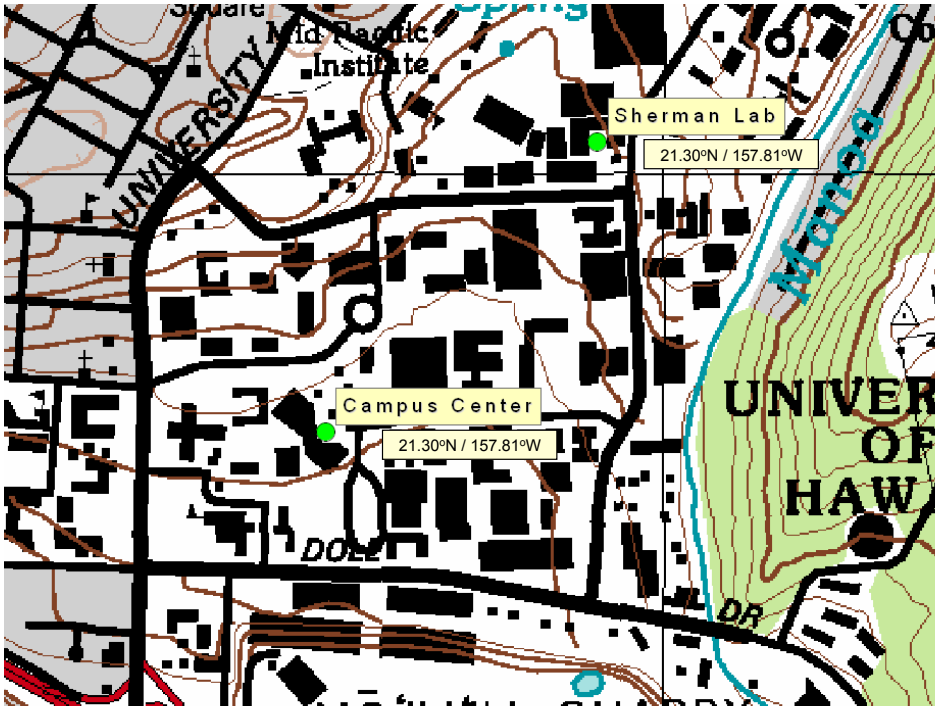
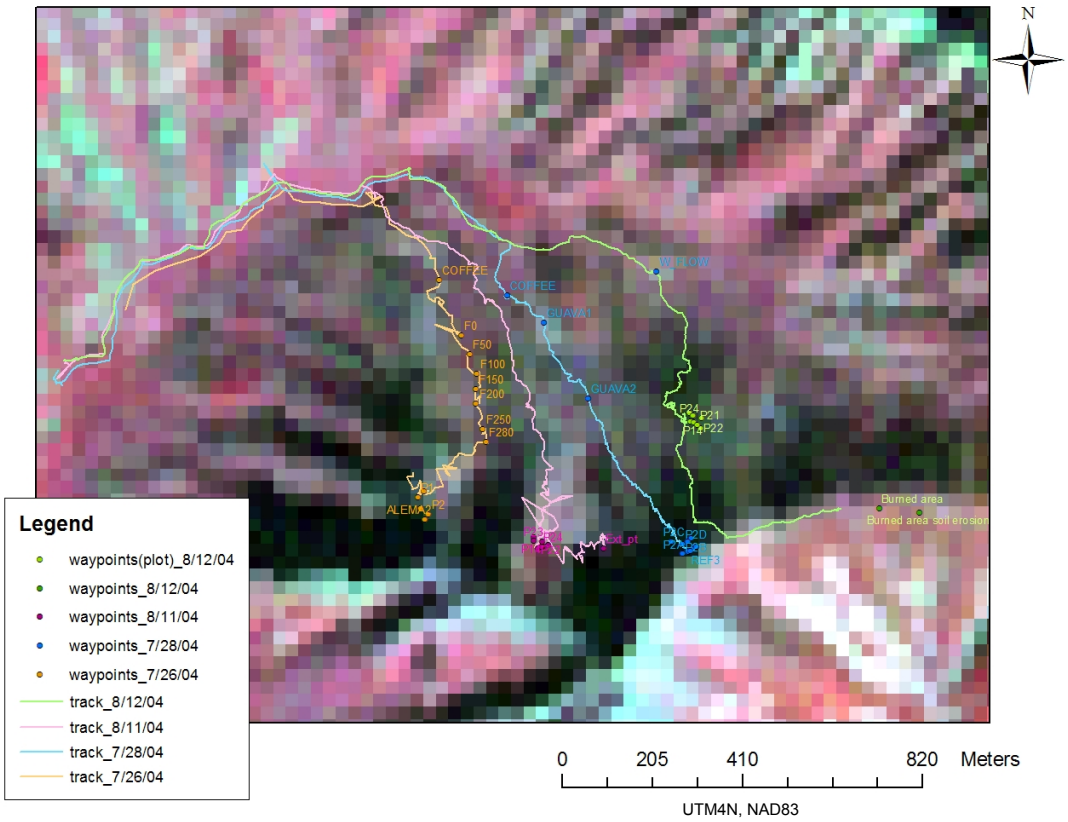
# Where Are We?


