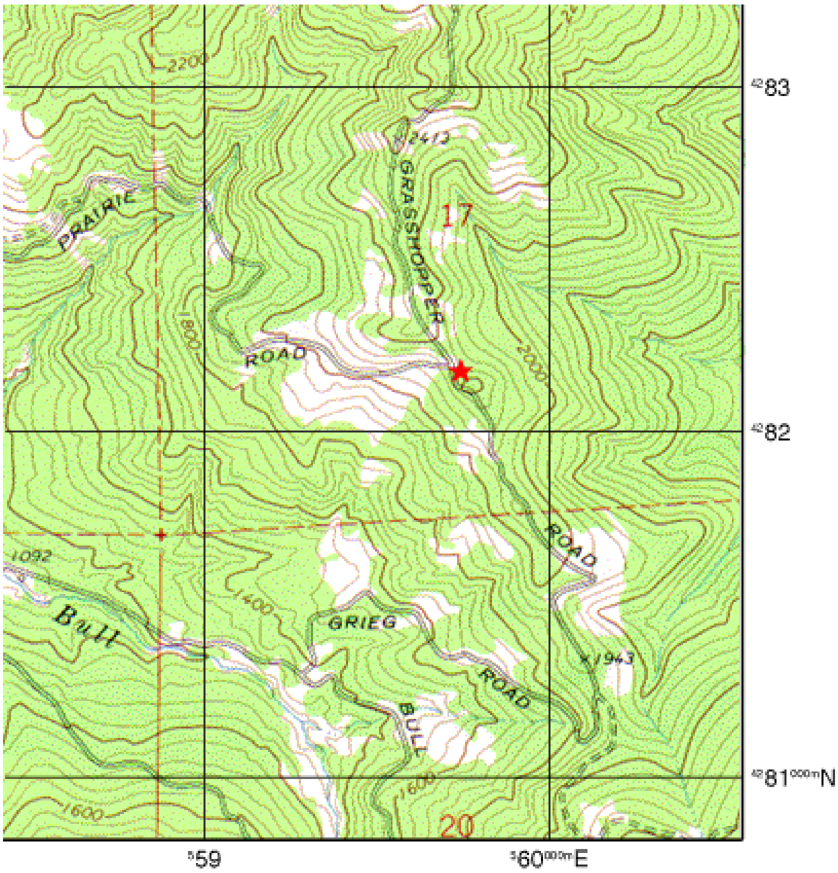
A Quick Guide to Using UTM Coordinates



Standing at the road junction marked with the star on the topographic map pictured above, a GPS unit set to display position in UTM coordinates, would report a location of:

10 S 0559741
4282182

The **10 S** represents the zone you are in. The zone is necessary to make the coordinates unique over the entire globe.

The top set of numbers, **0559741**, represent a measurement of East-West position, within the zone, in meters. It's called an easting.

The bottom set of numbers, **4282182**, represent a measurement of North-South position, within the zone, in meters. It's called a northing.

The map has Universal Transverse Mercator (UTM) grid lines spaced every kilometer or 1000 meters. The vertical grid lines determine East-West position and the horizontal grid lines determine North-South position.

Look along the bottom edge of the map at the labels for the vertical grid lines.

559 and 560000 mE.

The label, 560000 mE., reads "five hundred and sixty thousand meters East." The label, 559, is an abbreviation for, 559000 mE. The two grid lines are 1000 meters apart. The horizontal grid lines are labeled in a similar manner.

Getting to Know the Metric System

If the metric system gives you heartburn, here are a few tips to help you out.

The Truth (to within 3 or 4 significant digits)		What you can remember (You'll be about 10% too short.)	
1 meter	= 3.280 feet = 1.094 yards	1 meter	~= 3 feet ~= 1 yard
100 m	= 109 yards	100 m	~= 100 yards ~= length of a football field
1000 m	= 1 kilometer = 1 km = 0.621 miles ~= 5/8 mile	1000 m	~= 1/2 mile

Shorthand for UTM Coordinates

Most land navigation activities focus on a very small portion of the globe at any one time. Typically the area of interest to an outdoorsman is less than 20 miles on a side. This focus on a small area allows us to abbreviate UTM coordinates.

