Global Positioning System, part 1 of 2

YTA Newsletter, Summer 2007

Most of you have heard of GPS, and some of you use GPS, but I suspect that there's still a lot of confusion out there on this very useful navigation aid. If you don't own a GPS device, you may ask, "Why would I want one?"

Well, different people have different needs, but here are a few reasons that work for me, mainly for when I am exploring on trails or in the wilds. First, it will allow you to find a place that a friend (or a book or magazine) has suggested is well worth a visit. Second, it will allow you to record the location of a place so that you can tell a friend, or revisit it yourself months later when your memory has dimmed. Third, if you want to take a particular turn at a junction shown on a map, you can confirm the junction you are at is the one on the map, not a nearby junction. Fourth, if you are lost, it can tell you where you are, thus allowing you to find your way back to safety. Fifth, if you record the place where you parked your car, it will help you get back to your car, and lastly, if you are hurt and have a cell phone that is in range, you can tell your rescuers exactly where to find you.

A GPS device receives signals from a network of GPS satellites that orbit around the Earth, about 12,000 miles above us. The system came into use around 1980 with a lesser number of satellites; the number was increased to the current 24 in 1994. It works anywhere in the world. A lot of the information in this article is background material that is of interest, but does not need to be remembered (or even understood) to use a GPS device.

The GPS device, the brain of which is a specialized computer, can very accurately derive its position on the Earth from these satellite signals, using triangulation. Normally a GPS device can "see" at least six of these satellites, but theoretically all it needs is three. Its screen can display its position in a number of formats, but this information is largely useless unless you have a good map. Modern GPS devices can display an electronic map on the screen, but, while the level of detail of these internal maps may be fine for driving, they are useless for finding your way over trails away from roads. So, you will also need a good printed map.

The positioning accuracy of most GPS devices is about 10 to 15 meters (for the purposes of this article, a yard and a meter are the same). There are ways to improve this accuracy, but if you are out in the woods, 15 yards is quite sufficient. The GPS satellite network is run by the US Department of Defense and was originally for military purposes only. It became available to the general public about 20 years ago and is free. Initially, the accuracy was downgraded to the public for security reasons, but this is no longer the case.

Okay, so back to the maps. When I hike on the trails, the map I like to use is the 7.5-minute USGS topological version. This map has a scale of approximately 2.5 inches to the mile, providing plenty of detail of contours, streams, roads, trails, etc. If you own some of these maps, I suggest you get one out now to make it easier to follow my description – the size is about 26 x 21 inches, so you'll need plenty of room.

How do you use the position reading from your GPS to find out where you are on your map? Well, most people were taught latitude and longitude when they were at school, so that's what they use. On the USGS topo maps, lat/long values are printed on the edges of the maps, and the crossing points of latitude with longitude are also marked on the maps every 2.5 minutes. However, if your GPS says you are at 28d 2m 30s longitude and 112d 23m 15s latitude, just try converting that to a point on the map! (In my shorthand d = degrees, m = minutes and s = seconds.) When I bought my first GPS about ten years ago, I tried to do just that, and I produced complex grids on 8 x 11 inch transparencies to help. That made it possible, but still very difficult and cumbersome.

There is a very simple solution that I now use, as do most other experienced GPS users. It is called UTM (for Universal Transverse Mercator). UTM is a uniform grid system that uses nice squares of one kilometer per side everywhere! In contrast, lat/long is not user friendly – a degree of latitude represent a different distance than a degree of longitude, and the distance of a degree of longitude diminishes as you go from the equator to the poles. Now, please don't think UTM isn't for you because you never understood the metric system at school. What matters is how a UTM reading can easily be converted to a point on the USGS topo map. Some USGS maps have these grids printed on them (e.g., the Iron Springs map) while others don't (e.g., the Prescott map). However, the ones without grids have UTM "tick marks" in blue along all four edges of the map. So, all you need to do is place the map flat on a table, and use a pencil and straight edge to join the tick marks on opposite sides of the map (tick marks are numbered ^{3}61 or ^{38}19, for example).