Sherman Lab
21.30ºN / 157.81ºW
Campus Center
21.30ºN / 157.81ºW
UNIVERSITY
Institute
DOLE
DR
UNIVER
OF
HAW


N
COFF2E
COFFEE
W_FLOW
GUAVA1
F0
F50
F100
F150
F200
F250
F280
GUAVA2
P24
P21
P14
P22
ALEMA2
P2
Burned area
Burned area soil erosion
Legend
waypoints(plot)_8/12/04
waypoints_8/12/04
waypoints_8/11/04
waypoints_7/28/04
waypoints_7/26/04
track_8/12/04
track_8/11/04
track_7/28/04
track_7/26/04
0
205
410
820
Meters
UTM4N, NAD83

# What is a GNSS?

- It is a satellite navigation system to precisely and automatically identify locations on earth.

- The GNSS of U.S., ***the United States NAVSTAR Global Positioning System (GPS)***, was initiated by U.S. Department of Defense for the military to have a precise form of world wide positioning (~$12 billion funding).

# Other GNSS

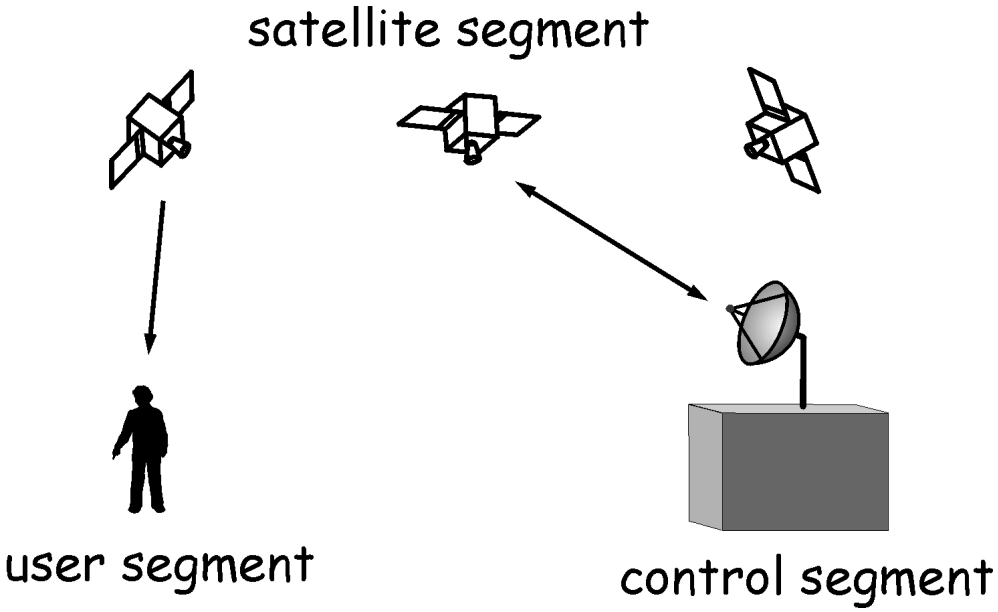
- The US NAVSTAR GPS
  - a fully operational GNSS
- The Russian GLONASS
  - the only alternative navigational system in operation with global coverage and of comparable precision to GPS
- The EU's Galileo
  - in initial deployment phase and scheduled to be fully operational in 2019
- The China's COMPASS (BeiDou)
  - scheduled to be operational by 2020

# Applications

- Tracking
- Navigation
- Field Digitizing
- Surveying

- Geology – Natural Disasters
- Atmospheric Science

## GNSS (Global Navigation Satellite System) - GPS (Global Positioning System) -



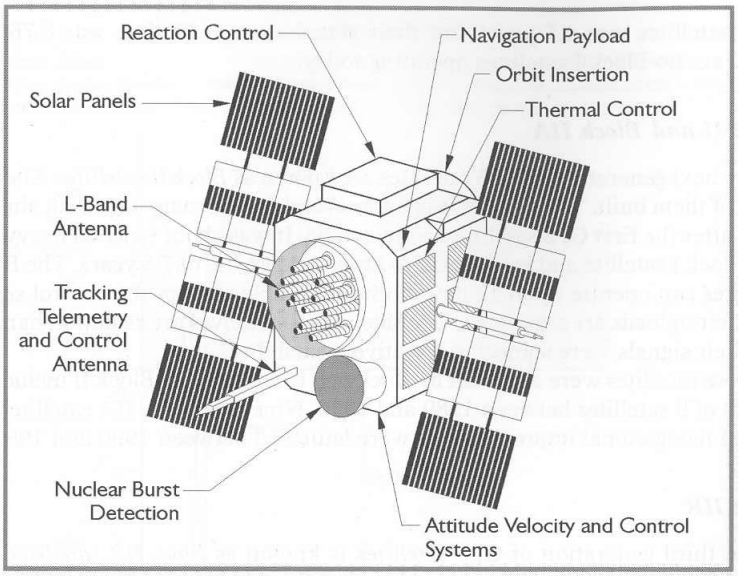
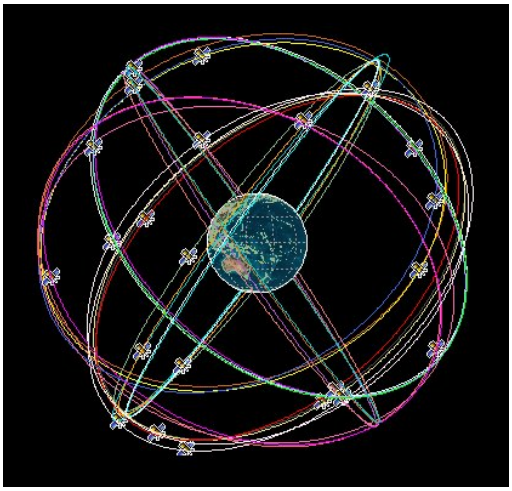



**Figure 3.8.** GPS Block II Satellite.

- The first GPS satellite was launched in 1978.
- A full constellation of 24 satellites was achieved in 1994.
- Each satellite is built to last about 10 years. Replacements are constantly built and launched in orbit.

