The Tacoma Mountaineers

Wilderness Navigation

UTM Coordinates—What (little) you really need to know (and a little bit more)

You may have heard of UTM, and you may have hoped that, as with so many high-tech TLAs (three-letter acronyms), if you ignored it, it would go away. Well, it's been around a long time, and it doesn't look like going away. Instead, it's beginning to look like the best friend a backcountry navigator can have for communicating positions.

It doesn't matter, but UTM stands for "Universal Transverse Mercator". Fortunately, to use UTM, you don't have to know what *that* means. It's sufficient—almost—to understand that UTM is a standard means of stating one's position, or any position on earth, by giving two numbers—coordinates, they're called. The first number is the *easting*, and, as you've guessed, it tells you how far east you are. The second number is the *northing*, and it… oh, you guessed it.

For example, the easting and northing at the Mountaineers' clubhouse are respectively 548144, 5274179. To get to Mt. Rainier from there you'd go more or less southeast, so you'd expect the easting to get bigger and the northing to get smaller, and, sure enough, the coordinates at the summit are 594603, 5188886.

One reason UTM is valuable is to communicate with others, such as SAR (search-and-rescue) organizations. Of course, if you know your coordinates you're not really lost, but it is more precise and more helpful to inform people, via telephone or radio, that you last saw your missing member at 615244,5183026 than to try to explain that it was where Panther Creek's north and south branches come together. There may be several Panther Creeks, and reasonable men and women may differ as to which branches are north and south.

Similarly, UTM is an aid to guidebook writers (and readers). Increasingly, route descriptions are featuring coordinates as an efficient way to convey information that readers can easily link to a map.

The steadily increasing use of recreational GPS receivers has been another spur to the growing popularity of UTM. Receivers can easily display your location in UTM, and it's probably the easiest GPS location format to understand in the field.

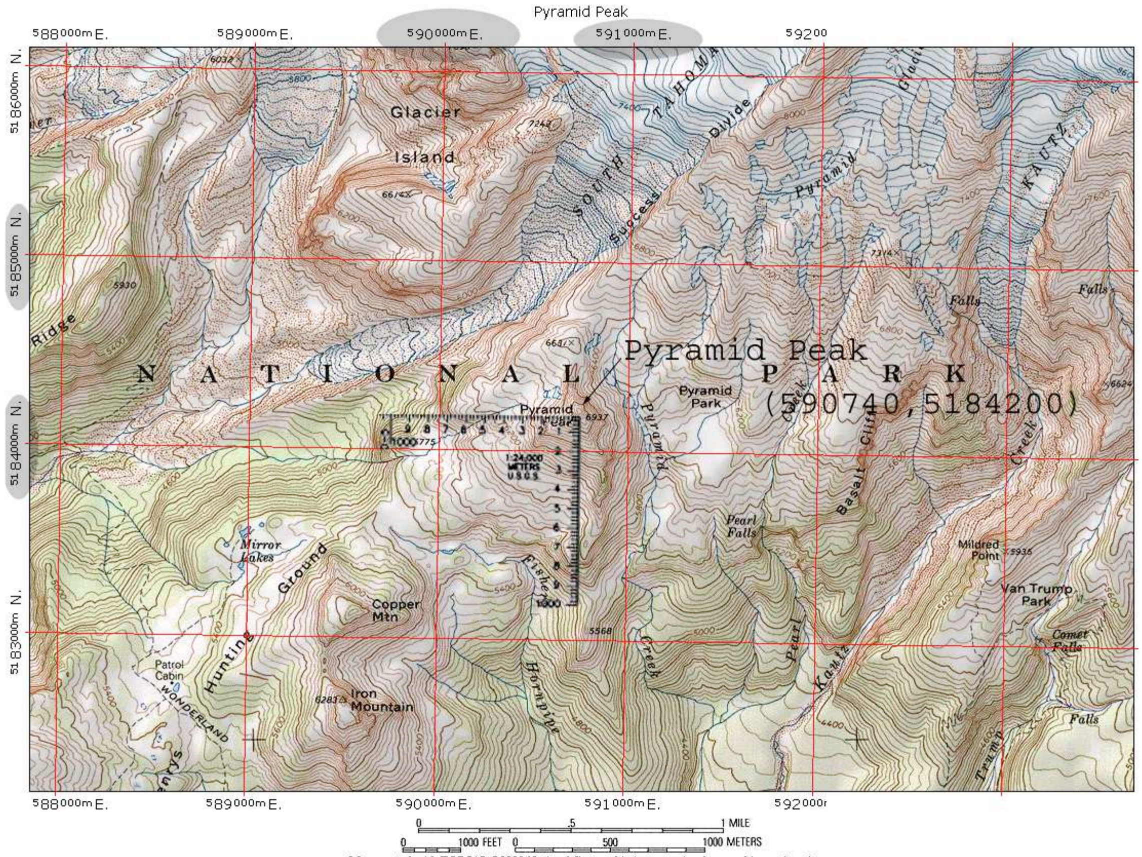
Doesn't our venerable Township-Range-Section system do the job? Yes, but it's a qualified yes. TRS is mostly a system, antiquated to say the least, for legal descriptions of property boundaries. Places where property boundaries don't matter much, such as the interiors of national parks and wilderness areas, have probably never been surveyed and quite possibly have never had land lines defined even theoretically. Look at a map of Mt. Rainier, for instance. You'll most likely find that the central part of the park has nary a township, nor range, nor section. Furthermore, TRS is too complicated for GPS receivers.

