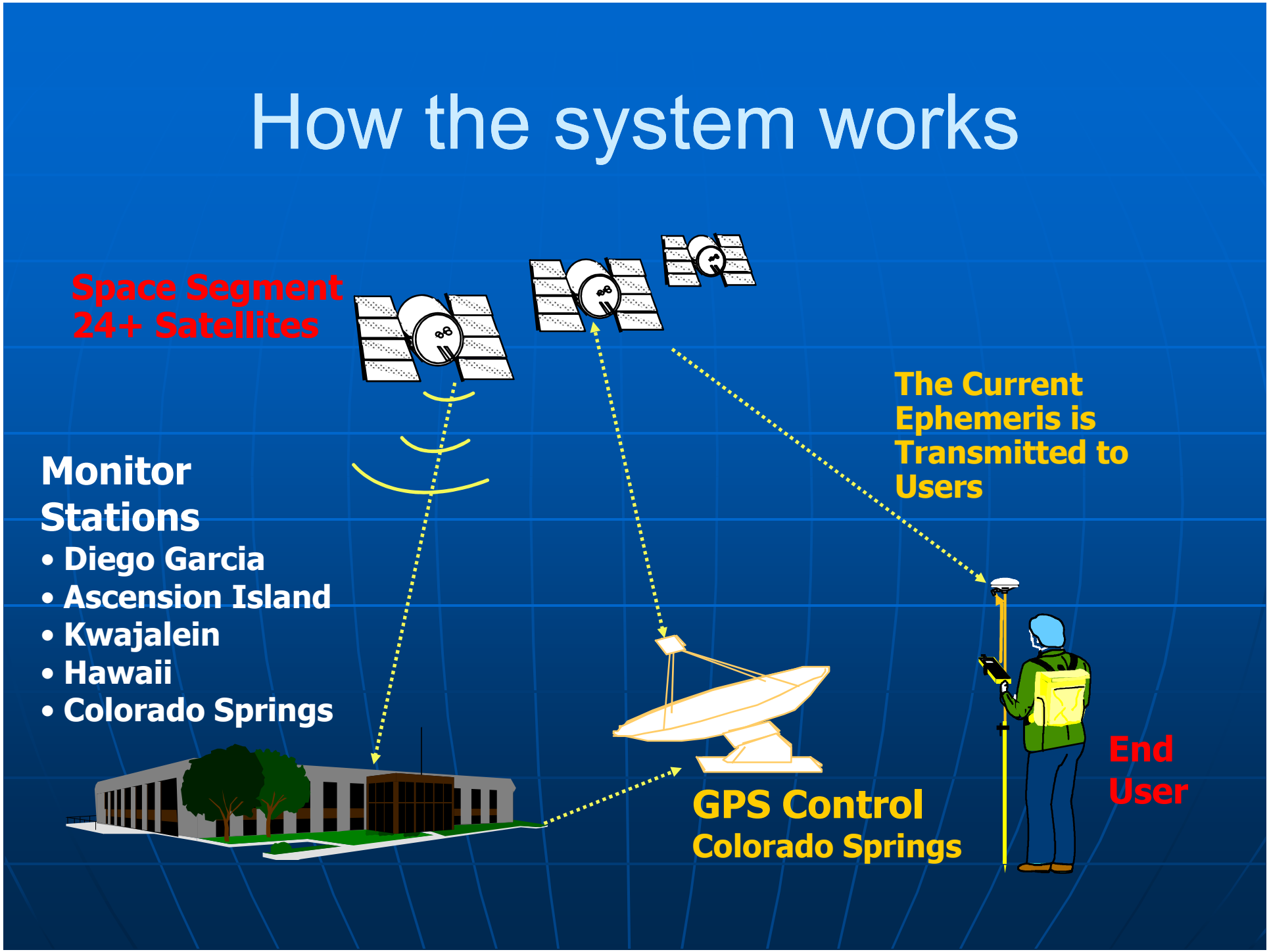
for the Purpose of Defining Geographic Positions On and Above the Surface of the Earth. It consists of Three Segments:



GPS Lineage

- Phase 1: 1973-1979
  CONCEPT VALIDATION
  1978- First Launch of Block 1 SV
- Phase 2: 1979-1985
  FULL DEVELOPMENT AND TESTS
- Phase 3: 1985-Present
  PRODUCTION AND DEPLOYMENT

How the system works



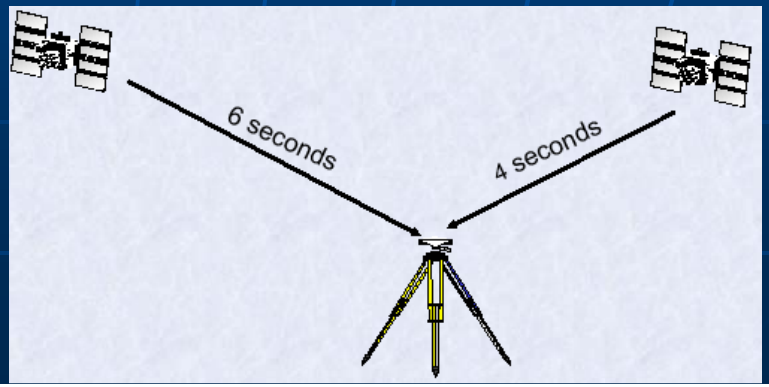
GPS- How it works

- Measuring the distance from a satellite by measuring travel time of radio signals seconds

  Distance = speed of light * latency in time

Pseudo Range :- the pseudo Range of a satellite with respect to a receiver is its apparent distance to receiver , computed from time delay with which its radio signal is received.