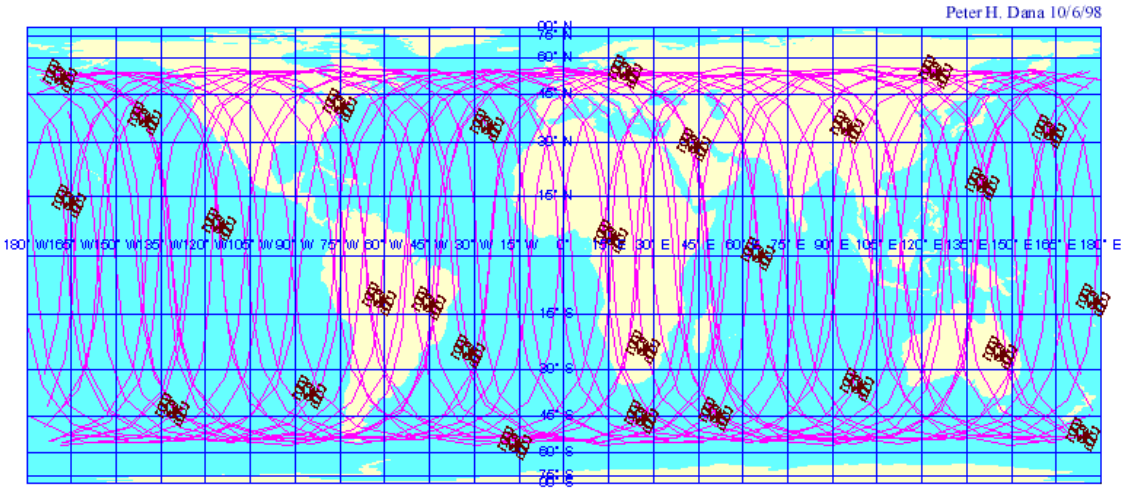
# The Satellite Segment of GPS



- Six unique orbital planes with ascending nodes approximately 60 degrees apart.
- Their orbit inclinations at 55 degrees to the equator.
- Four GPS satellites in each of these orbital planes.
- 20,200 km altitudes.

# The Satellite Segment of GPS (cont.)

- Every satellite orbits the Earth twice daily.
- Four to eight active satellites are typically visible from any unobstructed viewing location on Earth.

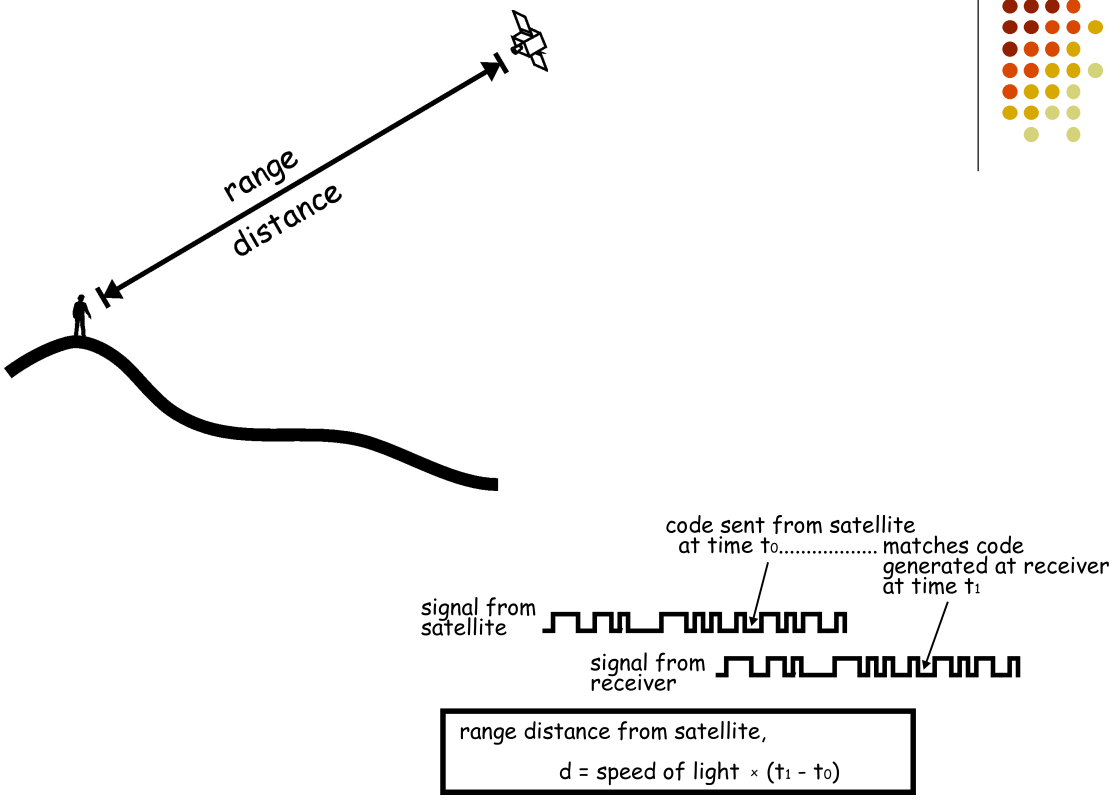


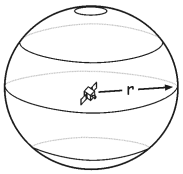

Global Positioning System Satellites and Orbits
for 27 Operational Satellites on September 29, 1998
Satellite Positions at 00:00:00 9/29/98 with 24 hours (2 orbits) of Ground Tracks to 00:00:00 9/30/98