I'll complete this tutorial in the next issue, so don't throw this article away! Nigel Reynolds

Global Positioning System, part 2 of 2

YTA Newsletter, Winter 2007

The first half of this article was published in the Summer 2007 newsletter – it explained the UTM grid system. This second half explains how to use your GPS to find where you are on a USGS topo map

The diagram (next page) represents the southwest corner of the Iron Springs topo map, with the map part replaced with grey shading to better understand how to use UTM. Remember from the first article, UTM uses a grid system, marked on topo maps as squares with sides of one kilometer (1000 meters). You can see one of these full squares in the diagram (the square in white), as well as some partial squares. The number in the bottom margin, ^{3}61, defines the left edge of this full square, and is known as the "easting" because it's value increases as you go east (e.g., from ^{3}61 to ^{3}62). Similarly, the number in the right margin, ^{38}19, defines the bottom edge of this square, and is known as the "northing" because it's value increases as you go north. The UTM reading for this square (actually its southwest corner, defined by the small circle) is [0361.000E 3819.000N] – I'm using square brackets rather than quotes to define the reading. The UTM reading for the partial 1 km square that's immediately to the northeast of this full square is [0362.000E 3820.000N] – this point is marked with a solid black triangle.

The small solid black square represents where we are on the map, and its reading would be [0361.810E 3819.370N]. The last three digits of both the easting and northing being the distance in meters we are from the SW corner of the 1 km square. To be precise, the reading on our GPS is actually [0361.805E 3819.372N]. Due to the approximate ten-meter accuracy limit of the GPS discussed before – not to mention the limited precision of measuring these distances on the map – I rounded the "units" digit of the two numbers to 810 and 370 respectively for simplicity.

