Setting Your GPS Datum and Coordinate System

What It Means And Why It Matters

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When using your GPS receiver have you wondered what is the significance of that "datum" setting? Let's take a look at how the datum and coordinate system settings relate to finding our way from one point to another when we combine a paper map with a GPS unit.

The datum setting in a GPS receiver is a reference which describes the origin and orientation of coordinate systems we use on maps to identify points on the earth's surface. Suppose we look at a paper map (maybe a USGS 7.5 minute topo map) and decide we want to travel to a specific point. We read the map coordinates that describe that point and plug them into the GPS as a waypoint and away we go. But how do we know the GPS is speaking the same language as the map? That is where the datum and coordinate system come in.

If we were going to meet at a trailhead somewhere you could tell me how to get there by giving me exact driving directions from your home. You have exactly described the destination point in relation to your home - your home is the "datum", or point of reference, and the roadways are the coordinate system. But, if you don't live in the same area I do and if I am going to be leaving from my house instead of yours the driving directions you gave me won't do much good. Now if my next door neighbor had been to that same trailhead he could give me driving directions using my house as the "datum" and describe how to get to exactly the same point you described. Both sets of directions describe the exact same destination point, but we have used two different datums and coordinate systems to get there.

You can describe the location of any point on earth using coordinate systems referenced to any other arbitrary point, but this makes it difficult to tell someone else how to find your point unless they understand your coordinate system. One solution is to define a spherical coordinate system which describes a point as a latitude/longitude pair. This gives the location in terms of degrees and fractions of a degree from a known point - the point on earth where the reference longitude (0 degrees - the Prime Meridian) crosses the reference latitude (0 degrees - the Equator). So the location of the trailhead would be given as the point where a line so many degrees, minutes, seconds east or west of the prime meridian crosses another line so many degrees, minutes, seconds north or south of the equator.

As long as everybody agrees where the prime meridian is, and where the equator is, we have exactly defined that point for anyone in the world to find. These definitions were not always agreed on - the prime meridian once ran through Paris France instead of Greenwich England.

A problem comes up when we try to extend this spherical coordinate system to paper maps. Paper maps are flat but the world isn't so mapmakers have had to fudge things to make it work out right. Various systems have been developed to represent the real world on a two dimensional sheet of paper with minimum error. By referencing paper maps to a standard datum mapmakers can get reasonable accuracy but we have to pay attention to which datum was used in preparing the map.

For use in the continental US the two primary datums are the older NAD27 CONUS used on many older USGS 7.5 minute topo maps and the newer NAD83/WGS84. NAD is "North American Datum" and 27 or 83 refer to the years of adoption (1927 and 1983). NAD83 is equivalent to WGS84, which stands for "World Geodetic Standard 1984". NAD83 describes the continental US while WGS84 describes the whole world and uses NAD83 data for the US part. Depending on the age of a USGS 7.5 minute topo map, you may see reference marks for both NAD27 and NAD83. GPS units usually allow the choice of NAD27 or WGS84 as well as many others.

GPS units usually default to a datum selection of WGS84. However, most USGS topo maps are still keyed to NAD27 unless they are relatively new. Most wilderness area USGS maps that I have seen don't get updated that often (not much changes out there) so they tend to be NAD27. The difference isn't huge, no more than 200 meters, but that can be significant if you are searching for a pointer to a cache. The notes on a topo map will tell you which datum it is based on and you should select that datum in your GPS setup for best accuracy. If you aren't using a map but just storing waypoints in the GPS as you go then the default WGS84 is fine.

So now we know that we have to set the GPS receiver to match the datum which was used to prepare the map, but what about the coordinate system? Latitude/longitude is the traditional way sailors navigated their way around a more or less spherical globe. In the old days being within a mile or so was very good accuracy - after all, if wasn't foggy or dark they could see the coast from that distance. However, to simplify land navigation using flat paper maps other systems were developed, and UTM (Universal Transverse Mercator) was one of them.

The numbers that make up a UTM pair are in meters and they describe a rectangular grid system instead of a point. The basic UTM grid is a series of longitude zones and a series of latitude bands. Each longitude zone is 6 degrees wide. The zones start at Zone 1, which runs from 180deg longitude (the International Date Line) to 174deg west longitude, The center of that zone is exactly on 177 west longitude. Zone 2 is from 174deg to 168deg west and the numbering continues towards the east until you get to Zone 60 (174deg east longitude to 180 deg and back where you started). Each zone is bounded on the north by 84deg north latitude and 80deg south latitude. Western Washington, Western Oregon and Western California are in Zone 10, which is 126deg to 120deg west and is centered on 123deg west.

Latitude bands C through M (skipping I) are in the southern hemisphere and N through X (skipping O) are in the northern hemisphere. Bands C through W are 8 degrees high and band X is 12 degrees high. Here in western Washington we are in band T. Some maps may not show the letters but a GPS receiver does.

The Northing is the number of meters north of the equator to the south-west corner of a square. The Easting is calculated from your position relative to the center of the zone. No zone is over

999,999 meters wide, so the centerline (exactly 123deg west longitude for Zone 10) is defined as being Easting 500,000. Everything between 126 deg west longitude and 123deg has a number smaller than 500,000 and everything from 123 deg to 120 deg has a number larger than 500,000. The next zone starts all over again with it's centerline being defined as 500,000.

Since UTM coordinates are given as pairs referenced to the southwest corner of a rectangle they are read from west to east for the Easting and south to north for the Northing. The rule is to "read right and then up" so the pairs are given with the Easting first and then the Northing. Coordinate pairs can be abbreviated on maps by dropping the last three digits, writing them to a resolution of 1000 meters. The Easting contains a leading zero which can be dropped, giving the Northing one more digit than the Easting in a pair.

So the following NAD27 UTM coordinates all apply to the Mt St Helens crater in southwest Washington: 11T 0562E 5116N is a square 1000 meters x 1000 meters containing the old lava dome. For the rest of the examples we will drop the leading zero of the Easting. 11T 5626E 51162N is a square 100 meters x 100 meters starting at roughly the southwest corner of the old dome. 11T 56266E 511628N is a square 10 meters x 10 meters near the center of the dome. 11T 562661E 5116282N is a square 1 meter x 1 meter at the center of the dome. The numbers can be run together like 11T5625116 or 11T56266511628 with the Easting having one less digit then the Northing. A GPS receiver will read out to one meter but you can't plot that accurately on a map (or read the map, either).

The main problem with using UTM is that most maps, other then USGS topo maps, don't show UTM coordinates - they only show lat/long or even just an arbitrary grid system. Newer maps are beginning to show UTM because of the popularity of GPS units but they can be expensive. Older USGS 7.5 minute topo maps show UTM tic marks along the margin edges and newer ones have the full grid printed on them. The first thing I do with an older USGS map is use a long straight edge to draw lines between the margin tics so the grid shows over the whole map.

So now you know - it is important to set your GPS receiver to use the same datum and coordinate system that your paper map is based on. Just like teams should standardize compass usage (true versus magnetic north) they should ensure all members are using the same GPS settings to avoid confusion in the field.

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