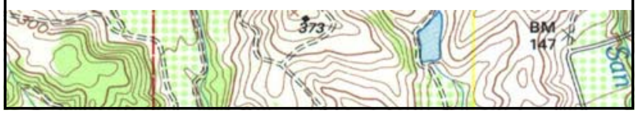
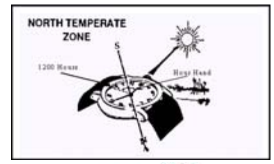
Geography 12: Maps and Spatial Reasoning

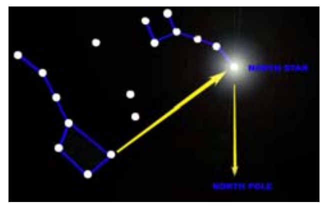
Lecture 10:
Position Determination

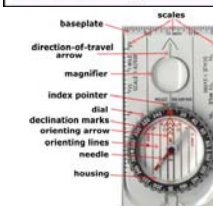
Professor Keith Clarke



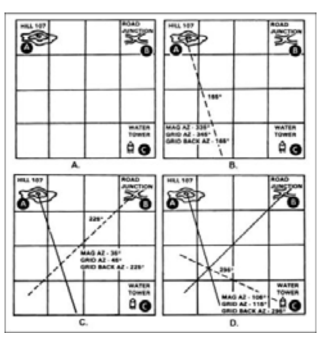
We can measure direction in the real world!





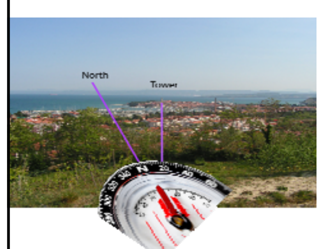


Resection



Back azimuth
Forward bearing + or - 180

Resection Example: Isola, Slovenia



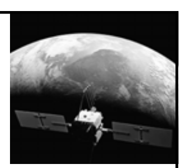
Best way to determine position: Use GPS

- GPS is a Satellite-based Navigation System (GNSS)
- Funded by and controlled by the U. S. Department of Defense (DOD)
- Designed for military tasks: Dual Use
- Operational since August 30th, 1991

One of five such GNSSs

- GPS Blocks I and II
- GLONASS
  - Russian positioning system
- Galileo
  - Proposed EU system, in design
- Compass
  - Chinese system, under development
  - Regional/Global
- Indian **IRNSS**
  - Regional
- GPS 2.0 Block IIR

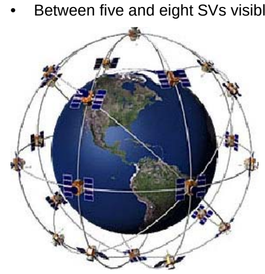
Space Segment I

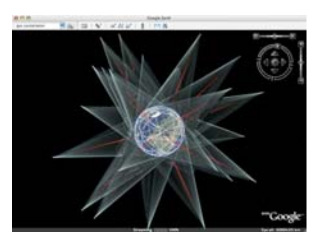


- Space vehicles (SVs) send radio signals from space
- The signals contain the time from on-board atomic clocks
- The nominal GPS Operational Constellation consists of 24 satellites that orbit the earth in 12 hours
- Often more than 24 operational satellites as new ones are launched to replace older satellites

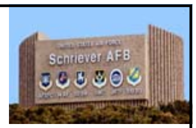
The Space Segment II

- The orbits repeat the same track and configuration over any point approximately each 24 hours
- There are six orbital planes (four SVs in each), equally spaced (60 degrees apart), and inclined at about fifty-five degrees to the equatorial plane
- Between five and eight SVs visible from any point on the earth





Control Segment

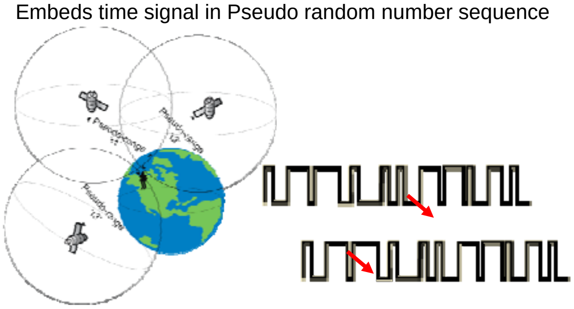


- World wide tracking network
- Master Control facility is located at Schriever Air Force Base in Colorado
- The models compute precise orbital data (ephemeris) and SV clock corrections for each satellite, uploaded to satellites
- The SVs then send ephemeris data to GPS receivers over radio signals