The zone information and the digits representing 1,000,000m, and 100,000m are dropped. The 1m, 10m and 100m digits are used only to the extent of accuracy desired.

A GPS unit might read

10 S 0559741
4282182

Using a notation similar to the one found on a USGS topographic map, this would be written as:

Zone 10 S 559741 mE. 4282182 mN.

An abbreviated format for the same coordinates would look like:

59 82	Describes a 1000m by 1000m square.
597 821	Describes a 100m by 100m square.

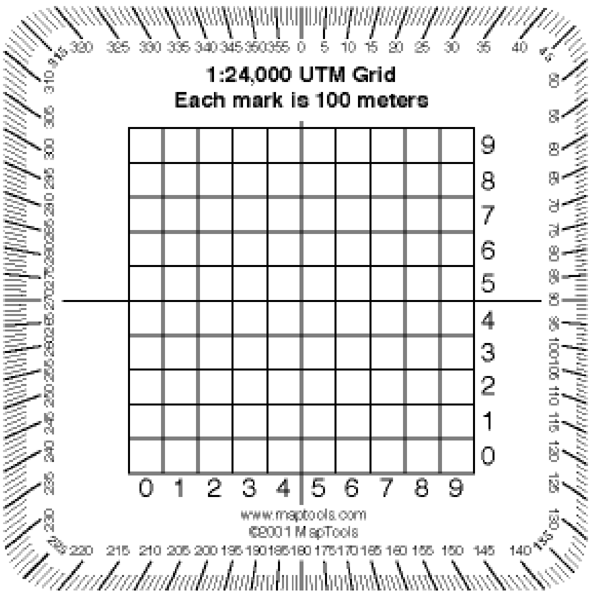
5974 8218	Describes a 10m by 10m square.
59741 82182	Describes a 1m by 1m square.

The 100m abbreviated format, **597 821**, and the 10m abbreviated format, **5974 8218**, are the most commonly used.

Notice that the easting is reported first, followed by the northing. Remember the phrase "read right up" to help you remember to read the easting from left to right, followed by the northing from the bottom up.

Also notice that when you abbreviate coordinates you should not do any rounding. **0559651** becomes **596** not **597**. This ensures that your position is still within the reported square. As accuracy decreases, the square gets bigger.