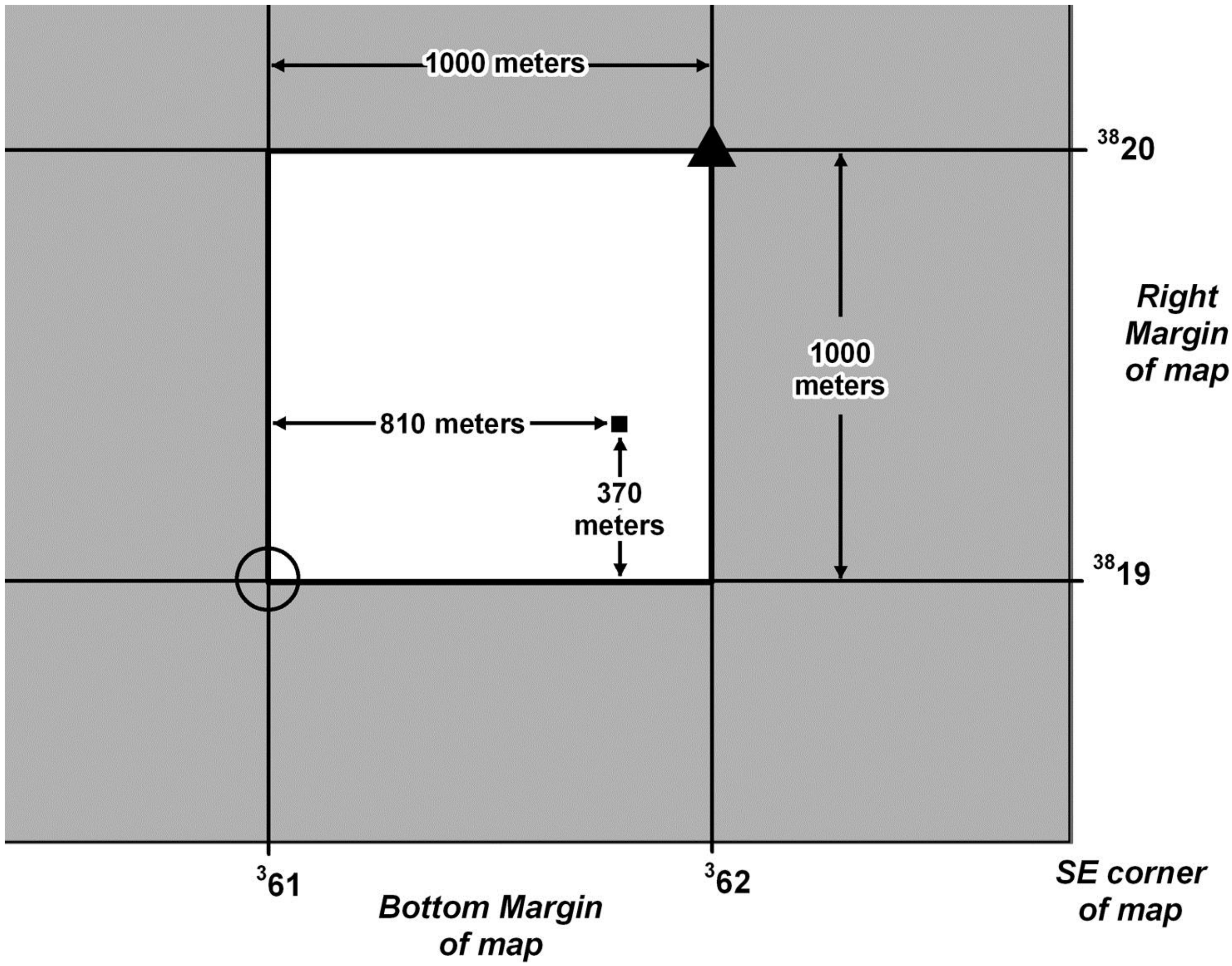
Well, I hate to admit it, but I have lied just a little. The actual reading on your GPS looks slightly different, and would be [12S 0361805 3819372] not [0361.805E 3819.372N]. I mentally add the decimal points to differentiate the location within the 1km grid from the grid numbers on the map margins, and I add the E (for easting) and N (for northing) to remember which number is which. An easy way to remember the order (E then N) is to "ENjoy life" or "ENjoy using your GPS." Well, you may ask, what's that "12S" doing at the front of the GPS reading? It refers to the much larger 1,000 by 1,000 km grid that you are in (~625 miles). The whole world has been divided up into many major grids of this size (this is another slight simplification to ease understanding). You will always be in the major grid "12S" in Yavapai County (and in most of Arizona), so just forget that part of the reading unless you are far from home.

To "eyeball" our above position on the map, take a point about ¾ of the way between the left and right of our grid square (810 is close enough to 750, which would be the ¾ point of the 1000 meter side), and about 1/3 of the way between the bottom and top of the grid square (370 is about 1/3 of 1000) – that's where you are! For more precision, you can buy or make a small transparent plastic square which, when "overlaid" on top of the 1km grid square, shows each 100 meters – in my example the "8 digit" in the easting and the "3 digit" in the northing. Most overlays usually show lines down to an accuracy of 25 meters, rather than 100 meters. By now you may be thinking "this guy is crazy, this is too complicated for me." However, if you follow my guidance step-by-step, or better yet, try it yourself on a real map, you'll find out it really isn't that difficult.

To use UTM on your GPS (or even lat/long), you will need to set-up you GPS device. Go to the Set-up menu (probably there's a "set-up" for Navigation or Units) and change the position format to UTM (it may be called UTM UPS). Then change the map datum to NAD27 CONUS – this stands for "North American Datum 1927, Continental United States" and is the datum used by USGS topo maps. Your instruction manual will give you guidance on set-up. Alternatively, ask someone at the store where you bought it, or consult an experienced friend. To become more expert yourself, consider attending a course – Yavapai College offers one-day GPS courses from time to time. In the past, some have been given there by a member of YTA (Tracy Devault) – I have learned a lot from him!

Have fun with your GPS – it can do much more than I have covered in this article, so just experiment and learn!

Nigel Reynolds


1000 meters
1000 meters
810 meters
370 meters
38 20
38 19
3 61
3 62
Right Margin of map
Bottom Margin of map
SE corner of map