

Global Navigation Satellite Systems

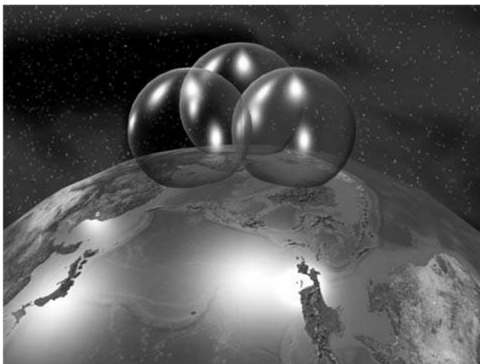
GPS GLONASS Galileo
BeiDou II (COMPASS) ?

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How Does a GNSS Work?

- Based on principle of triangulation
 - Also called satellite ranging
- Signal travels at constant speed (3.0×10^8 m/s)
- Distance from each satellite to receiver is calculated based on travel time ($d = s \times t$)
- Exact location of each satellite is known
- So, your position is located at the point of intersection between overlapping spheres around each satellite

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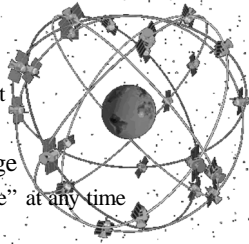
What is a GNSS Made up of?

- Satellite-based positioning and navigation system made up of:
 1. Space Segment
 - A constellation of satellites
 2. Ground Segment
 - Network of ground control/monitoring stations
 3. User Segment
 - You and your relatively inexpensive receiver

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Space Segment

- Constellation of 24 satellites
- Six orbital planes
 - 55° inclination
 - four SVs in each 60° apart
 - 20,200 km altitude
- Provides optimal coverage
 - Normally 5-8 SVs “visible” at any time

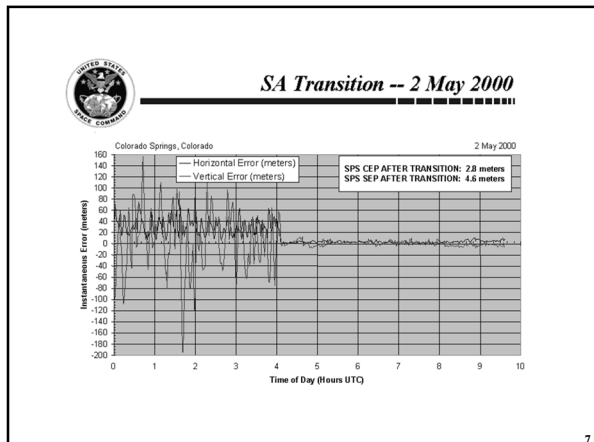


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Space Segment

- Continually broadcasts two carrier signals
 - L1 (1575.42 MHz) signal transmits:
 - C/A (Course Acquisition) code (civilian)
 - Encrypted P(Y) (Precise) code (restricted access)
 - Navigation Message (uploaded from ground control stations)
 - SV ephemeris (orbital characteristics)
 - Clock errors that are updated every few hours
 - Almanac - orbital characteristics of SV's, good for a few months
 - Provides sub-metre level accuracy under ideal circumstances
 - L2 (1,227.60 MHz) carrier signal:
 - Encrypted P(Y) (Precise) code (restricted access)
 - Used to measure ionospheric/tropospheric delay; dual frequency
 - Atmospheric attenuation model used to post-process data
 - Provides decimetre level accuracy under ideal circumstances

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Control Segment

- Network of ground control stations that monitor/track orbital characteristics of SVs
- Relay corrected ephemeris, clock and almanac (course position) back to SV
- Four unmanned stations and master control station

The slide illustrates the GPS Control Segment. It includes a map of the United States and the Pacific region with several ground control stations marked: Falcon AFB, Colorado Springs, Hawaii, Ascension Island, Diego Garcia, and Kwajalein. A photograph of a large white spherical structure, a GPS ground control station, is shown on the right. The number '8' is in the bottom right corner.

User Segment

- Consists of you and your GPS receiver and possibly:
 - A fancy data logger ?
 - A base station (dGPS) ?
 - Carrier Phase Antenna?

The slide describes the User Segment. It features three images: three different types of GPS receivers at the top, a small GPS data logger device in the middle, and a person standing in a field with a GPS antenna mounted on a tripod. The number '9' is in the bottom right corner.

