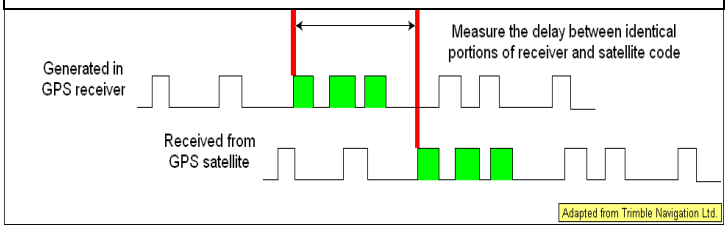
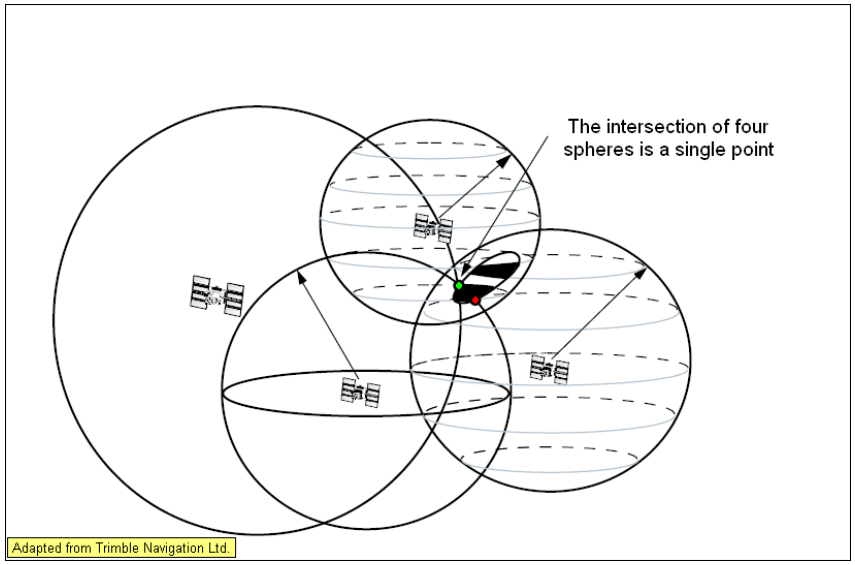
GPS How it Works

- 24 or more GPS Satellites orbit the earth every 12 hours
- Each satellite transmits
    - PRN Code-

GPS receivers examine incoming code from each satellite and calculate how long ago the receiver generated that same bit of code. The observed time difference is applied to the speed of radio waves to establish the receiver's distance from each satellite.



    - Ephermeris data-Satellite orbital information
    - Atmospheric data- Helps GPS account for signal delay due to atmosphere
    - Clock Information- Defines exact time of satellite transmission
    - An Almanac- Schedule of satellite positions
- Satellite Trilateration



Accuracy and Error

Source of Error	Amount of Error
• **Selective Availability**	**Currently set to zero**
• **Satellite clock errors**	**1.5 to 3.6 meters**
• **Orbital errors**	**Less than 1 meter**
• **Ionosphere**	**5.0 to 7.0 meters**
• **Troposphere**	**0.5 to 0.7 meters**
• **Receiver noise**	**0.3 to 1.5 meters**
• **Multi-path**	**0.6 to 1.2 meters**
• **Sky obstructions**	**Depends on amount**
• **User mistakes**	**Depends on the error**
• **Control mistakes**	**Depends on the error**

All errors are cumulative!

Selective Availability was an intentional degradation of GPS signals by the Department of Defense prior to May, 2000. Currently, Selective Availability has been suspended, and is set to zero.

Satellite clock errors are caused by slight discrepancies in each satellite's atomic clocks. Errors are monitored and corrected by the Master Control Station.

Orbital errors pertain to the altitude, position, trajectory, and speed of satellites. Orbits may fluctuate due to gravitational pull and solar pressure. Orbital errors are also monitored and corrected by the Master Control Station.

Ionospheric interference occurs when GPS signals slow down and scatter as they pass through the ionosphere. GPS signals contain information to help correct about half of the interference.

Tropospheric interference is caused mostly by water vapor and, to a lesser extent, temperature and pressure changes in the lower layer of Earth's atmosphere.

Receiver noise is the electromagnetic field generated by a receiver's internal electronics. Electromagnetic fields can distort radio waves, and affect the travel time of GPS signals just before they can be processed by the receiver. External antennas may help alleviate receiver noise, but can't compensate for other electromagnetic fields associated with power lines, generators, two-way radios, and so on.

Multi-path interference is caused by GPS signals reflecting off surfaces near the GPS receiver that can either interfere with, or be mistaken for, the "true" signal that follows a straight-line path from a satellite. Common sources of multi-path include rock outcroppings, vehicles, and buildings.

Sky obstructions include vegetation, terrain, buildings, your body, or anything that blocks a receiver's view of the sky. In severe cases, a GPS receiver may not even be able to "see" enough satellites to calculate a position. In less severe cases, a GPS receiver may

have to use a less than optimal combination of satellites, resulting in less precise positions.