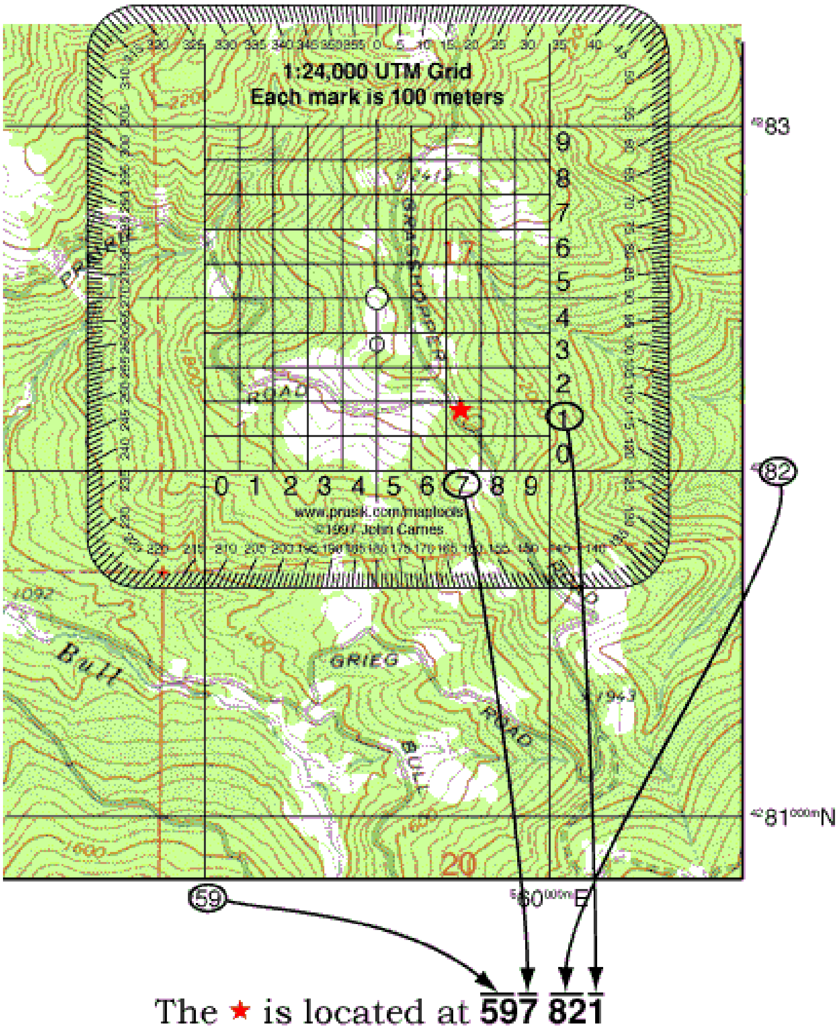
Using a UTM grid overlay tool



If you want to find your location with more precision than is available from the grid lines on the map, you will need a tool that is marked in finer divisions. One such tool is a grid overlay. The grid overlay is placed on the map with its edge aligned with the grid lines. Then the position of the mark can be determined using the tool's additional precision. Additional precision is available by either by "eyeballing" or by using a UTM Corner Ruler with finer markings. For many land navigation situations 100m precision is quite adequate.

The example shown here locates the  to a precision of 100m. The 10,000m and 1,000m digits of the coordinate are taken from the map. Thus the coordinates **59 82** locate the 1,000 meter square containing the star. The grid overlay is placed over the grid and the 100m digit is determined. Remember to read the Easting followed by the Northing.

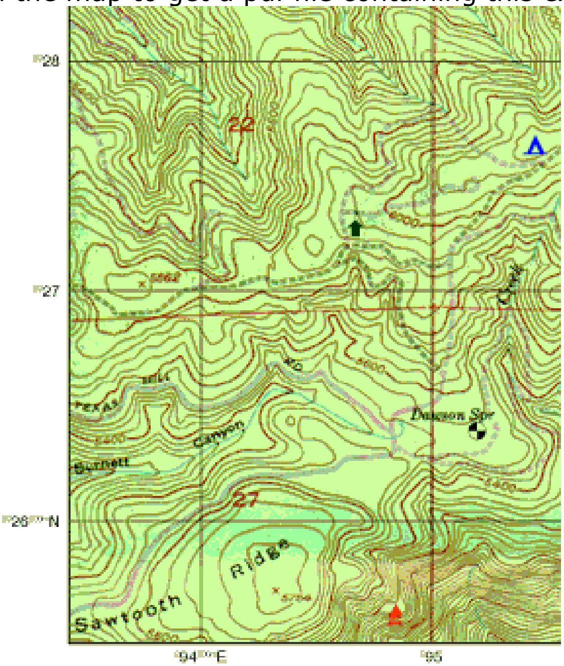
In 100m abbreviated format the coordinates of the ★ are **597 821.**



The "pocket sized" UTM grid overlay shown here is available from Map Tools.

Try it out using your overlay and the following map...

Click on the map to get a pdf file containing this exercise.



Your GPS unit reads...

10 S 0294324
3925702

Plot your position on the map.

What would that be in 100m abbreviated format?

Locate the following on the map...

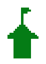
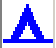
943 265
948 264
9375 2702

Report the positions of the following symbols in 100m abbreviated format...

You should have come up with the following results...

Your plotted position should be just north of the 5784 elevation mark on Sawtooth Ridge.
That would be **943 257** in 100m abbreviated format.

943 265	5400 ft level in Burnett Canyon
948 264	Dawson Spring
9375 2702	x5862

	**946 272**
	**948 255**
	**951 263**
	**954 276**

Why Use UTM Coordinates

The UTM coordinate system offers the following benefits:

A square grid

UTM Provides a constant distance relationship anywhere on the map. In angular coordinate systems like latitude and longitude, the distance covered by a degree of longitude differs as you move towards the poles and only equals the distance covered by a degree of latitude at the equator. Since land navigation is done in a very small part of the world at any one time using large scale maps. The UTM system allows the coordinate numbering system to be tied directly to a distance measuring system.