Sources of Error

- Clock error
- Orbital errors
- Multi-path error
- Satellite geometry
- Satellite visibility/signal strength
- Ionospheric and Tropospheric delay

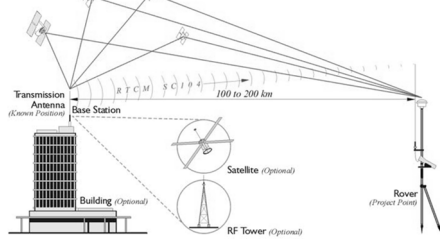
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dGPS (differentially corrected)

Differential GPS/dGPS

Position Accuracy: 10 - 1 meter or so

- Same Satellite Constellation (Base Station - Rover or Rover)
- Code Phase/Pseudorange (Track 4 Satellites Minimum)
- Radio Link (a) Less information than RTK; (b) Slower transmission; (c) Real-time or post-processed results

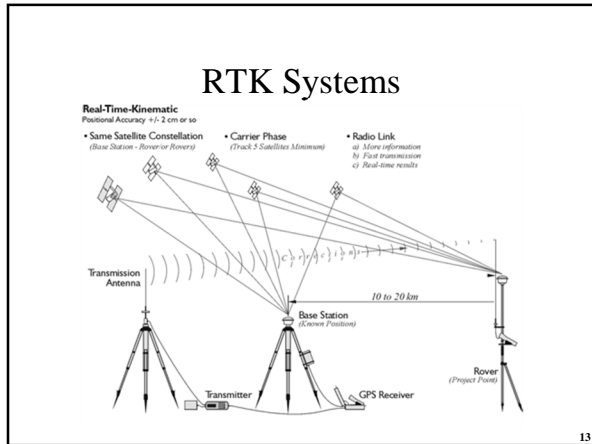


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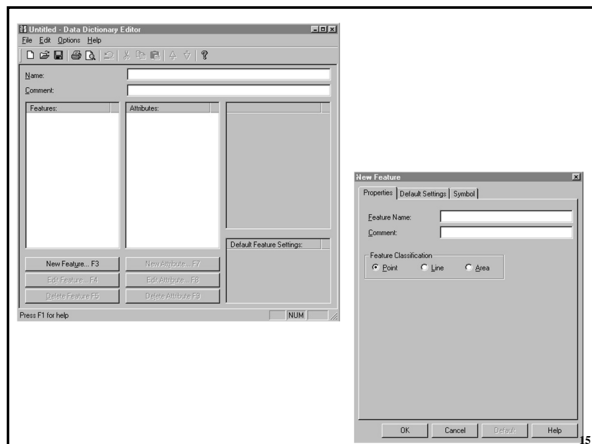
Dual Frequency Receivers

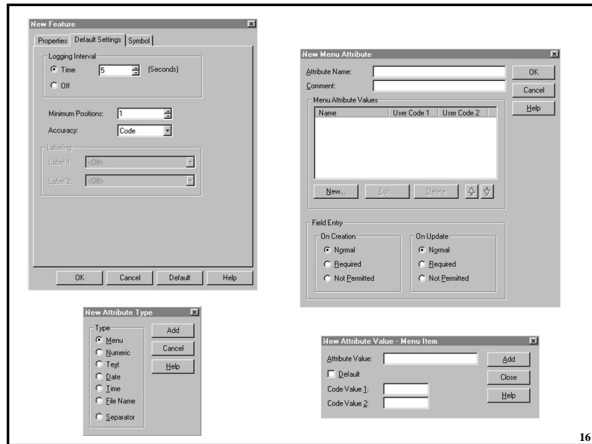
- L1 and L2 carrier signals are diff freq.
- Move through atmosphere more/less easily
- Difference in arrival time used to construct atmospheric attenuation model