Latitude and longitude can be used to state a position unambiguously of course, and, unlike UTM, they may be old friends from grade school days. They do constitute an acceptable alternative to UTM, but later on we'll explain why, for our purposes, UTM is superior.

What do the numbers mean? We'll also postpone a discussion of that until later, because we don't really need to understand the underlying mathematics, but we'll admit here, just because it's convenient to do so, that the units are meters. If you were to walk a line that kept your northing constant while your easting increased by a thousand, you would be going (very nearly) one kilometer to the east.

Nowadays, most large-scale maps, including USGS, the newer Green Trails®, and Canadian topographic maps, either come printed with an overlaid UTM coordinate grid or at the least have marginal tick marks (colored blue on USGS quadrangles) that can be connected with a pen and straight edge to supply such a grid. Further, most map-generating software can calculate coordinates for points and overlay a grid for viewing and printing maps. Grid lines on large-scale maps are usually spaced at intervals of 1000 meters, so you can expect to be able to identify locations and interpolate points by eye to an accuracy of better than 100 meters.

Here's an example of a map of Pyramid Peak with a UTM grid overlaid in red. The summit lies between easting lines at 590000 and 591000, and one can estimate its easting at about 590700.



Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

Similarly, the northing is between lines 5184000 and 5185000, between which we interpolate by eye an estimate of 5184200.

Although it is not necessary, those with a penchant for precision can overlay a transparent plastic UTM grid reader on the map as shown. With its aid we can read the Pyramid Peak coordinates to within about twenty meters: 590740, 5184200. But for most purposes this is more accuracy than we really need. (At first, a grid reader may be confusing because it has to have a section for each scale commonly encountered on large-scale maps. In the Pyramid Peak example, I've suppressed all of the grid reader except the half-square labeled "1:24000/METERS/USGS" that has its northeast corner positioned on the summit. The 590000 easting line crosses the top edge of the square at about 740; the 5184000 northing line crosses the right-hand edge of the square at about 200.)

Is this all there is to UTM? Well, not quite. To use UTM to specify a position *anywhere*, you must also state the zone. The world is divided into sixty zones, each spanning six degrees of longitude and numbered from west to east from the dateline. All that we really need to know is that all of western Washington (west of about Vantage) is in Zone 10. If you go somewhere else (but why would you?), you might want to see a map of zones of the U.S.:

United States UTM zones

If you go to the southern hemisphere or the Polar regions you'll need to learn a little more about zones.