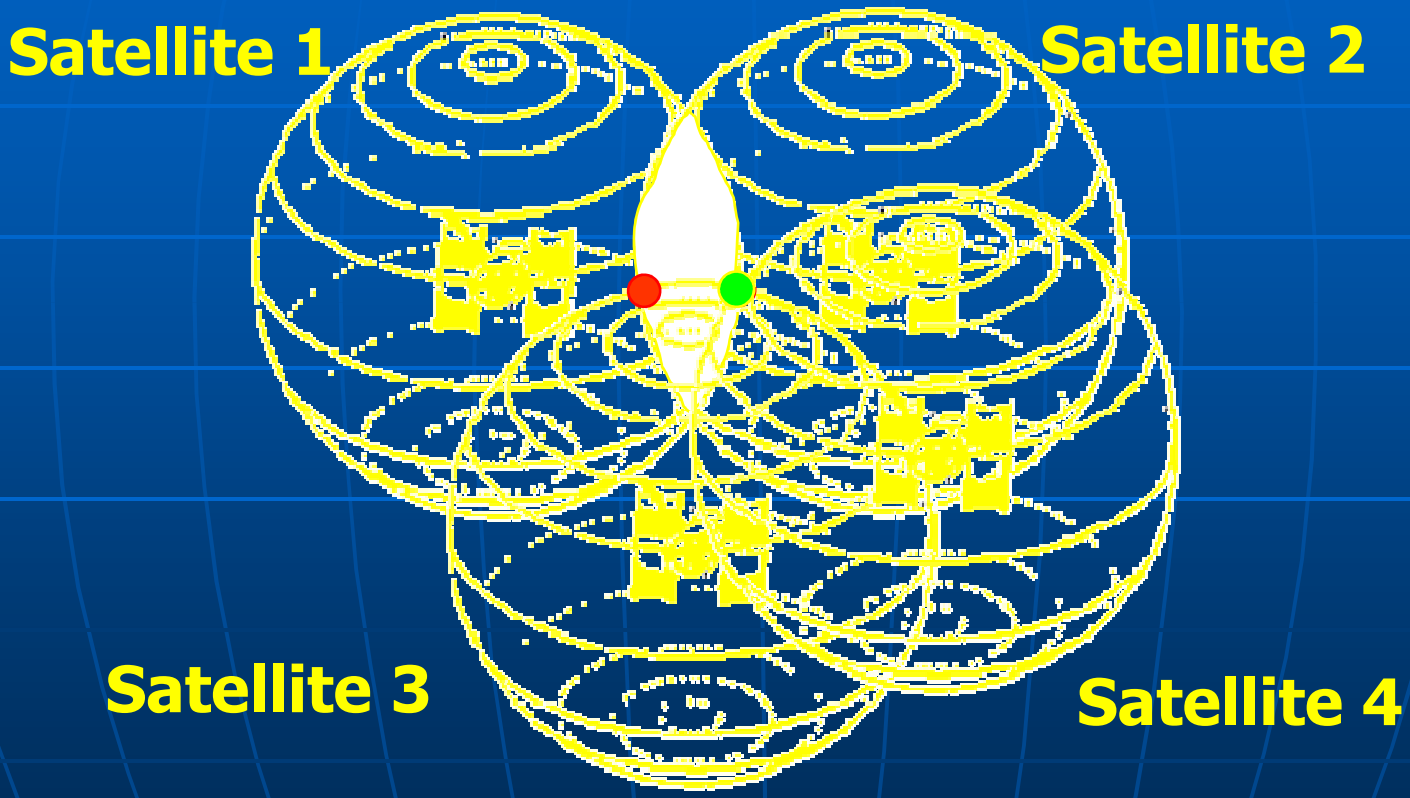
- Four GPS satellite signals are used to compute positions in three dimensions and the time offset in the receiver clock.