## GPS Control Segment Stations

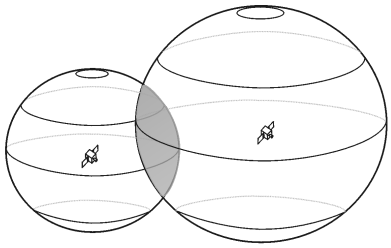

- In August and September 2005, six additional monitor stations of the NGA (National Geospatial-Intelligence Agency) were added to the grid. Now, every satellite can be seen by, at least, two monitor stations.

- In the near future, five more NGA stations will be added so that every satellite can be seen by, at least, three monitor stations.

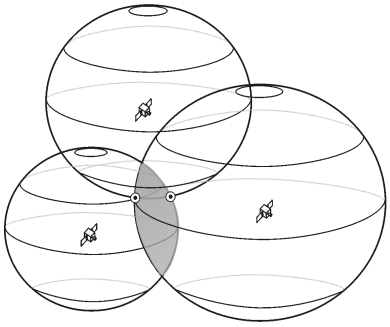




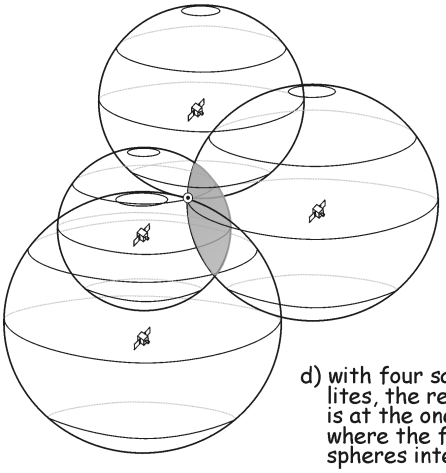

a) with a range measurement from one satellite, the receiver is positioned somewhere on the sphere defined by the satellite position and the range distance, r



b) with two satellites, the receiver is somewhere on a circle where the two spheres intersect

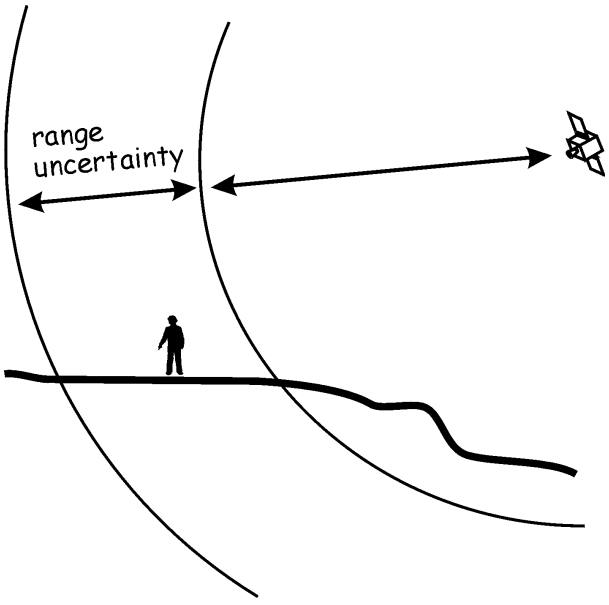


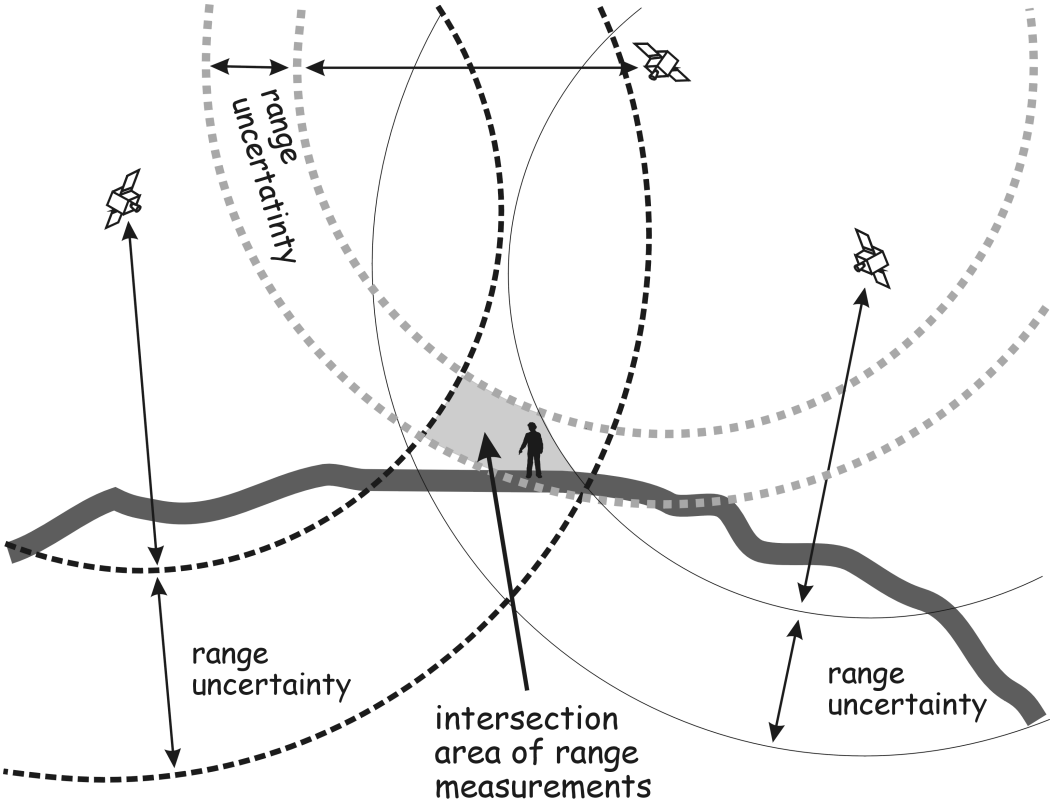
c) with three satellites the receiver is at one of two points where the three spheres intersect