Finally, as with *any* coordinate system, you must specify or ascertain the *datum*. For our purposes a datum simply defines what the eastings and northings are measured *from*. Throughout the world, hundreds of datums are in use; in the United States we're likely to encounter only two: NAD 27 CONUS (North American Datum, 1927, continental United States edition) and WGS 84 (World Geographic System 1984). The latter is virtually identical to NAD 83, which we can take to be an alternate name for it. All printed USGS quadrangles are referred to NAD 27; most GPS receivers are set to WGS 84 when you take them out of the box, so beware! Any good map will identify its datum, usually in the collar:

is not intended for navigational purposes

Mean lower low water (dotted) line and mean high water (soli
compiled by NOS from tide-coordinated aerial photographs

Projection and 10,000-foot grid ticks: Washington coordinate
system, north zone (Lambert conformal conic)
1000-meter Universal Transverse Mercator grid, zone 10
1927 North American Datum
To place on the predicted North American Datum 1983
move the projection lines 23 meters north and
94 meters east as shown by dashed corner ticks

Fine red dashed lines indicate selected fence lines

There may be private inholdings within the boundaries of

Any good guidebook will also state the datum it's using, possibly in the preface or introduction.

The most important thing to remember about datums is that *they matter!* A full expression of the location of the summit of Pyramid Peak would be: NAD 27, zone 10, 590740, 5184200. A point having the same location but referred to the WGS 84 datum would be about two hundred meters (yards) distant. Using the wrong datum with a map, guidebook, or GPS receiver is about like using a compass with an incorrect magnetic declination setting.

That's it, folks; that's all there is. Datum, zone, easting, northing.

You can stop reading here. If anything is still bothering you, however, I'll try to answer some of the questions some folks still have at this point.

(1) Isn't latitude/longitude easier?

No. Basically, it's subject to lots of opportunities for error.

First is the matter of units. Latitude and longitude may be given in degrees, or degrees and minutes, or degrees, minutes, and seconds. In communicating a position to someone else, say by phone or radio, it's easy for that someone to misinterpret, for example, 47.50° as 47°50'. Given a point that is seventy percent of the way from easting 590000 to easting 591000, most of us can figure out without a calculator that the point is at easting 590700. In an emergency, in the cold, in the wind, in the sleet, some of us might screw up figuring out what latitude is seventy percent of the way from 47°45' to

47°47’30”, which is precisely the sort of problem you would have to deal with on a USGS map.

Eastings and northings are always positive. *Always*. Latitudes and longitudes come in east and west, north and south. West and south are conventionally, although by no means universally, considered to be negative numbers. For us, located firmly north of the Equator and west of Greenwich, we’re certainly in north latitude, west longitude, but this means that longitudes on our maps increase from east to west, which is to say from right to left. Since we’re strongly accustomed to the convention on graphs that numbers increase from left to right, we are prone to errors when interpolating longitudes. Eastings *always* get bigger as you move to the right on your map; northings *always* increase as you move up.

The size of a degree, minute, or second of longitude varies with the latitude, so that most of us lack any useful sense of what it feels like to hike through ten seconds of thick brush. UTM numbers mean meters, and in the field we can judge a distance of a hundred meters pretty well. (If for some reason you don’t like meters, just think yards, and you’ll be right within ten percent.)

You don’t need to specify a zone when using latitude and longitude, that’s true, but when roaming around in the outdoors you’re very unlikely to mistake or misconstrue your UTM zone, and if you do, the error will be nearly obvious to anyone to whom you might communicate your coordinates. (When you step across a zone boundary, your northing doesn’t change appreciably. Your easting does jump sharply, but in a rather clever way such that if you state your coordinates for, say, zone 10 when you’re actually in zone 11, not only will the error be apparent to anyone receiving them, but he/she can easily figure out what the correct ones would be.)

You may have thought that latitude and longitude are absolute, independent of datum. Wrong! In western Washington two points having the same latitude and longitude, one referred to NAD 27 and the other to WGS 84, will be more than ninety meters—a hundred yards—apart. If you use latitude and longitude to describe a position, you must specify the datum. If you get latitude and longitude from some source such as a map, guidebook, Web site, or GPS receiver, you must know the datum to which it is referred.

Just as you can buy grid reader overlays for plane coordinates, such as UTM, you can buy latitude and longitude scalers from map stores that will help you figure the latitude and longitude of a point on a map. (Locally, REI and Metsker stock them.) If I haven’t convinced you yet that UTM is superior to latitude/longitude for our purposes in backcountry navigation, please look at one of these devices and practice using it. Also practice interpolating latitude and longitude on a USGS map *without* the benefit of a scaler.