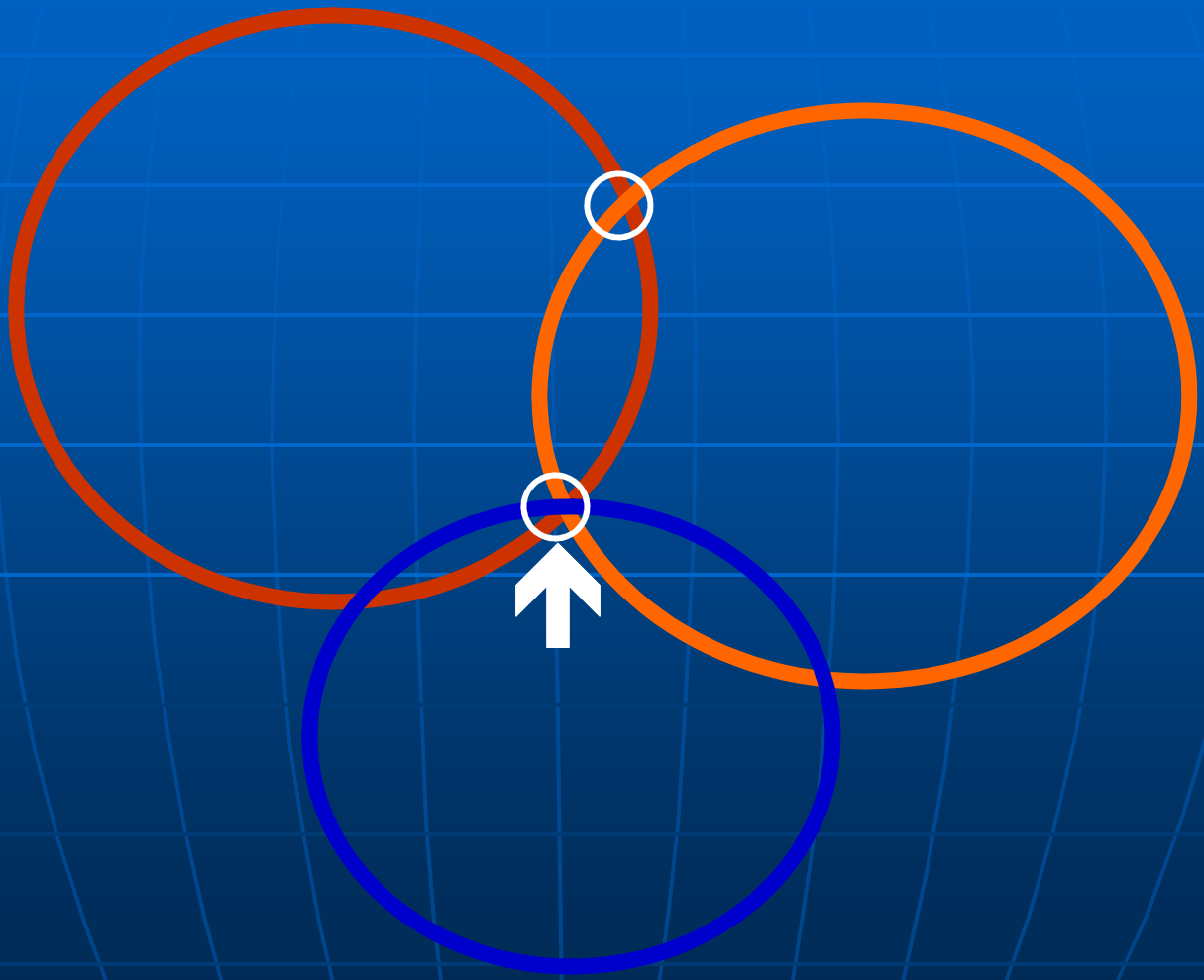
GPS- How it works

- 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.
- With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude).