No negative numbers or East-West designators

Grid values increase from left to right and bottom to top

This is just like the X Y Cartesian coordinate system you learned high school math class. Simple Cartesian coordinate mathematics can be used. No spherical trigonometry is required!

Coordinates are decimal based

Ones, tens, hundreds and so on. No more minutes and seconds to convert.

Coordinates are measured in metric units

All UTM coordinates are measured in meters. Most of the world has already adopted the metric system. Now you won't need to remember how many feet are in a mile. And what's that in yards?

More details about the UTM coordinate system

The Universal Transverse Mercator projection and grid system was adopted by the U.S. Army in 1947 for designating rectangular coordinates on large scale military maps. UTM is currently used by the United States and NATO armed forces. With the advent of inexpensive GPS receivers, many other map users are adopting the UTM grid system for coordinates that are simpler to use than latitude and longitude.

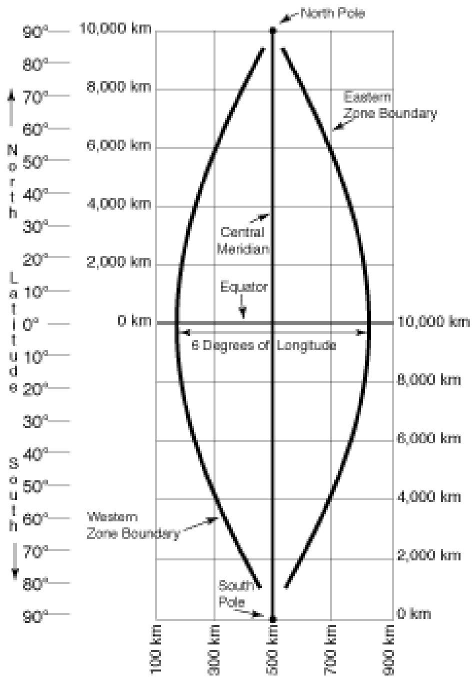
The UTM system divides the earth into 60 zones each 6 degrees of longitude wide. These zones define the reference point for UTM grid coordinates within the zone. UTM zones extend from a latitude of 80° S to 84° N. In the polar regions the Universal Polar Stereographic (UPS) grid system is used.

UTM zones are numbered 1 through 60, starting at the international date line, longitude 180°, and proceeding east. Zone 1 extends from 180° W to 174° W and is centered on 177° W.

Each zone is divided into horizontal bands spanning 8 degrees of latitude. These bands are lettered, south to north, beginning at 80° S with the letter C and ending with the letter X at 84° N. The letters I and O are skipped to avoid confusion with the numbers one and zero. The band lettered X spans 12° of latitude.

A square grid is superimposed on each zone. It's aligned so that vertical grid lines are parallel to the center of the zone, called the central meridian.

UTM grid coordinates are expressed as a distance in meters to the east, referred to as the "easting", and a distance in meters to the north, referred to as the "northing".



Eastings

UTM easting coordinates are referenced to the center line of the zone known as the central meridian. The central meridian is assigned an easting value of 500,000 meters East. Since this 500,000m value is arbitrarily assigned, eastings are sometimes referred to as "false eastings"

An easting of zero will never occur, since a 6° wide zone is never more than 674,000 meters wide.

Minimum and maximum easting values are:

160,000 mE and 834,000 mE at the equator

465,000 mE and 515,000 mE at 84° N

Northings

UTM northing coordinates are measured relative to the equator. For locations north of the equator the equator is assigned the northing value of 0 meters North. To avoid negative numbers, locations south of the equator are made with the equator assigned a value of 10,000,000 meters North.

Some UTM northing values are valid both north and south of the equator. In order to avoid confusion the full coordinate needs to specify if the location is north or south of the equator. Usually this is done by including the letter for the latitude band.

If this is your first exposure to the UTM coordinate system you may find the layout of zones to be confusing. In most land navigation situations the area of interest is much smaller than a zone. The notion of a zone falls away and we are left with a simple rectangular coordinate system to use with our large scale maps.

Frequently, in land navigation, the zone information and the digits representing 1,000,000m, and 100,000m are dropped. The 1m, 10m and 100m digits are used only to the extent of accuracy desired. Note that it's the smaller digits that are dropped in the notation used by the USGS on the edges of their maps. For example 4282000 mN. becomes 82.