Finally, if you like to hike in any of those far-away places with strange-sounding names, you need to be alert to the fact that not everyone measures latitude and longitude in degrees. Some nations use *grades*, equivalently, *gons*, of which there are a hundred to the right angle, so that one grade equals 54 minutes. In contrast, UTM is universally given in meters; if it's not in meters, it's not UTM. Even if you set your GPS receiver to display distances in miles and feet it will *still* give your UTM coordinates in meters. There's not much scope for ambiguity with UTM.

(2) The UTM coordinate grid I've got on my map is skewed. The northing lines don't run exactly north-south, and the easting lines don't run exactly east-west.

Good eyes! The problem is that UTM, like other plane coordinate systems, and like all map projections, is trying to impose a flat surface on a round world. The only practical concern with this is that with a UTM (or other plane coordinate) grid on a map we find it tempting to use that grid to align compass meridian lines when we're plotting or measuring map bearings. Most good maps will tell you, in the collar, what the angle of separation between "grid north" and true north is, and this information will help you to align your compass better. In our latitude, the separation is never much more than a degree and a half, attaining the maximum at the UTM zone boundary.

If you really care, the UTM grids on our USGS and newer Green Trails® maps aren't even straight lines; they're curves with really ugly mathematical equations. The grid "lines" do intersect at right angles, however.

(3) UTM coordinates are such big numbers. What (on earth) are they measured *from*?

First, the northing. It's more or less the distance from the Equator; in any case, the northing is zero on the Equator, and, of course, increases the farther we move north from the Equator. It's not exactly the *distance* from the Equator, because it's measured along a grid line of constant easting, and this "line" is actually a curve that does not run truly north-south.

The easting is measured from the center of the zone. You'd think that the easting would be zero on the central meridian (in western Washington, this is 123°, more or less the western shore of Hood Canal), but to keep eastings positive, a big number is added to them—500000—so that points on the central meridian have easting 500000 and points to the east have even larger coordinates. The big number (known in the jargon as a *false easting*) is big enough that eastings will nowhere be negative.

(4) On some maps UTM coordinates are printed with two digits larger than the others, *e.g.*, $^{52}84^{000}$. What does this mean?

It's just a convention, kinda like inserting commas into big numbers to make them easier to read. Most guidebooks seem to ignore it. Many maps that place grid lines at one-kilometer intervals, such as USGS 7.5 minute quadrangles, also suppress the last three digits in the grid labels, *e.g.*, print 5284 instead of 5284000.

(5) What happens in the southern hemisphere?

Northings *still* increase from south to north. They would be negative numbers except that a big number (the *false northing*)—10000000—is added to each, so that the Equator has a (southern hemisphere) northing of exactly 10000000 (that's ten million). Eastings are figured the same way as in the northern hemisphere.

(6) How about the regions near the Poles? The zones will be very narrow there, so that one would frequently move from zone to the next.

UTM doesn't cover the extreme Arctic and Antarctica. A complementary system, called UPS ("Universal Polar Stereographic") applies instead. Because only the Arctic Ocean and the Antarctic Continent are UPS regions, it's unlikely that many of us will need to understand how it works. Details are in the references.

(7) I still have questions! Where can I get more information?

Lots of books lay out a basic explanation of UTM. The Mountaineers Books publish Lawrence Letham's *GPS Made Easy*, which covers not only UTM but UPS as well. Full technical details concerning UTM and UPS are in the Defense Mapping Agency (formerly Army Map Service, later National Imagery and Mapping Agency, this week the National Geospatial-Intelligence Agency) Technical Manual 8358.2, *The Universal Grids: Universal Transverse Mercator (UTM) and Universal Polar Stereographic (UPS)* available from http://earth-info.nima.mil/GandG/pubs.html, which page lists other fascinating available documents as well. This will be of value only to those who actually want to program the conversions between latitude/longitude and UTM that map-generating software and GPS receivers do for you; others may enjoy looking at the manual merely to gasp in wonder at a small part of what programmers have crammed into one of those tiny Geko receivers.

Really good information about coordinate systems and datums is available, free, at http://www.colorado.edu/geography/gcraft/notes/coordsys/coordsys.html and http://www.colorado.edu/geography/gcraft/notes/datum/datum.html. These are provided by courtesy of Peter H. Dana, of The Geographer's Craft Project, Department of Geography, University of Colorado at Boulder. Enjoy!