Triangulation



Need at least 3 satellite signals

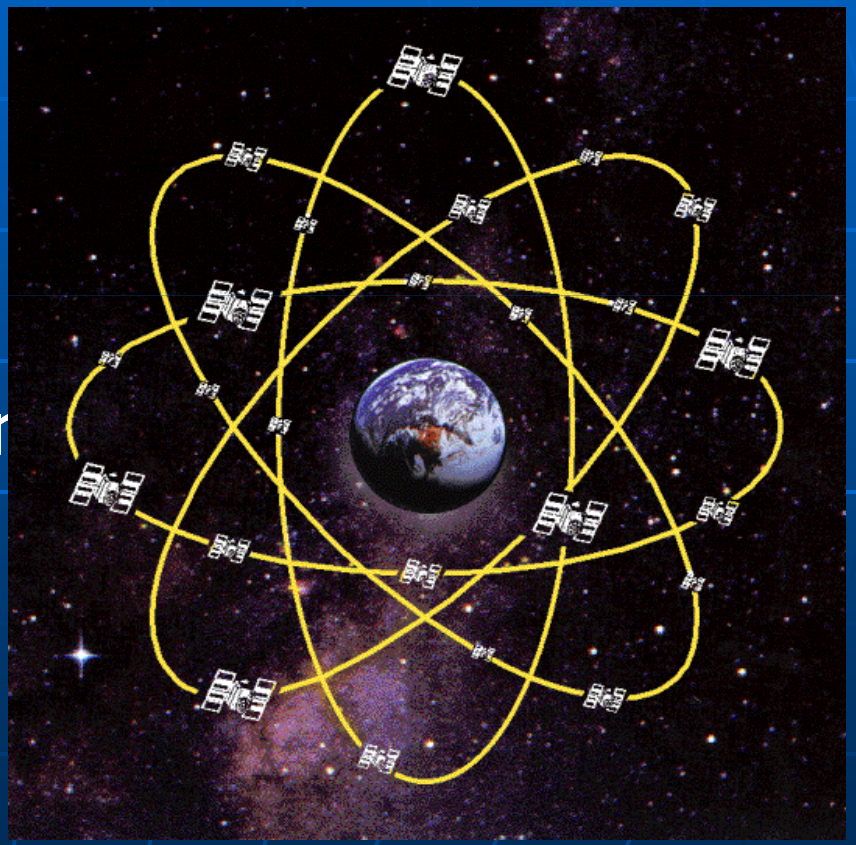


GPS SEGMENTS

- Space Segment
- User Segment
- Control SEGMENT

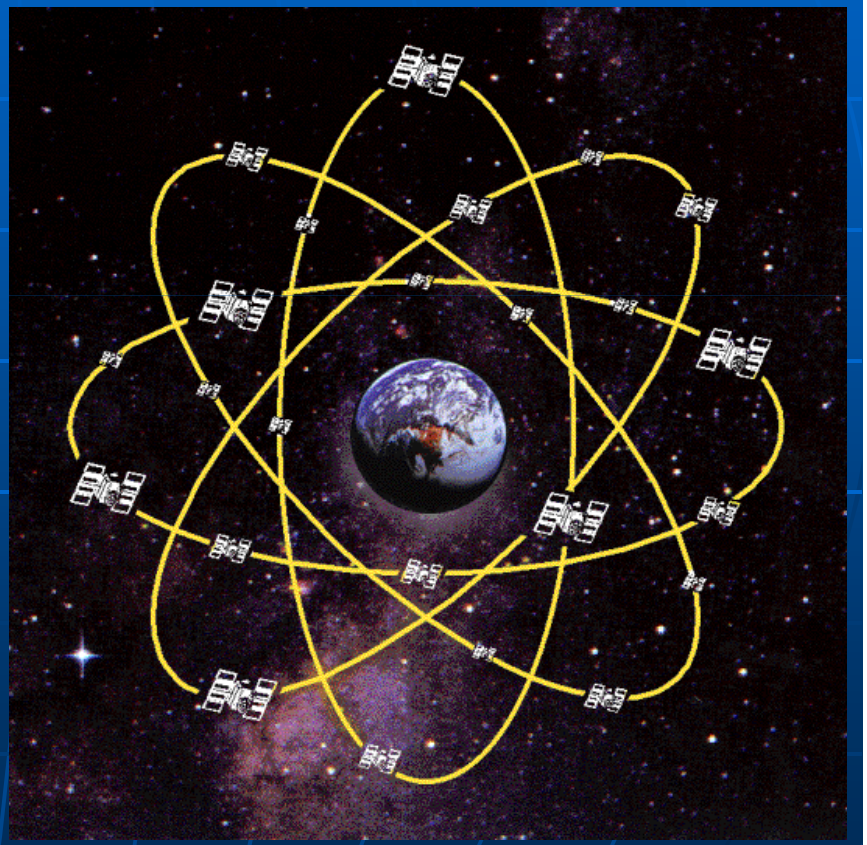
Space Segment

- 24+ satellites
  - 6 planes with 55° inclination
  - Each plane has 4-5 satellites
  - Broadcasting position and time info on 2 frequencies
  - Constellation has spares