Because pilots and sailors navigate over much greater distances they still favor the latitude longitude coordinate system.

UTM Coordinates on USGS Topographic Maps

All USGS topographic maps printed in the last 30 years or so include UTM grid tick marks, in blue, on the margin of the map. For a short time period after 1978 the USGS was printing a fine lined UTM grid on their topographic maps. They have since discontinued this practice.

Since most USGS 1:24,000 scale topographic maps do not have grid lines printed on them, you will need to draw them in by hand.

Start by finding a flat surface to work on. Use a straightedge that is long enough to draw a line across your map. Two to three feet long is a good length.

Line the straightedge up between two corresponding UTM tick marks along the neat line (the edge) of the map. Remember that UTM grid lines are not exactly North-South or East-West anywhere but in the center of a zone. This means that the grid lines will not be parallel to the neat lines.

Using a mechanical pencil or a fine pointed pen draw a line between the two tic marks. If you are using a pen, select one that has waterproof ink. In addition, you will want to use a straightedge that has the edges lifted off of the paper. This will help keep from leaving an ink smudge when you move the straightedge. High quality straightedges will often have a thin piece of cork stuck to the bottom. This helps keep the rule from slipping, and keeps the edge off of the paper. A piece of masking tape centered on the bottom of your straightedge will work also. Occasionally wipe of the edge of the straightedge to avoid any ink build up.

Griding maps is tedious work. We all wish the USGS would go back to printing the grid on the map. But even then, we would still need to grid our existing maps. As you can see this is not the kind of thing you want to do on the hood of a truck or using a flat rock. Grid your maps before you need them in the field! In a pinch you can fold the map over on itself and use the edge of the paper as a straightedge.

Photocopies of Maps

Frequently, you may use a photocopy of a small portion of a map rather than the entire map. This cuts down the wear and tear on the original map and allows several copies to be distributed among a group.

Make sure you transfer at least the large-print portion of the UTM grid markings onto the photocopy. It's also helpful to provide scale and contour information. Preprinted scale bars on Post-It note paper are available or just make a copy of the scale bars and "cut and paste"

Avoid the temptation to change the scale of the map with the zoom on the copier. If you use maps often you will have a good sense of distance. Alter the scale and it will be harder to judge distances. Plus your overlay tools will no longer be useful.

If you do change the scale using the copier, be sure and copy the scale bars at the same time, so they will correctly reflect the new scale.

If you are marking roads, trails or boundaries on the photocopied map, avoid obscuring the underlying feature with the mark. Pencil lines will usually allow the feature to show through as will highlighter pens.

There is nothing more frustrating than needing to know what is under a big black mark on your copy of the map.