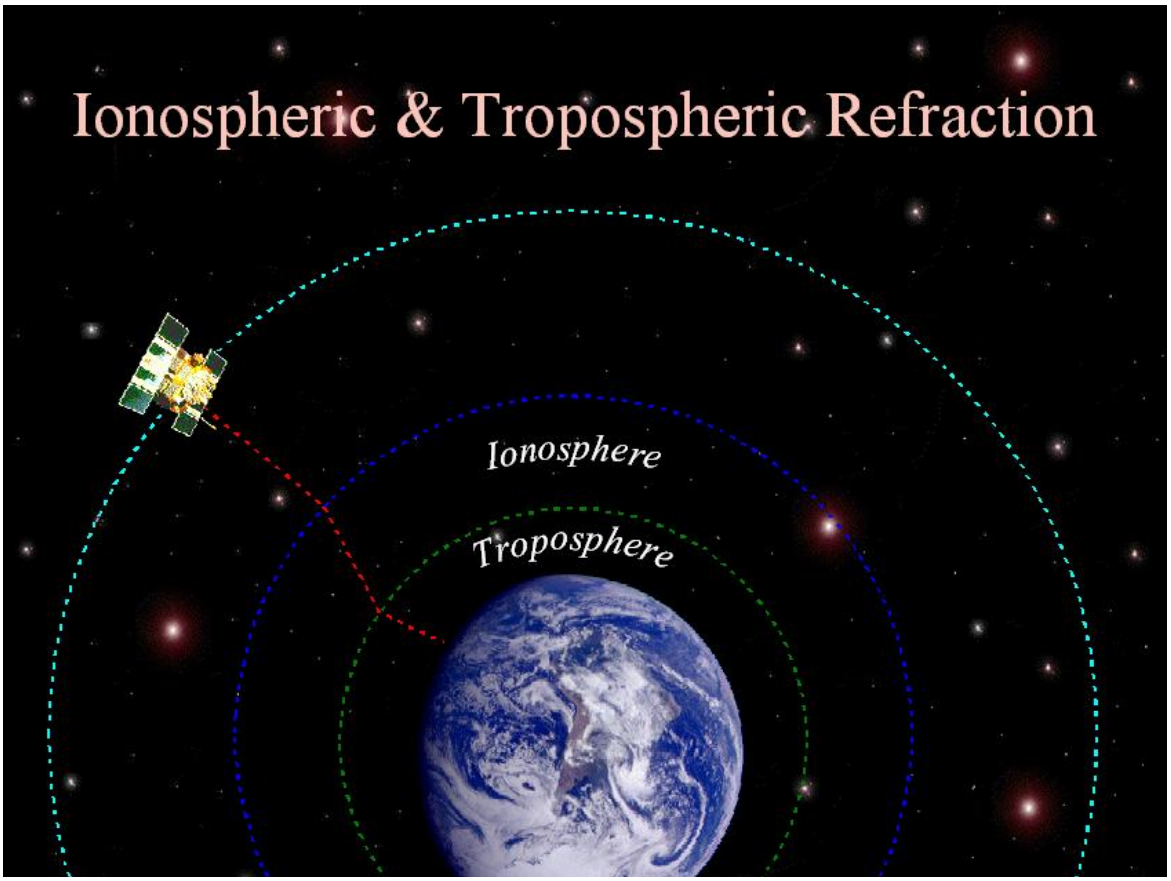


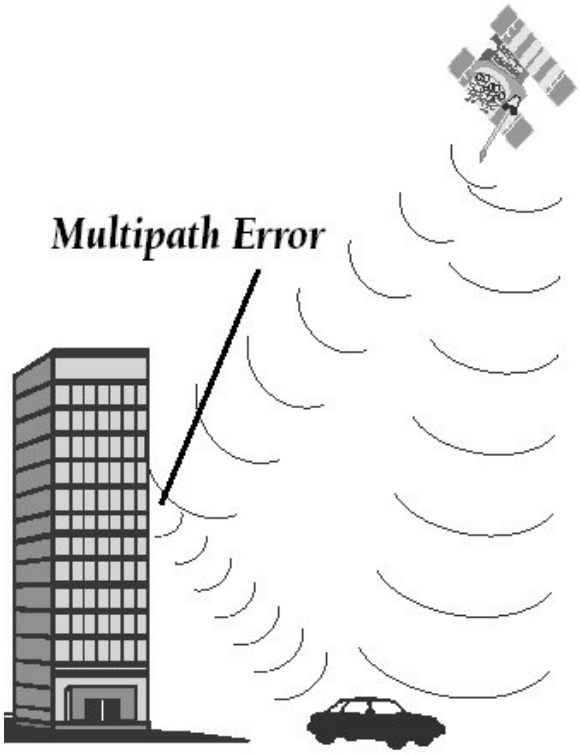
d) with four satellites, the receiver is at the one point where the four spheres intersect.