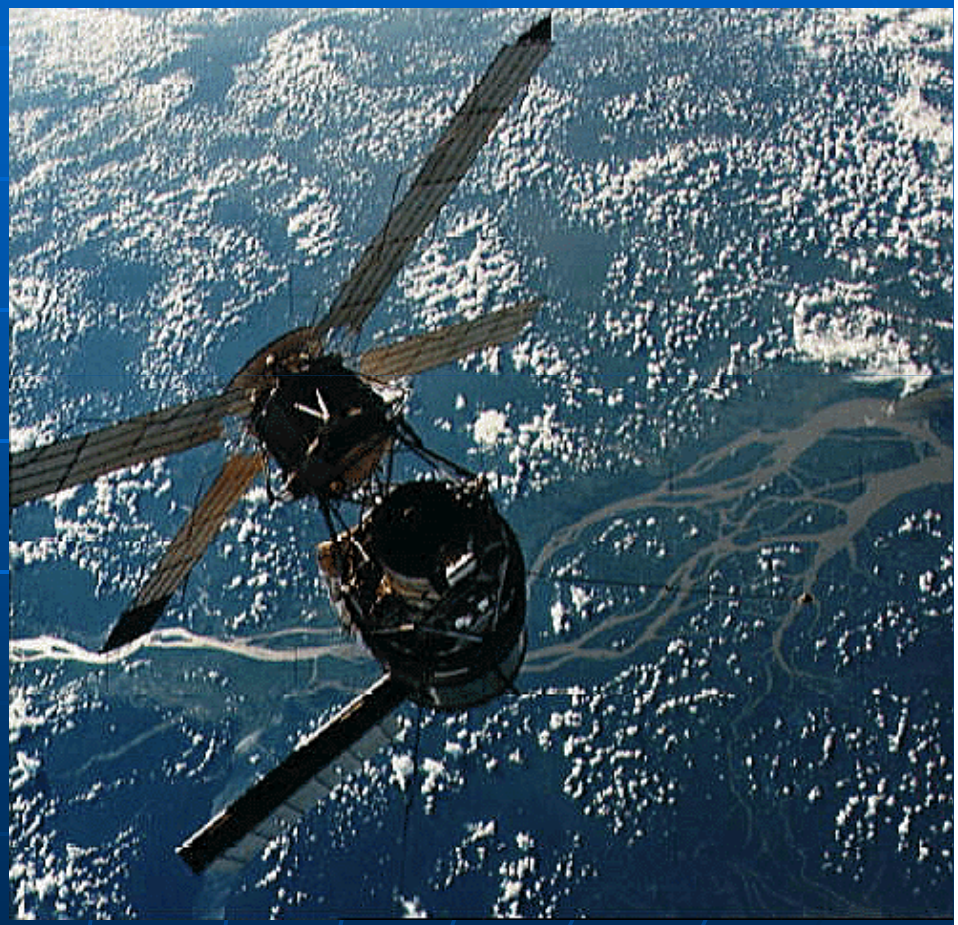
Space Segment

- Very high orbit
  - 20,200 km
  - **1 revolution in approximately 12 hrs**
  - **Travel approx. 7,000mph**
- Considerations
  - Accuracy
  - Survivability
  - Coverage



GPS Satellites (Satellite Vehicles(SVs))

- First GPS satellite launched in 1978
- Full constellation achieved in 1994
- Satellites built to last about 10 years
- Transmitter power is only 50 watts or less



GPS SIGNAL AND CODES

- L1, L2, C/A CODE, P CODE , Y code , Z code

Precise Positioning System (PPS)

- Authorized users ONLY
- U. S. and Allied military
- Requires cryptographic equipment, specially equipped receivers
- Accurate to 21 meters 95% of time

Standard Positioning Service (SPS)

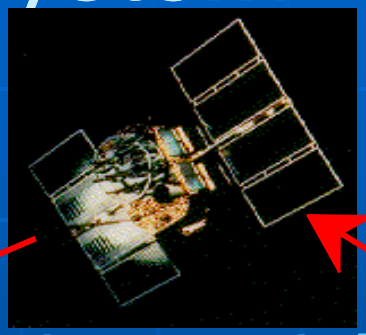
- Available to all users
- Accuracy degraded by Selective Availability until 2 May 2000
  - Horizontal Accuracy: 100m
- Now has roughly same accuracy as PPS

User Segment

- Dual Use System Since 1985
  (civil & military)
- Civilian community was quick to take advantage of the system
  - Hundreds of receivers on the market
  - 3 billion in sales, double in 2 years
  - 95% of current users
- DoD Executive Board sets GPS policy