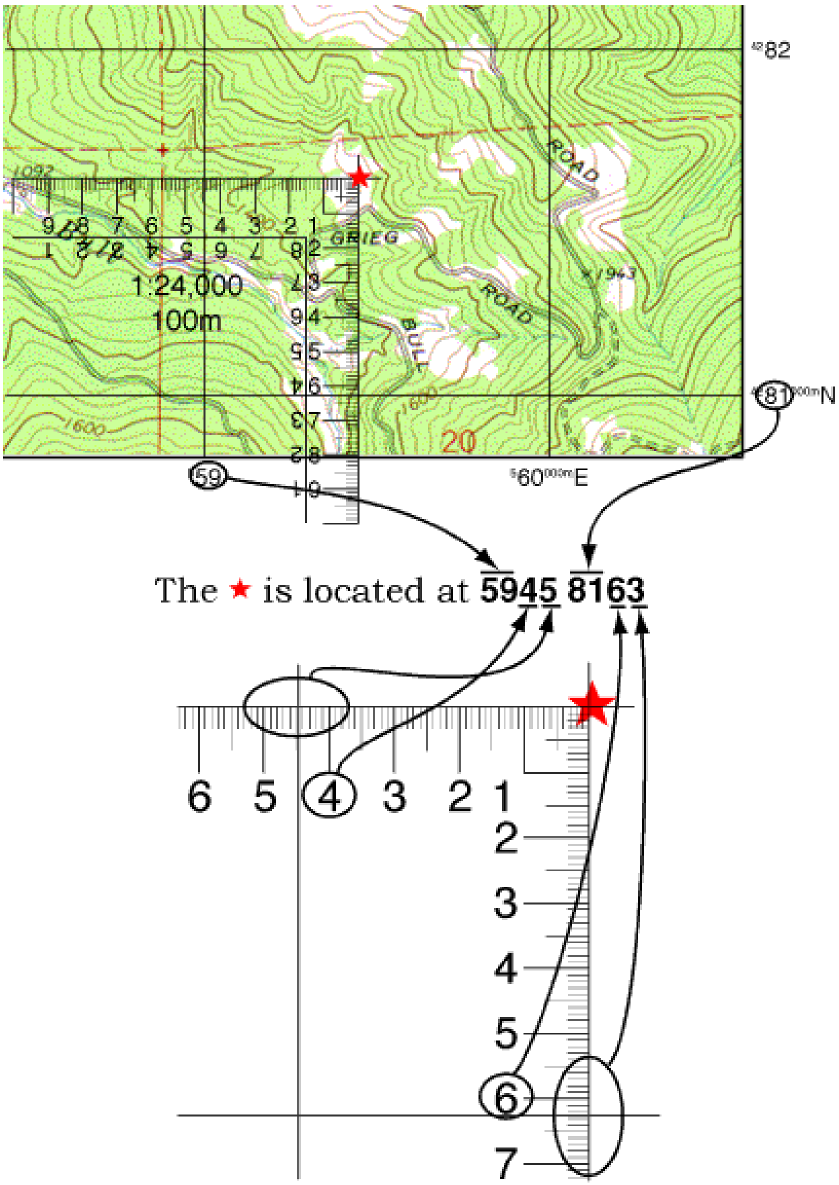
Using a UTM Corner Ruler

A UTM Corner Ruler consists of two scales at right angles to each other. UTM Corner Rulers will typically provide an additional digit of precision beyond a UTM Grid Overlay. On a 1:24,000 scale map you will be able to determine a position to within a 10m square. The trade off is that the Corner Ruler is somewhat harder to use.

Start by placing the top right corner of the Corner Ruler on the SW corner of the UTM grid that contains the feature. The ruler edges should extend to the West and South. To find the UTM coordinates of a feature marked on your map slide the rulers North and East until the corner is on top of the feature to be measured. Read the UTM coordinate values from the starting grid lines. To locate a UTM coordinate on the map slide the ruler North and East until the desired distances are indicated at the grid lines.

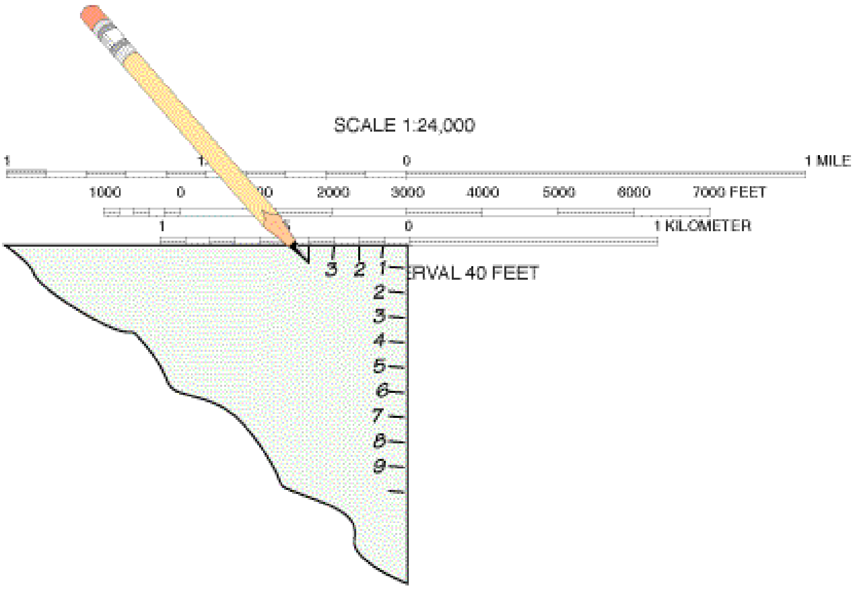
If the grid square you are using is on the edge of your map, you may need to start from a corner other than the southwestern one. You can still use the corner ruler, remember that UTM coordinate values increase from West to East and from South to North.

