Local Area DGPS

Localized DGPS has not been eliminated by WAAS. The U.S. Coast Guard operates over 60 DGPS sites along U.S. coasts, the Great Lakes, Puerto Rico, parts of Alaska and Hawaii. The organization is also developing a ground-based system to provide coverage across the entire continental U.S.

The Coast Guard system requires the user to purchase an antenna and a DGPS unit in addition to a DGPS enabled receiver. Most outdoor users will not be interested in the Coast Guard system because WAAS is more convenient; however, other countries like Norway, Sweden, Finland and the Netherlands have established DGPS sites comparible to the U.S. system. If you travel the oceans, you may want to buy the equipment necessary to receive DGPS RTCM transmissions because DGPS may be available in a country where WAAS is not available.

The U.S. Federal Aviation Administration is developing a system for aircraft landings at small- and medium-sized airports called the Local Area Augmentation System (LAAS). It operates on an area within a 20-30 mile radius, broadcasting a correction message via a VHF radio data link from a ground-based transmitter. LAAS has a demonstrated accuracy of less than 1 meter in both the horizontal and vertical axis which will provide the neccessary accuracy for Category I, II, and III precision approaches.

One fascinating application of DGPS equipment is to track the movements of hydrological dams. You might question the need of tracking the movements of a dam that holds back a lake of water. You might think that visual inspection could settle the question as to the dam's location and that proper operation will brevent a dam from collapsing. All those observations are correct, but still, highly accurate DGPS makes it possible to track the movement of a dam down to a few millimeters. As the lake fills with water, the DGPS equipment can report how much the dam has flexed and allows the operators to keep the water levels and the fill rate below the failure point of the dam.

17 Degrees, Minutes, Seconds and Mils

The circle is an important part of navigation because once the circle on the compass is oriented correctly, you can orient yourself and travel in the right direction. How the circle is subdivided into degrees, minutes, seconds and mils is described below. How to do arithmetic using these units is also demonstrated.

Relating Degrees, Minutes and Seconds to Each Other

In order to understand latitude/longitude or bearings, you need to understand how degrees, minutes, seconds and mils are related. The equator wraps around the entire earth and forms a circle that is the basis of degrees, minutes, seconds and mils. If you want to talk about only part of the circle, it must be subdivided. The most common subdivision of a circle is called the degree. The unit of mils is another way to subdivide the circle, but it will be discussed after degrees, minutes and seconds are explained. There are 360° in a circle. A part of a circle can be expressed as degrees. A half circle is 180°, a quarter is 90°, and so forth.

The degree is subdivided into minutes. There are 60' (the single tick mark is the symbol for minutes) in a degree. Minutes are also subdivided into seconds and following a familiar pattern, there are 60" (the symbol for seconds is two tick marks) in a minute. The relationships between degrees, minutes and seconds are as follows:

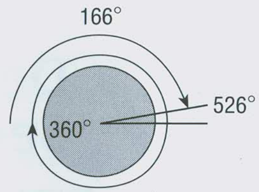
1 full circle = 360°
1° = 60' = 3,600"
1' = 60"

When adding degrees, remember to wrap around from 359° to 0° and when subtracting, 0° is followed by 359°. It is possible to have more than 360°, but it just means you have turned full circle and then some more. For example, 526° is simply a full circle of 360° plus an additional 166° as shown in the figure on the next page.

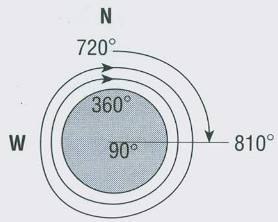
When a bearing is greater than 360°, simply subtract 360 until the result is less than 360° and that is the direction you should go. For example, if you are told to walk a bearing of 810°, you would do the following math:

810° - 360° = 450°

450° - 360° = 90°



The result shows that the bearing 810° is really just 90°, which is due east as shown in the figure opposite.