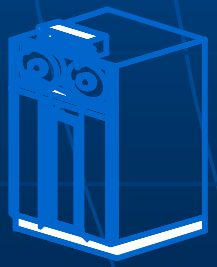
GPS

Control Segment: Maintaining the System

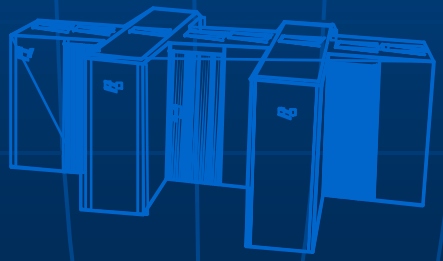


- *Correct Orbit and clock errors*
- *Create new navigation message*

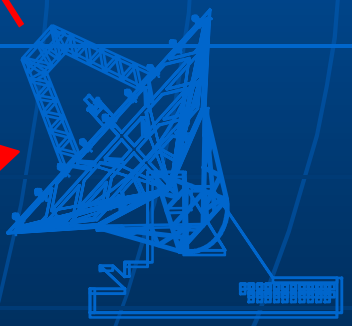
- *Observe ephemeris and clock*



(5) Monitor Stations

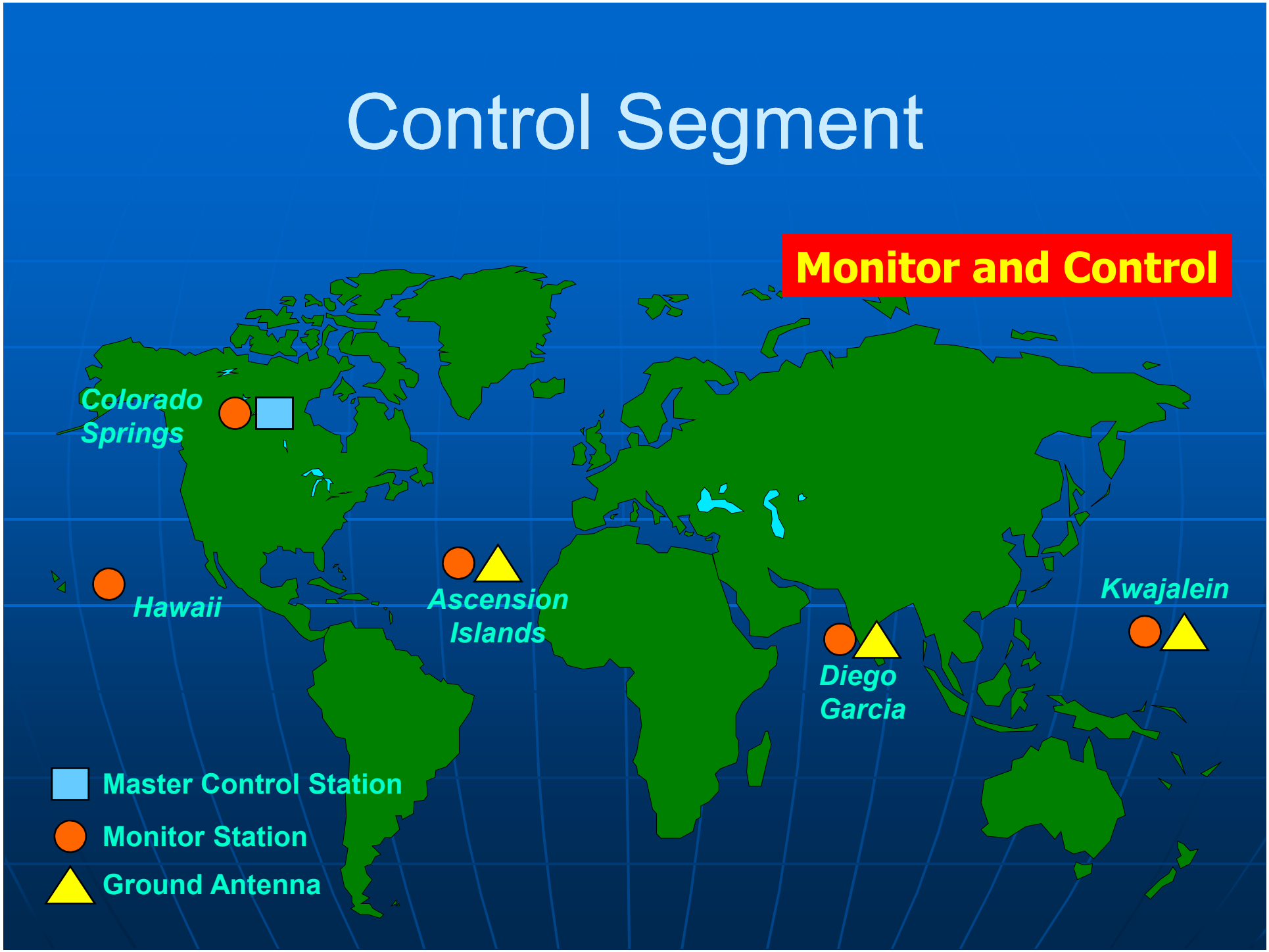


Falcon AFB



Upload Station

Control Segment



Different Methods of Data Acquisition through GPS

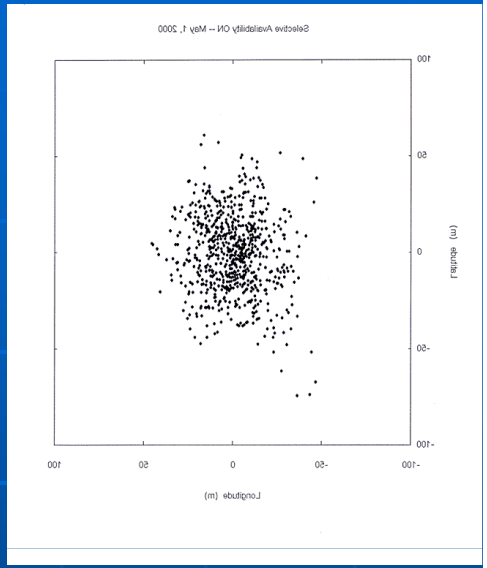
- Real Time
- Differential GPS

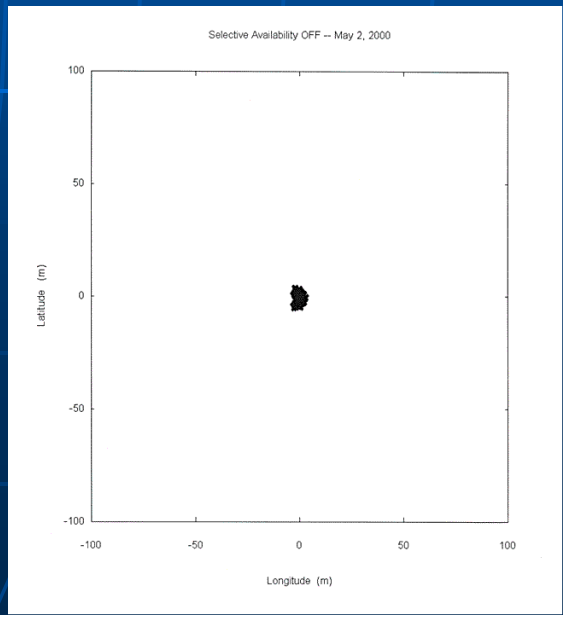
Differential GPS

- Real Time Processing
  - Real time kinematics
- Post Processing
  - Static
  - Pseudo Kinematics (Stop and Go)
  - Kinematics