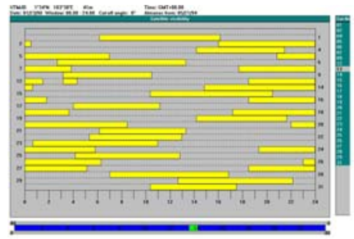
Monitoring network

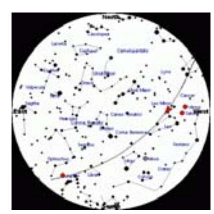
How it works: Trilateration

- Four satellites are required to compute the four dimensions of X, Y, Z (position) and Time
- Embeds time signal in Pseudo random number sequence



SV "visibility"





GPS doesn't work…

- Indoors
- Underground
- Under water (unless…)
- When satellites horizon is obscured

GPS trace (GPS MotionX on iPhone)

GPS errors :

A combination of noise, bias, blunders

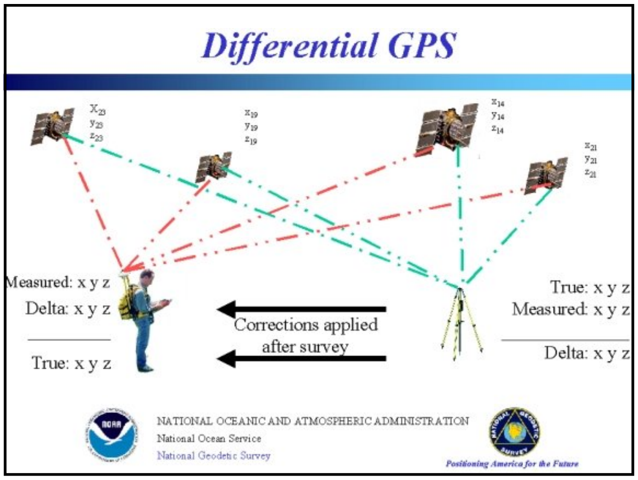
- PRN noise (1 m) and receiver noise (1 m)
- Bias errors result from Selective Availability and other factors : 30-100m
- SV clock errors uncorrected by Control Segment:1m
- Ephemeris data errors: 1 m
- Tropospheric delays: 1 m
- Unmodeled ionosphere delays: 10 m

Multi-path Error

GDOP Components

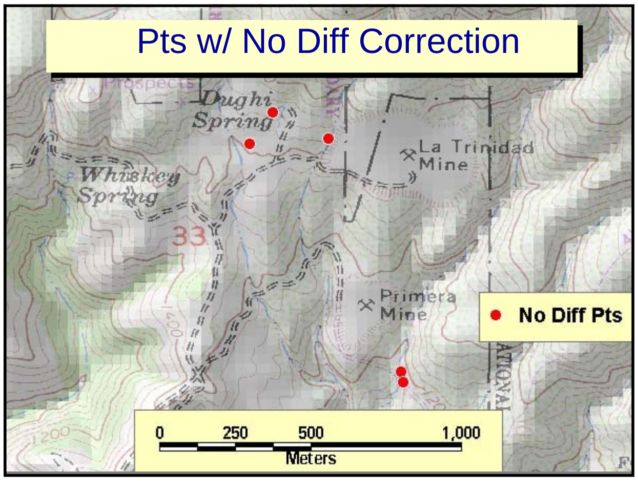
- PDOP
  - Position Dilution of Precision (3-D), sometimes the Spherical DOP
- HDOP
  - Horizontal Dilution of Precision (Latitude, Longitude).
- VDOP
  - Vertical Dilution of Precision (Height)
- TDOP
  - Time Dilution of Precision (Time)

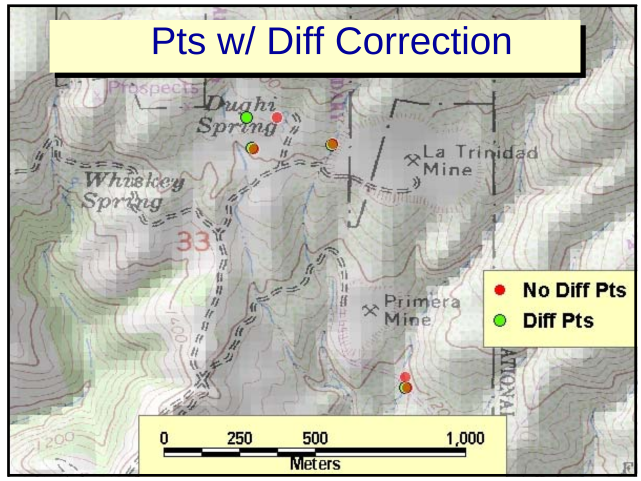
Wide Area Augmentation System



DGPS Characteristics

- DGPS removes common-mode errors, those errors common to reference and remote receivers
- Errors are more common when receivers are close together (less than 100 km).
- Differential position accuracies of 1-10 meters are possible
- Special software is required to process carrier-phase differential measurements


