Some handy notes about the Global Positioning System

(GPS) and the use of GPS devices.

1.0 Overview: The GPS system is a satellite system used for navigation and enables anyone with a GPS receiver to know where they are. Around the globe the GPS system launched by the US military consists of between 24 and 29 satellites that circle the Earth. Eighteen satellites are typically the number used for worldwide coverage. These satellites beam radio signals from their positions to the surface of our planet. Each satellite sends it own unique code which then in turn are then received by the GPS receiver that sees these signals and then calculates the receiver's position from that particular satellite. Satellites send different details: an almanac, then a PC "Precision Code" used by the military and then a "Coarse Acquisition" code called CA for civilians. In the United States, increased accuracy of the read signals by the unit is made available by the introduction of land based systems that also transmit data, called Wide Area Augmentation System. (WAAS). This has increased the accuracy of readings from approximately 15-20 m down to 3-9 m.

In actual operation, when a GPS device is turned on, the GPS receiver uses the radio signals of all the satellites, even if the satellite is on the other side of the world. Then the unit receives the almanac (details of all satellites), then the exact time. Almanac data is stored in the GPS unit's information and it takes about 12.5 minutes for the satellite to transfer this data to the receiver. In regular use, four overhead satellites must be detected or seen by the GPS receiver: one for time (based on an atomic clock), the other three their individual codes. A calculation is made by the GPS device between when a code was sent and when it was received and the time it took for the signal to arrive at the GPS receiver. As the speed of transmission is known, (more on this later) the GPS receiver then uses the 3 satellites with what we call a 3D lock to then calculate the three dimensional position of the receiver (User), namely: latitude, longitude and altitude of the person.

2.0 About Accuracy: As mentioned previously, GPS while supported and used by causal users, public safety agencies as well as the military, there are issues with GPS and variances in signal reception due to many factors not controllable by the user, such as:

-Ionospheric interference

-reflected or multipath signals

-satellite geometry

Ionosphere interference sees signals received from the satellite slowed down .The receiver cannot determine the change in speed as it is typically a fixed setting, accuracy may change upwards of 10 m.

Reflected or multipath signals are just that where sometime signals from the satellite do not reach the receiver directly, rather multiple signals are received from the same satellite arriving at different times due to the signal being reflected from objects, buildings, etc nearby. In this case the signal arrives to the receiver in more than one path. Most GPS receivers do no account for this error.

Satellite Geometry: (also known as satellite constellation) refers to satellites and their position on the sky that are relative to your position. For best accuracy the best geometry is one satellite directly overhead and three other satellites evenly spaced around the horizon. This obviously may not always happen. The amount of error introduced by this error of geometry is called the dilution of precision. Several GPS receiving units how the PDOP Position of Dilution of Precision Number (PDOP). In the Infinity GPSA microphone, this appears on the bottom of the unit's main screen. Poor geometry due to users position and not being able to see the best satellite for the best PDOP calculation may occur, causing hundreds of meters of error. In the screen and if you see PDOP numbers of between 1 and 3, this provides aprox a 15 m accuracy while values between 4 and 6 may cause inaccuracies of 20-100 m. Move around or wait a few minutes as the constellations change as the earth is in motion. If a user is close to a building or side of a mountain, satellites may be masked and may affect accuracy.

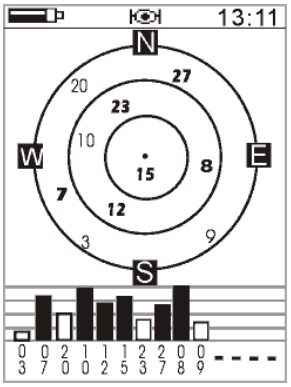
3.0 USE OF ELECTRONIC COMPASS

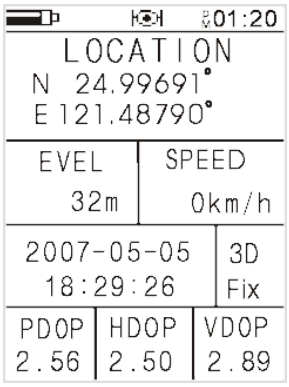
The use of an electronic compass in a GPS device is not like using a standard compass, do not rely on the compass in the GPS unit for your traditional tracking requirements. This is mentioned as the electronic compass in the GPS unit reports your direction of travel by calculating the direction between your current position and where you were seconds ago. If you stop, the receiver may no longer calculate your direction of travel. The unit will calculate once again your direction of travel if you start to move

again. If you stand and slowly move and turn around in a circle after you have stopped moving, the compass will not change because you have not moved far enough for the receiver to calculate a direction.