Sources of Error

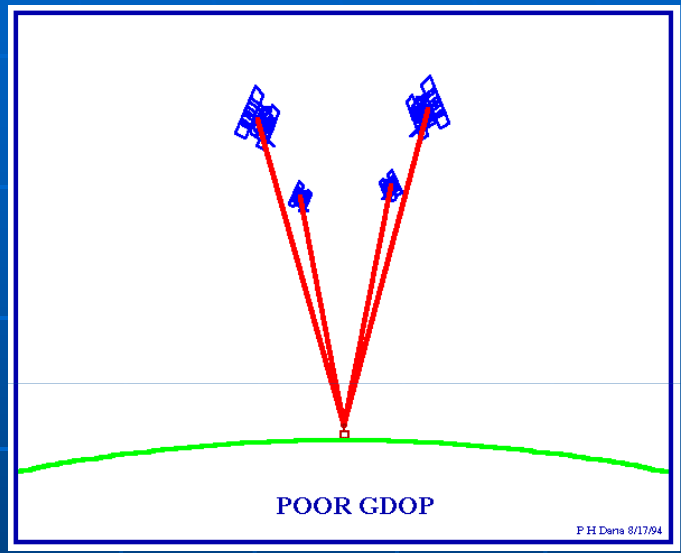
- Selective Availability
  - Intentional degradation of GPS accuracy
  - 100m in horizontal and 160m in vertical
  - Accounted for most error in standard GPS
  - Turned off May 2, 2000

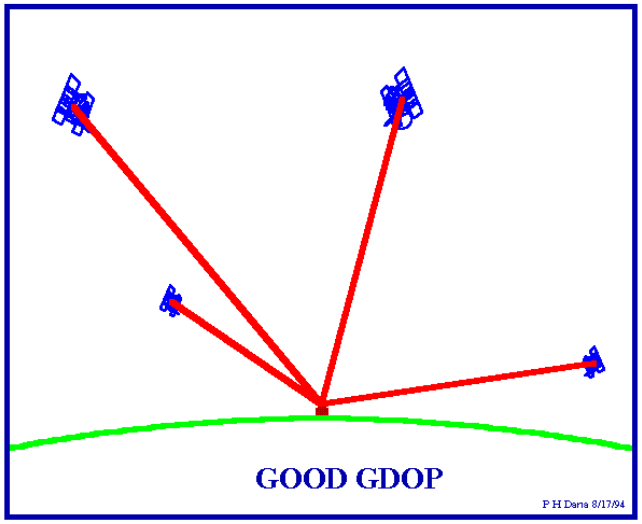




Sources of Error

- Geometric Dilution of Precision (GDOP)
  - Describes sensitivity of receiver to changes in the geometric positioning of the SVs
- The higher the DOP value, the poorer the measurement