You should return to the exercise and try it using a 1:24,000 scale UTM Corner Ruler.



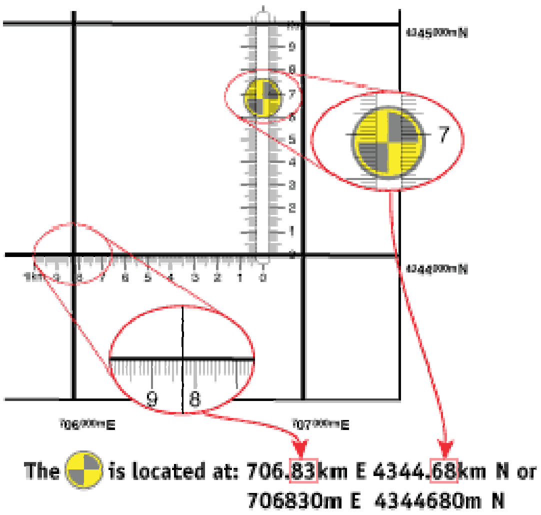
If you are using an odd scaled map or if you left your UTM tools behind, you can quickly make a simple corner ruler using the scale bars on the map.

Start with the corner of a scrap of paper. Mark off a one kilometer distance and the 100m subdivisions using the metric scale bar. Repeat this process along the other edge. Number both rules starting from the corner which would be zero.



Overlays containing UTM corner rulers for several different map scales are available from MapTools.

Using a UTM Slot Style Tool



Click the diagram for a larger image.

- Position the base of the tool on the southern grid line. Slide the tool E-W until the target is centered in the slot.
- Read the Easting value for the grid from the edge of the map.
- Read the additional Easting digits from the E-W ruler where it crosses the **western grid line**.
- Read the Northing value for the grid from the edge of the map.
- Read the additional Northing digits from the N-S ruler where it crosses the target.

Overlays containing UTM Slot Style Tools for several different map scales are available from MapTools.

Map Datums

A datum describes the model that was used to match the location of features on the ground to coordinates and locations on the map. Maps all start with some form of survey. Early maps and surveys were carried out by teams of surveyors on the ground using transits and distance measuring "chains". Surveyors start with a handful of locations in "known" positions and use them to locate other features. These methods did not span continents well. Frequently they also did not cross political borders either. The "known points" and their positions are the information that the map datum is based. As space based surveying came into use, a standardized datum based on the center of the earth was developed.

Every map that shows a geographic coordinate system such as UTM or Latitude and Longitude with any precision will also list the datum used on the map.

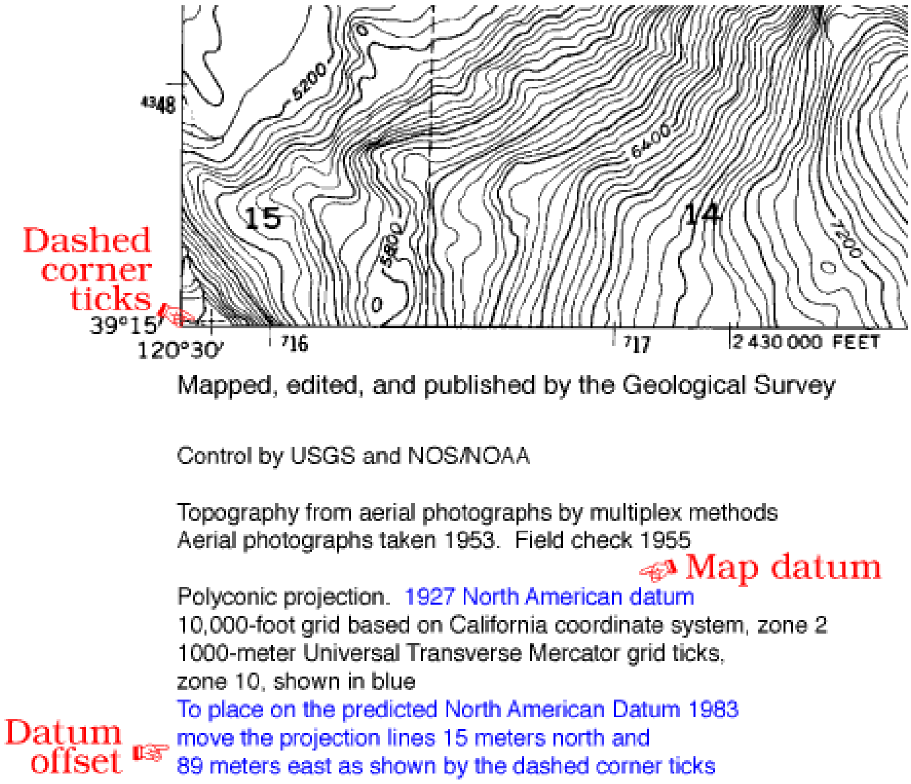
The Global Positioning System uses an earth centered datum called the World Geodetic System 1984 or WGS 84. WGS 84 was adopted as a world standard from a datum called the North American Datum of 1983 or NAD 83. For all practical purposes there is no difference between WGS 84 and NAD 83.