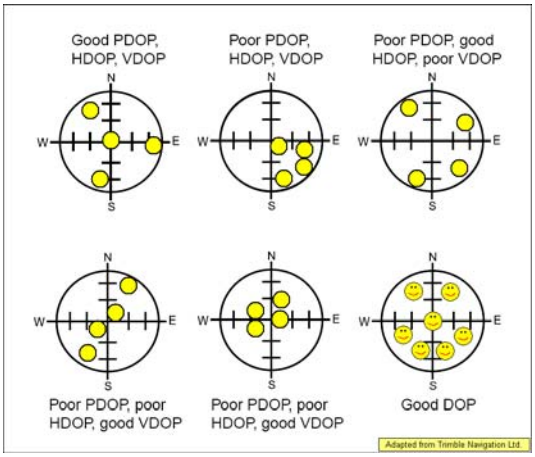
User mistakes include incorrect datum or transcription errors during manual coordinate entry, relying on 2-D positions instead of 3-D positions, or holding a GPS receiver too close to the body.

Control segment mistakes arising from human or computer error could occur, but are unlikely.

GPS errors are cumulative, and are compounded when the shifting arrangement of satellites creates poor DOP conditions. DOP concepts will be covered next.

Satellite Geometry and DOP

- Satellite geometry (arrangement) can affect the precision with which receivers calculate positions.
- Dilution of Precision (DOP) is an index of how well satellites in a receiver's working constellation are distributed across the visible sky, and the effect of that distribution on the quality of calculated positions.
- There are five kinds of DOP.
- Position Dilution of Precision (PDOP) is the value most commonly used by GPS practitioners to determine the overall quality of data collected by receivers.
- GPS receivers automatically select the combination of satellites that provide the best (lowest) DOP.
- Advanced GPS receivers can suspend data collection when poor DOP conditions occur.

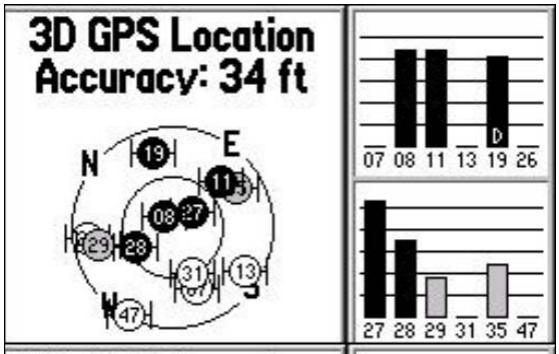


BOTTOM LINE-Accurate enough for everything, but legal locations. Averaged points can easily get with 15m and close at 2m with good PDOP and low error and WASS. Sub-meter accuracy has been reported using similar GPS Units.

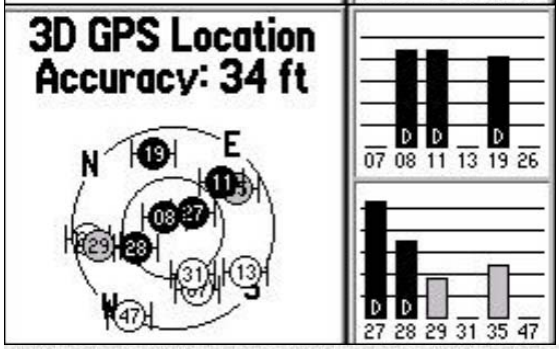
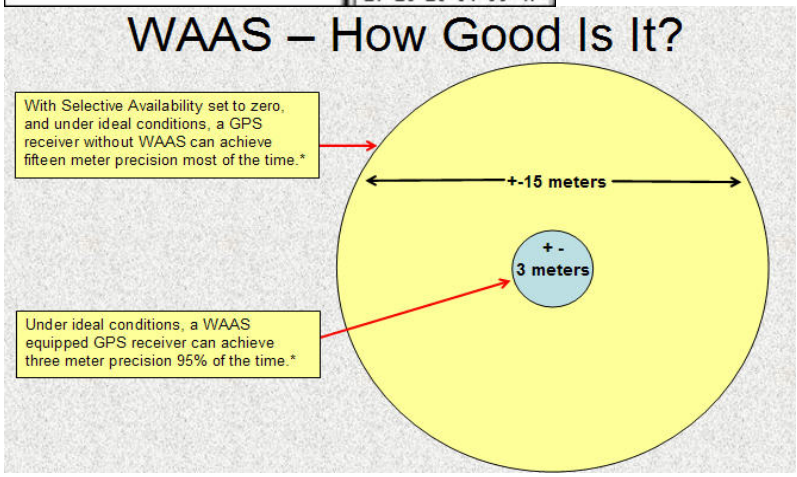
WASS- Wide Area Augmentation System

The Wide Area Augmentation System (WAAS) is designed to enhance GPS positioning over the United States, as well as portions of Mexico and Canada. There are 25 Wide Area Reference Stations positioned across the United States (including three in southern Alaska, and one each in Puerto Rico and Hawaii) that monitor GPS satellite signals. These stations continuously receive and calculate GPS satellite timing corrections. Each reference station then transmits those timing corrections to one of two WAAS Control Stations located on the Pacific and Atlantic coasts of the U.S. The control stations, in turn, transmit timing corrections to two geosynchronous WAAS satellites for re-broadcast to GPS receivers in the field.

WAAS is available to any GPS receiver capable of receiving the WAAS signal. WAAS limitations include signal blockage by vegetation and terrain, poor coverage over portions of the northern U.S., and very slow signal acquisition time.



WAAS should **NOT** be enabled if receipt of the correction message for **EACH** satellite in the working constellation is incomplete, or intermittent.



WAAS **MAY** be enabled if receipt of the correction message for **EACH** satellite in the working constellation is continuous and complete.