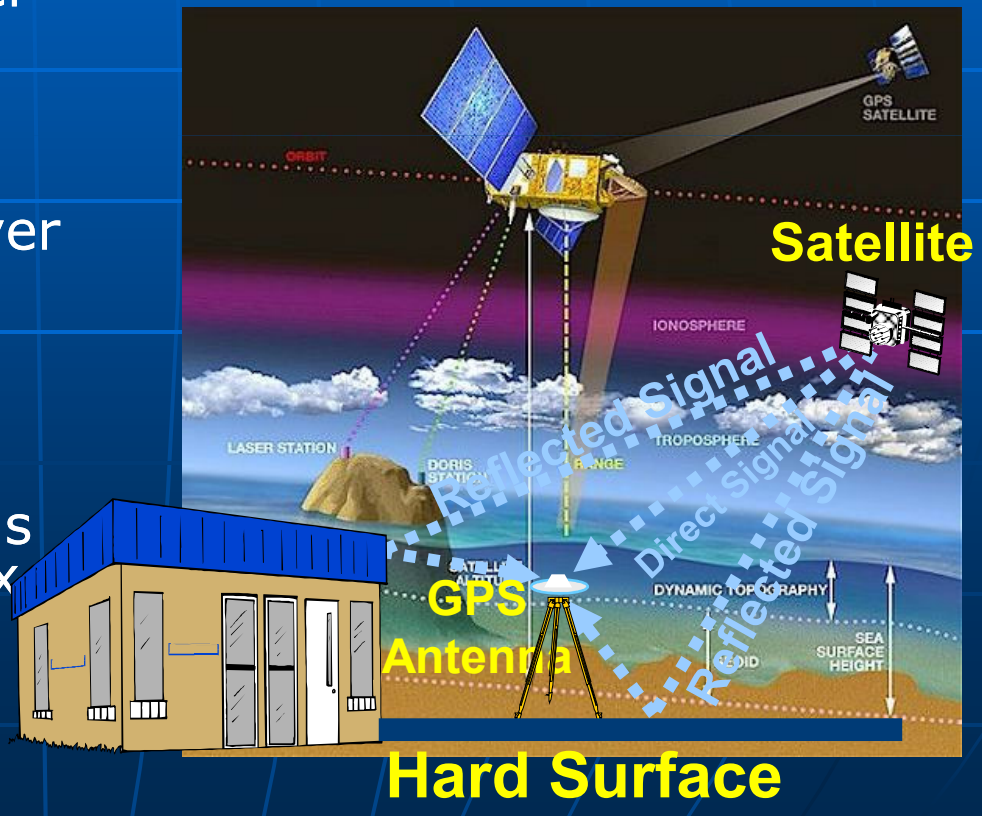




QUALITY	DOP
Very Good	*1-3*
Good	*4-5*
Fair	*6*
Suspect	*>6*

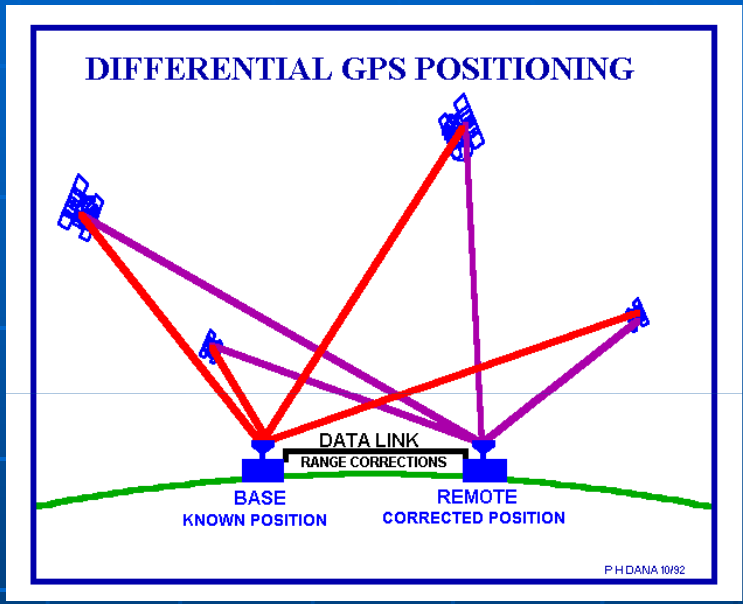
Sources of Error

- Clock Error
  - Differences between satellite clock and receiver clock
- Ionosphere Delays
  - Delay of GPS signals as they pass through the layer of charged ions and free electrons known as the ionosphere.
- Multipath Error
  - Caused by local reflections of the GPS signal that mix with the desired signal



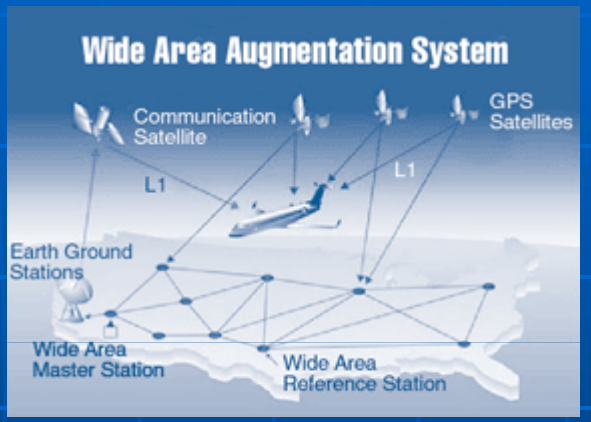
Differential GPS

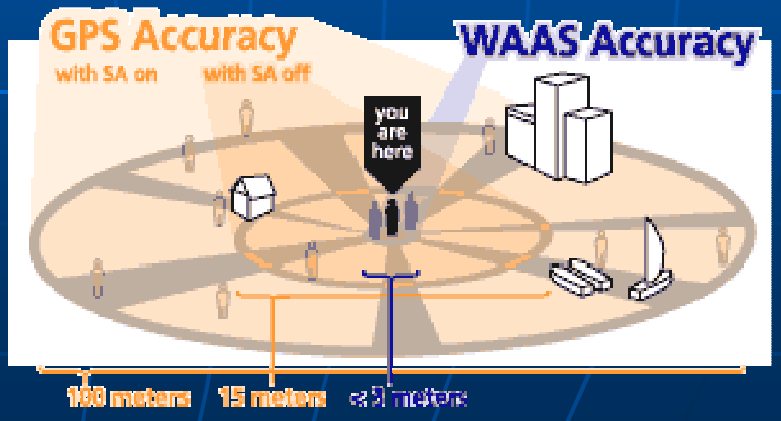
- Method of removing errors that affect GPS measurements
- A base station receiver is set up on a location where the coordinates are known
- Signal time at reference location is compared to time at remote location
- Time difference represents error in satellite's signal
- Real-time corrections transmitted to remote receiver
  - Single frequency (1-5 m)
  - Dual frequency (sub-meter)
- Post-Processing DGPS involves correcting at a later time



Wide Area Augmentation System (WAAS)

- System of satellites and ground stations that provide GPS signal corrections
- 25 ground reference stations across US
- Master stations create GPS correction message
- Corrected differential message broadcast through geostationary satellites to receiver
- 5 Times the accuracy (3m) 95%





Common Uses for GPS

- **Surveying/ Mapping**
- **Military Applications**
- **Recreational Uses**
- **Emergency Services – Fire & Police**
- **Business – Site Location, Delivery Systems**
- **Environmental**
- **Natural Disasters**
- **Education**
- **Government**
- **Medical**
- **Industry, Businesses**
- **Defense**
- **Land, Sea and Air Navigation and Tracking**

“Mobile Mapping”

- Integrates GPS technology and GIS software
- Makes GIS data directly accessible in the field
- Can be augmented with wireless technology