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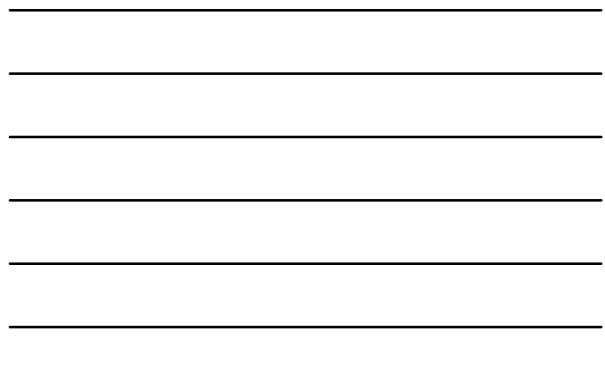
- ### GPS Survey Guide
- Determine exactly what data are going to be collected
 - Determine how features will be collected (points, line, or polygons)
 - Determine what attributes will be measured/assessed and how
 - Develop a data dictionary or similar template if appropriate
 - Determine optimum date/time for data collection
 - Check NANUs for planned outages, and constellation status
 - Check tropospheric weather advisories and forecasts
 - Check space weather advisories and long-term forecasts
 - Proper clothing, bug spray, sunscreen, food, water, first aid kit, cell phone, TP and a shovel
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ALMANAC FOR SATELLITE 1 :

- PRN number for data 1
- Health of SV 0
- Reference Week of Almanac 797
- Eccentricity 0.00346661
- Corr: inclination angle (rad) ... 0.00388718
- Mean Anomaly @ ref time (rad) ... 2.79387
- Argument of Perigee (rad) -1.31888
- Rate right ascension (rad/sec) .. -8.01176E-09
- Right ascension @ ref time (rad) -0.296182
- Sqrt semi-major axis (m^{1/2}) 5153.58
- Clock correction term 1 0.000148773
- Clock correction term 2 7.63976E-11
- Reference time almanac 466944
- Semi-Major Axis (meters) 2.65594E+07
- Corrected Mean Motion (rad/sec) . 0.000145862
- Inclination angle (rad) 0.95469



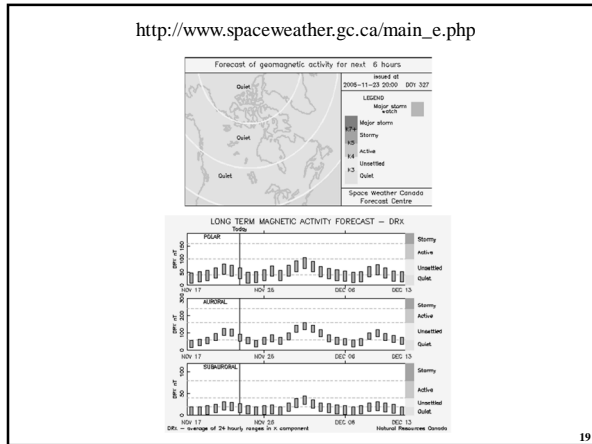
EPHEMERIS FOR SATELLITE 2 :

- PRN number for data 2
- Issue of ephemeris data 224
- Semi-Major Axis (meters) 2.65603E+07
- C(i) (rad) 1.88127E-07
- C(o) (rad) -1.00583E-07
- C(r) (meters) 321.656
- C(r) (meters) 87.6875
- C(u) (rad) 4.36418E-06
- C(u) (rad) 2.70829E-06
- Mean motion difference (rad/sec) ... 5.04521E-09
- Eccentricity (dimensionless) 0.0139305
- Rate of inclination angle (rad/sec) .. 4.11089E-10
- Inclination angle @ ref. time (rad) . 0.950462
- Mean Anomaly at reference time (rad) . -2.62555
- Corrected Mean Motion (rad/sec) ... 0.000145859
- Computed Mean Motion (rad/sec) ... 0.000145854
- Argument of perigee (rad) -2.56865
- Rate of right ascension (rad/sec) ... -8.43857E-09
- Right ascension @ ref time (rad) ... 1.75048
- Sqrt (1 - e²) 0.999903
- Sqr root semi-major axis, (m^{1/2}) ... 5153.67
- Reference time ephemeris (sec) 240704

CLOCK FOR SATELLITE 2 :

- PRN number for data 2
- Week number 797
- Predicted user range accuracy 32
- Health of satellite 0
- L1 - L2 Correction term 9.31323E-10
- Issue of clock data 224
- Time of clock data 240704
- Clock offset -0.000158074
- Clock drift -2.50111E-12
- Rate of clock drift 0





Base Station and Rover Setup

- Base Options
 - Logging interval
 - Position Mode
- Masks: set lenient
 - PDOP (Max. 5.0)
 - SNR (Min. 6)
 - Elevation (Min 5)
- Rover Options
 - Logging Intervals
 - Position Mode
 - Carrier On/ Min. Time
- Masks: set strict
 - PDOP (Max. 3.0)
 - SNR (Min. 8)
 - Elevation (Min 10)
 - PDOP Switch