Pts w/ No Diff Correction
Prospects
Dughi Spring
Whiskey Spring
La Trinidad Mine
33
Primera Mine
No Diff Pts
0
250
500
1,000
Meters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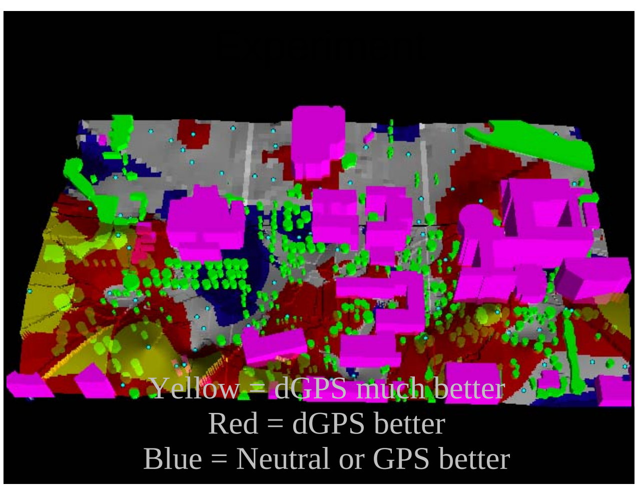
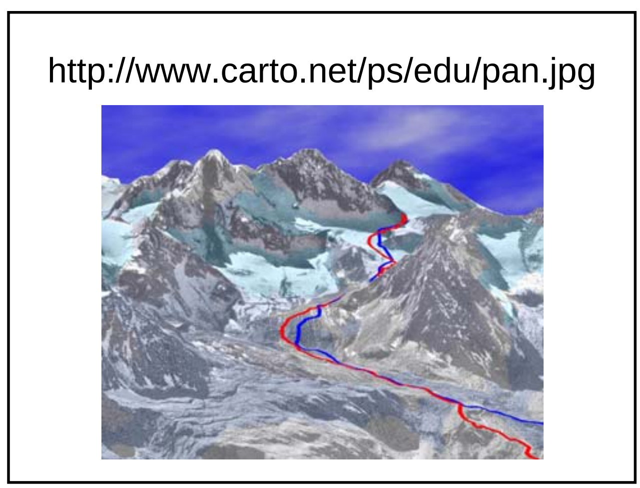

Yellow = dGPS much better
Red = dGPS better
Blue = Neutral or GPS better


http://www.carto.net/ps/edu/pan.jpg

Personal GPS

- A major breakthrough came when GPS started to being integrated in portable gadgets that could be used for personal navigation
- Some Gadgets which have GPS in them
  - Watches
  - PDAs
  - Laptops Computers
  - Cell Phones

Most common application: IVNS

Mobile phones

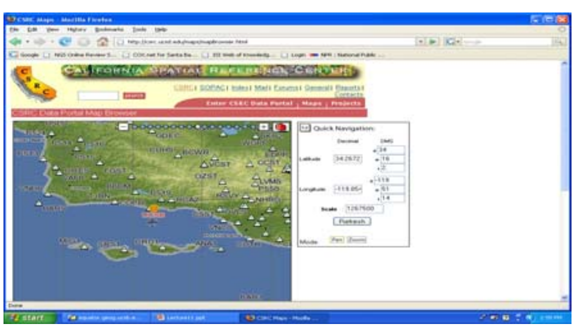
Mobile devices

Carrier Phase Tracking (Surveying)

- Carrier-phase tracking of GPS signals has resulted in a revolution in land surveying.
- A line of sight along the ground is no longer necessary for precise positioning.
- Positions can be measured up to 30 km from reference point without intermediate points.
- This use of GPS requires specially equipped carrier tracking receivers, not instantaneous
- L1 carrier wavelength is 19 centimeters
- System detects leading edge of wave, adds partial distance
- Carrier signals relative accuracies of millimeters under special circumstances

GPS control stations for positioning

California CORS stations



GPS Logging at UCSB

Summary

- There are many ways to approximate position in the field, e.g. map and compass resection
- GPS is a GNSS (one of several)
- Works under specific circumstances
- GPS receivers capable of 30m accuracy
- Using differential, about 1-10m depending on PDOP
- With WAIS about 1-7m common
- With carrier phase: millimeters