4.0 HOW THIS APPLIES TO THE GPS SPEAKER MICROPHONE

The Infinity GPS unit is a computerized handheld unit that scans the open skies looking for 14 GPS satellites overhead. The unit "listens" to these orbiting satellites and eliminates the weakest satellite signals. Four satellites are needed for a 3D full lock as described earlier. From this point the unit computes the location of the receiver based in the relationship to the satellites being received. The unit them computes the user's longitude and latitude which is updated every second, computing direction of travel, speed and altitude and shown on one main screen.





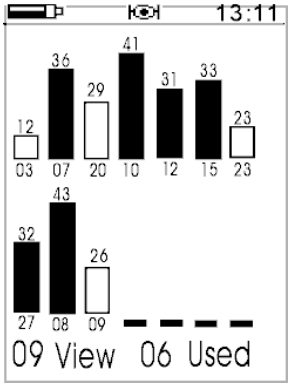


Figure 1 **Figure 2** **Figure 3**

As explained earlier, a GPS unit locates all satellites in the constellation. Upon GPS cold start, the Infinity GPS unit in the Satellite Utility Screen shows the location and number of the satellites seem, as well as their relative signal strength as shown in Figures 1 and 2 above. Figure 2 shows the user screen that shows user location, status of the receiver (3D lock, 2 D lock, or no lock), as well as PDOP values to the user.

Stored in the non volatile solid state on-board memory of the unit is the information from each update. This recording also consists of one setting waypoints, event marker points and icons, trails and routes as well as when asked, a relationship between the user and field units.

As mentioned previously understand of the PDOP allows one to relate to the overall accuracy of the information being given. In the USA and to augment accuracy, the WAAS (Wide Area Augmentation System) increases GPS performance increasing GPS accuracy. In other countries accuracy of all GPS units are affected if there is no WAAS transmitter. Having said this, and even in the case of remote areas in the USA that do not receive WAAS signals, the GPS unit will operate normally using the GPS receive only portion of the satellite signal, providing the lesser accuracy.

Referring to the VDOP mentioned earlier, the Infinity GPS device also shows VDOP Vertical Dilution of Precision) and HDOP (Horizontal Dilution of Precision). Most GPS units do not show these. A low value of the Vertical and horizontal element of the DOP calculation made by the unit means that the receiver has made a more accurate position calculation over a higher value which shows more error in the position calculation. The lower the number, just as with PDOP, the better. Good values are between 1 and 3.

Interesting to note: If one was to remain motionless and stay in the same position for several hours or days and not move, and one then writes down the position on a paper of the location's reading as shown in Lat and Long, it would seem that the user would be moving even when the user did not. This si because of the fact that the receiver reported different positions such as the factors previously described: ionospheric changes, satellite geometry, and multipath signals. Accuracy in the GPS readings and position given is measured as a percentage on how close the receiver will get you to the center of the circle that you have just charted if you were stationary 95% of the time. End result is where even without the WAAS enabled signals which is not available outside of the United States, a GPS system makes navigation still quite useful and useable as well as accurate within the PDOP calculation shown on the receiver's display.

4.0 WARNINGS about using GPS:

While a GPS receiver is a useful tool always use another method of navigation such a map and chart and compass. Never rely solely on a GPS unit. When setting a course to a person or waypoint, the unit will always show the navigation information with the shortest line from your current location to a selected waypoint, regardless of terrain or obstructions. As a result, the system will not alert you to dangers or obstructions. As mentioned with higher PDOP numbers, accuracy becomes a factor. Moving around or waiting for the satellite constellation to change and thereby providing you with a visible calculation of the PDOP and lower number increases accuracy. Users should be aware of how GPS operates and should be responsible for safe navigation.

Many thanks to the following resources:

Global Positioning Theory and Practice, 5th rev.ed. B Hoffman-Wellenhof et al., Springer-Verlag 2002

Basic Essentials Using GPS, 2nd (Basic Essentials Series) (Paperback), Brice Grubbs

GPS for Dummies, (series) Joel McNamara