# Positional Uncertainty
# - Sources of Range Error -




range
uncertainty
range
uncertainty
intersection
area of range
measurements
range
uncertainty


Ionospheric & Tropospheric Refraction
Ionosphere
Troposphere

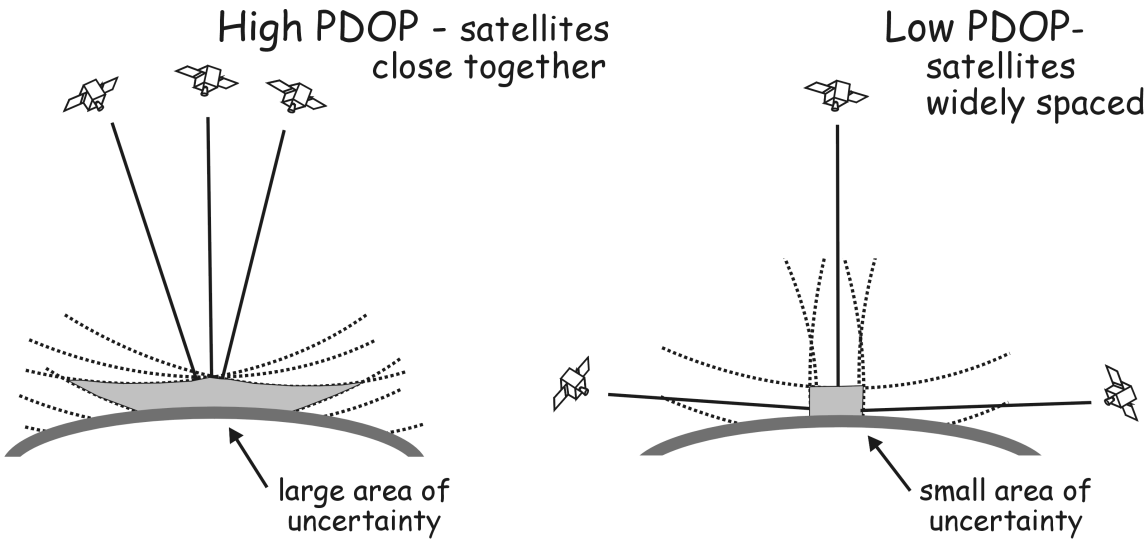



# GPS Error Budget

- Ionosphere.....5.0 meters
- Troposphere.....0.5 meters
- Ephemeris data.....2.5 meters
- Satellite clock drift.....1.5 meters
- Multipath.....0.6 meters
- Measurement noise.....0.3 meters
- ~~Selective availability.....30-100 meters~~