Adding and Subtracting Minutes and Seconds

When working with minutes and seconds, the value wraps from 59 to 0 and 0 to 59 when adding and subtracting respectively, but in these cases, either the degrees or minutes is also affected, so you have to keep track of them. Here are a few examples:

45" + 20" = 65" = 60" + 5" = 1' 5"
23' + 58' = 81' = 60' + 21' = 1° 21'
5' 19" – 20" = 4' (60" + 19") – 20" = 4' 79" – 20" = 4' 59"
56° 25' – 47' = 55° (60' + 25') – 47' = 55° 85' – 47' = 55° 38'

82° 45' 23" – 56' 43"
= 82° 44' (60" + 23") - 56' 43"
= 82° 44' 83" – 56' 43"
= 81° (60' + 44') 83" – 56' 43"
= 81° 104' 83" – 56' 43"
= 81° (104' – 56') (83" – 43")
= 81° 48' 40"

Adding/Subtracting Degrees and Minutes

The same care with minutes must be taken when the format is degrees and minutes as demonstrated in the examples below:

219° 19.42' + 36.81'
= 219° (19.42' + 36.81')
= 219° 56.23'

61° 27.46' – 53.41'
= 60° (60' + 27.46') – 53.41'
= 60° 87.46' – 53.41'
= 60° 34.05'

The use of degrees only eliminates all the work required to keep track of minutes and seconds, but you still need to remember there are 360° in a circle.

46.492° - 21.613° = 24.879°

105.386° - 283.426°
= (360° + 105.386°) - 283.426°
= 465.386° - 283.426°
= 181.96°

315.395° + 284.305° = 599.7°
= 599.7° - 360°
= 239.7°

Converting Degrees to Degrees and Minutes

Another requirement to become proficient is the ability to convert from degrees to degrees and minutes. The transformation is done as follows.

57.146° = 57° (0.146 x 60')
= 57° 8.76'

357.963° = 357° (0.963 x 60')
= 357° 57.78'

Converting Degrees to Degrees, Minutes and Seconds

Conversion from degrees to degrees, minutes and seconds is similar to the above translation with one additional step.

295.248° = 295° (0.248 x 60')
= 295° 14.88'
= 295° 14' (0.88 x 60")
= 295° 14' 52.8"

136.389° = 136° (0.389 x 60')
= 136° 23.34'
= 136° 23' (0.34 x 60")
= 136° 23' 20.4"

Converting Seconds to Minutes

The conversion of degrees, minutes and seconds to degrees and minutes is also important. Seconds are converted to minutes by multiplying by 1'/60". Remember from above that 1' is equal to 60", so the term 1'/60" is really just equal to one. This means you are multiplying the seconds by a number with a value of 1, so its value does not change, but it allows the units to convert from seconds to minutes. The example below explicitly shows the number's units.

$$39'' \times [1'/60''] = \frac{39'' \times 1'}{60''}$$

The seconds unit of the 39" on top cancel out with the seconds unit of the 60" on the bottom. The equation becomes:

$\frac{39 \times 1'}{60}$ The final value becomes $\frac{39}{60} \times 1' = (0.65) \times 1' = 0.65'$

The examples below demonstrate conversion from degrees, minutes and seconds to degrees and minutes. The units are not explicitly shown, but just remember that when seconds are divided by 60, they become minutes.

105° 47' 51" = 105° (47 + [51/60])'
= 105° (47 + 0.85)'
= 105° 47.85'
326° 9' 32.4" = 326° (9 + [32.4/60])'
= 326° (9 + 0.54)'
= 326° 9.54'

Converting Minutes to Degrees

The conversion from degrees and minutes to degrees requires minutes to be converted to degrees. Minutes are converted to degrees by multiplying by 1°/60'. As with the previous case, 1° is equal to 60', so multiplying by the term 1°/60' does not change the value of the minutes, it simply converts the unit from minutes to degrees. The units are explicitly shown below:

$$46' \times [1°/60'] = \frac{46' \times 1°}{60'}$$

The minutes unit of the 46' on top cancel out with the minutes unit of the 60' on the bottom and the equation becomes:

$\frac{46 \times 1°}{60}$ The final value becomes $\frac{46}{60} \times 1° = (0.767) \times 1° = 0.767°$

The examples below demonstrate conversion from degrees and minutes to degrees. The units are not explicitly shown, but just as it was shown above, when minutes are divided by 60, they become degrees.

261° 36' = (261 + [36/60])°
= (261 + 0.6)°
= 261.6°

57° 41.475' = (57 + [41.475/60])°
= (57 + 0.691)°
= 57.691°

Converting Degrees, Minutes and Seconds to Degrees

Take all the conversion knowledge acquired and convert degrees, minutes and seconds to degrees.

269° 42' 35" = 269° (42 + [35/60])'
= 269° 42.583'
= (269 + [42.583/60])°
= 269.71°

48° 37' 3.4" = 48° (37 + [3.4/60])'
= 48° 37.057'
= (48 + [37.057/60])°
= 48.618°

Finding the Opposite Direction

The opposite direction to any bearing can be found by simply adding or subtracting 180°. Obvious opposites are E at 90° and W at 270°, which have a difference between them of 180°. The other examples shown below reiterate what to do when addition results in a bearing over 360° or less than 0°. Just remember that adding or subtracting 180° provides the same result, so do whichever results in the easiest math.

271° 15' 39" + 180° = (271 + 180)° 15' 39"
= 451° 15' 39"
= (451 - 360)° 15' 39"
= 91° 15' 39"

271° 15' 39" - 180° = (271 - 180)° 15' 39"
= 91° 15' 39"

23° 43' 9" - 180 = (23 - 180)° 43' 9"
= ([23 + 360] - 180)° 43' 9"
= (383 - 180)° 43' 9"
= 203° 43' 9"

23° 43' 9" + 180 = (23 + 180)° 43' 9"
= 203° 43' 9"

How Mils Relate to Degrees

There is more than one way to subdivide a circle. The degrees subdivision is the most common unit on maps, but mils are also used and should be understood. A mil is one sixty-four hundredth (1/6400) of a circle. The mil has the advantage that there are no conversions between units like minutes and seconds and it is also a finer division of the circle as there are only 3600" in a circle. For most navigators, the best use of the mil is to know how the mil relates to the degree. That relationship is listed below:

$$1\,\text{mil} = \frac{360^\circ}{6400} = 0.05625^\circ$$

$$1^\circ = \frac{6400\ \text{mils}}{360} = 17.778\ \text{mils}$$

To convert from degrees to mils, multiply the number of degrees by 17.778. To convert from mils to degrees, multiply the number of mils by 0.05625.

A few examples of equivalent mils and degrees are given below.

0° = 0 mils
90° = 1,600 mils
180° = 3,200 mils
270° = 4,800 mils

Receiver Classes

Dividing a receiver into classes may help you select a receiver that suites your needs. Categorizing receivers is highly subjective; however, sorting receivers into four broad categories provides a general guideline.

Basic Provides current position, stores waypoints, maybe has 1 route, possibly makes a track log, possibly connects to a computer to transfer waypoints. Definitely does not have a base map or support downloadable maps. Good for hiking or other activities on foot where a paper map is the primary means of navigation. Possibly WAAS enabled. Provides few navigational statistics. Garmin Geko 101& GPS 12 XL, Magellan 310.

Mid Range Has at least one route. Keeps a track log. Provides some navigational statistics. Most likely connects to a computer. May have a limited base map, but may not accept downloadable maps. If it does accept downloadable maps, its memory is small can cannot hold much area. Does support an external antenna. Good for pedestrians, can be used in boats or cars where a paper map provides the primary information about the area. WAAS enabled. Brunton Multi-Navigator, Garmin Geko 201, eTrex & Venture, Magellan Sportrak & Sportrak Map.

Upper Range Multiple routes. Has a good base map. Supports downloadable maps, but cannot automatically generate routes. Has more than minimal memory for maps or accepts memory sticks for map storage. Definitely connects to a computer. Provides a full range of navigational statistics. WAAS Enabled. On screen maps can be used as the primary information of an area. Useful in any means of travel. Probably has a electronic barometer, electronic altimeter and an electronic compass. Garmin eTrex Legend & Summit, Lowrance iFinder, Magellan Sportrak Pro

Top Range Everything that an Upper Range model has plus more. More memory, downloadable maps of a larger area, ability to automatically generate a route using its internal or downloaded map information. Possibly a color screen. Garmin eTrex Vista & GPSmap 76S, Magellan Meridian Platinum & Meridian Color.

Also available are:

Automotive GPS Systems Capable of automatic route generation and giving turn-by-turn instructions. Garmin Street Pilot III, Navman iCN-630, Magellan 750 Nav+ & 750 Nav M.

PDA/Pocket PC Receivers (also requires a PDA or Pocket PC and mapping software). Navman, Pharos.