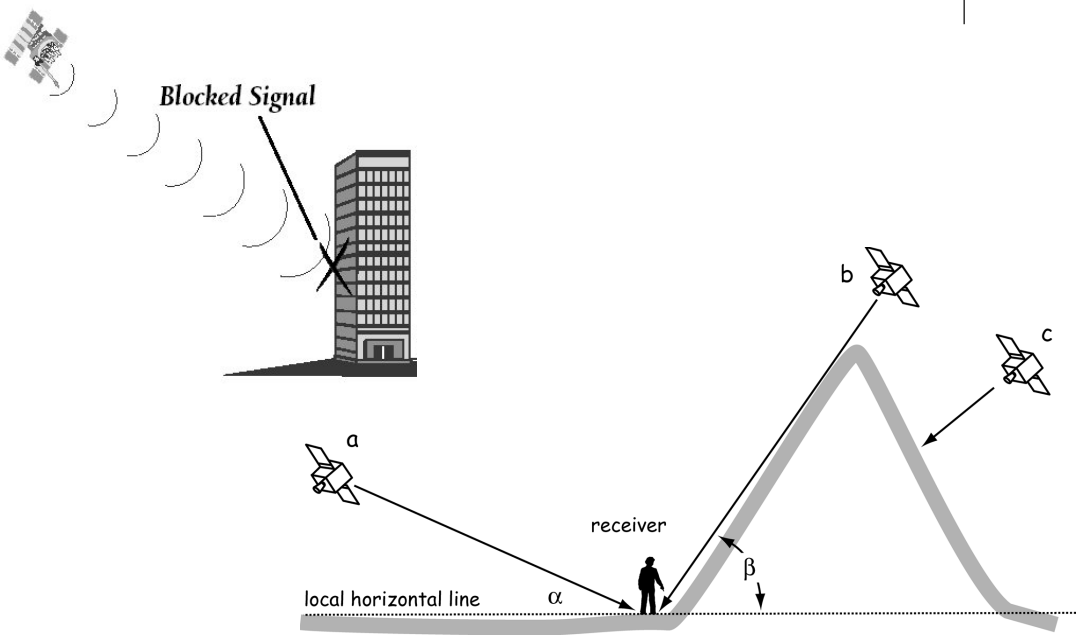
- Total.....~ 10 meters

# Other Factors for Consideration: Positional Dilution of Precision (PDOP)

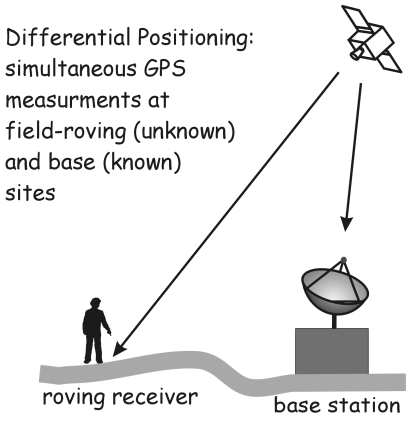


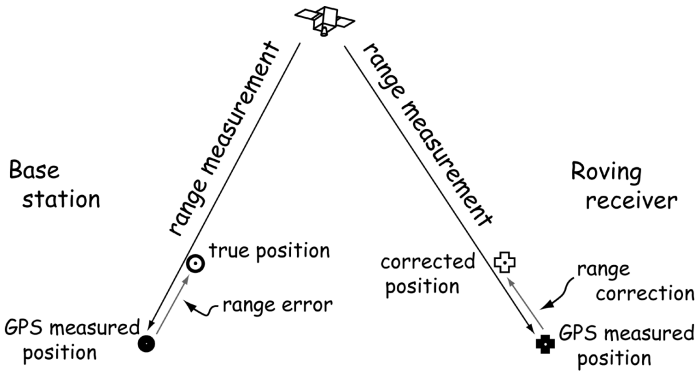

*15 degrees above the local horizontal plane

# Other Factors for Consideration: Blocked (Attenuated) Signals



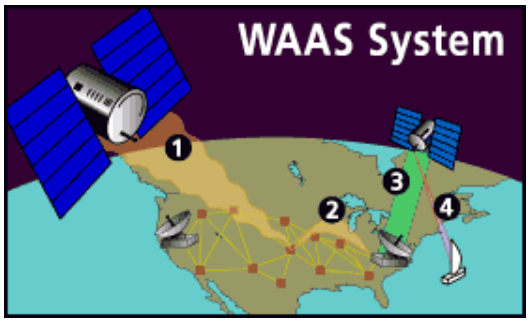
# Differential Correction



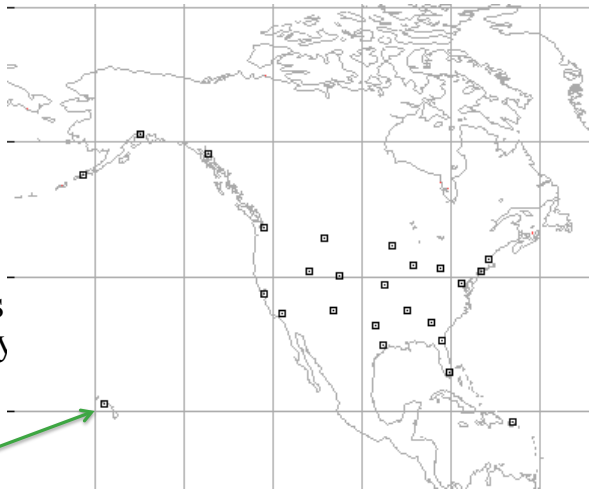

*Good correction is found when the roving receiver is within 300 km (180 miles) of the base station.

# Wide Area Augmentation System (WAAS)



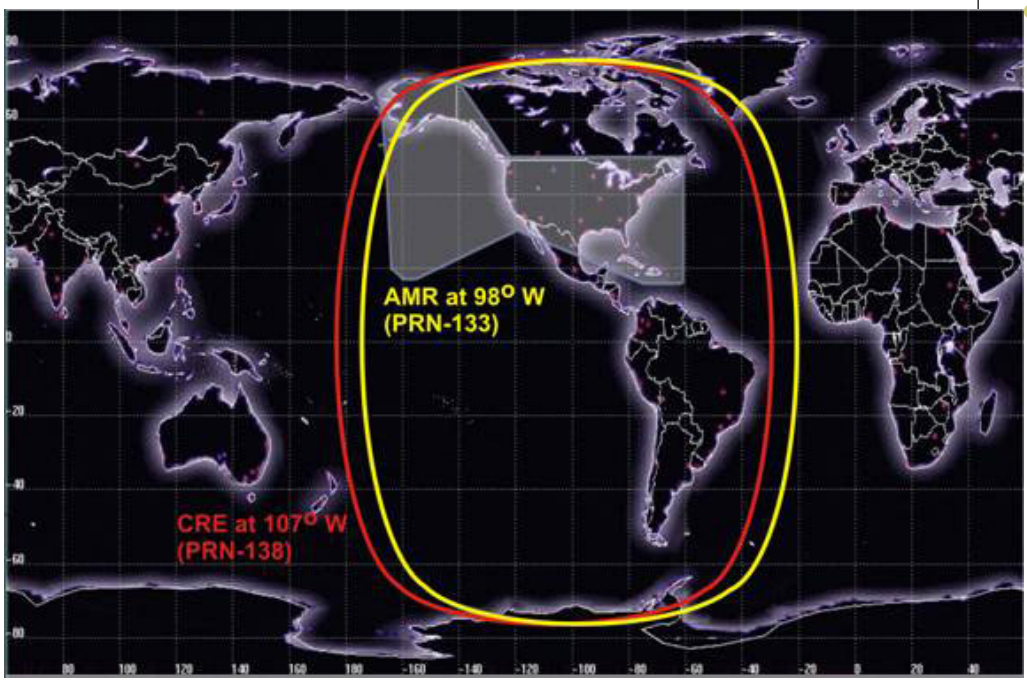

- The Federal Aviation Administration (FFA)
- The Department of Transportation (DOT)
- To meet the FAA's navigation requirements for precision flight approaches

- 25 ground reference stations across USA
- The corrected differential signals broadcast through a geostationary satellite

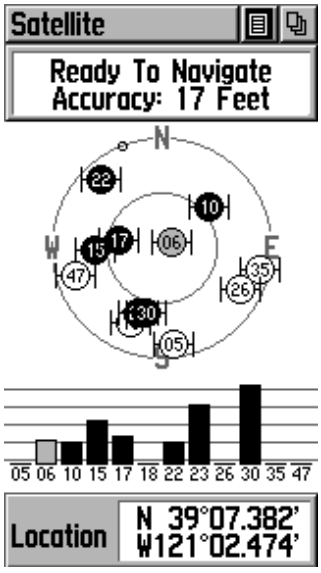


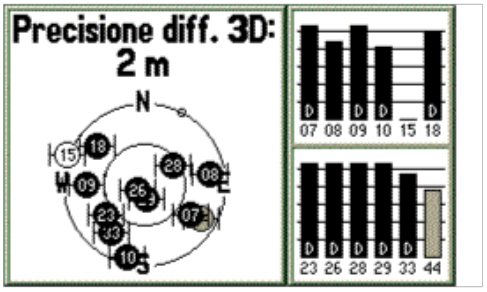
*Honolulu International Airport (HNL): 21.312783, -157.920877

# WAAS Coverage

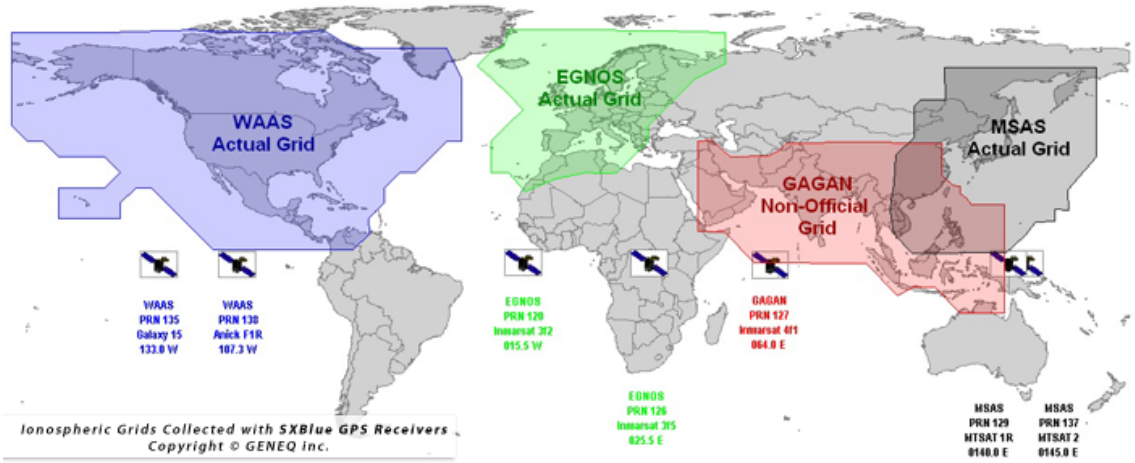



# Garmin GPS Control Panel



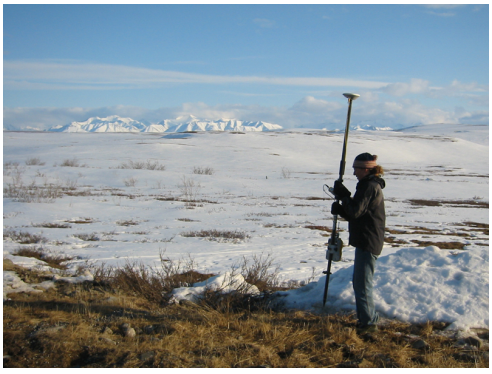



# Satellite-based Augmentation Systems (SBAS)

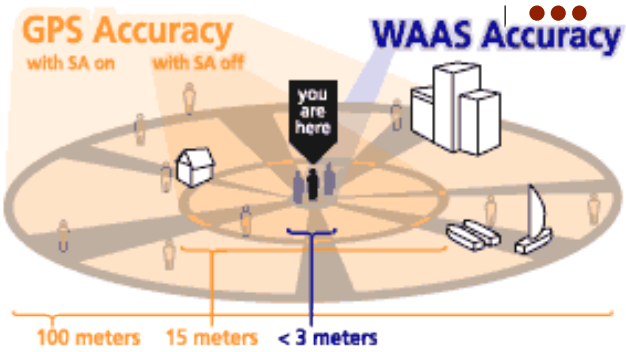



## Mapping- / Survey-grade GPS





# Summary of GPS Accuracy




| | |
|---|---|
| 150 m | The original GPS system under the Selective Availability (SA) program |
| 15 m | Typical GPS positional accuracy without SA |
| 4-6 m | Typical differential GPS (DGPS) positional accuracy |
| 3-5 m | Typical WAAS positional accuracy |
| < 1 m | “Mapping-grade” GPS units |
| ~ cm | “Survey-grade” GPS units |