Most USGS topographic maps are based on an earlier datum called the North American Datum of 1927 or NAD 27. (Some GPS units subdivide this datum into several datums spread over the continent. In the Continental United States use NAD27 CONUS.)

In the Continental United States the difference between WGS 84 and NAD 27 can be as much as 200 meters.

You should always set your GPS unit's datum to match the datum of the map you are using.

On a USGS topographic map the datum information is in the fine print at the bottom left of the map. The datum will always be NAD 27. There may be information on how many meters to shift a position to convert it to NAD 83. Think of this as the error that will be introduced if you leave your GPS unit set to WGS 84. A dashed cross in the SW and NE corners of the map gives a visual indication of the difference between the two datums.



If you have somehow set your GPS to use the Borneo Datum of 1818, it's hard to say how far off you position may be. Let's just sat that this "datum thing" is something you need to pay attention to.

If you are coordinating with aircraft, they will likely have their datum set to WGS 84, as most aviation charts now use WGS 84. Should you worry about the difference in datums? Typically a pilot will not have any difficulty locating you on the ground if you can get them within several hundred meters of your location. If you are engaged in a mission that requires more precision, then your datums should match.

Useful Map Tools for Downloading

These pages contain freely downloadable grids, roamers, and rulers for plotting UTM / MGRS and latitude longitude coordinates. You'll also find scale bars, area estimators, and compass roses here.

If you work with maps very often then you will probably find some of these tools useful. The tools you see here have evolved from doing ground search and rescue operations in the United States. Some are small pocket sized tools and others are more suited to working at a desk or table.

My interest in maps and related tools evolved from my work as search and rescue volunteer. I am interested in teaching people how to make the best use of their maps, compass, altimeter, and GPS unit. Part of that teaching process involves having some simple tools available. This web site has evolved to fill that need.

All of the tools on this page can be downloaded in Adobe Acrobat (pdf) format. Adobe Acrobat is available for free, and runs on many different platforms. See below for information on downloading Acrobat Readers from Adobe.

The pdf format should preserve the size of the overlay when you print them. But, you should double check that your final printed version is the proper size! Some folks have reported problems with the smallest type on some of the tools being impossible to read. The best printed results will come from a high resolution Postscript printer.

How to make overlays from these files

To produce usable overlays you need to print directly onto or copy onto clear transparency film. Toner based printers and copiers will produce overlays that are prone to having the toner scratched off. Some folks have reported success laminating the transparency film to protect the image. We have been using an old "thermofax" machine and a heat based film, to avoid that problem. But don't get the thermal based ones too warm, or they'll turn black! The smaller overlays are available as one per page or with as many as will fit on a page. The clear stuff is expensive, so we put as many overlays as we can on each sheet.

Some of these tools are for sale printed on sturdy plastic cards

Many people find that overlays copied onto transparency fill are too flimsy; the toner wears off quickly under field conditions. Other folks don't have the stuff to print a nice crisp copy of the PDF files.

To find out which tools are available visit the **Map Tools Products** page.

If the scale you need isn't here, follow these instructions to create your own scale

These tools were designed using Adobe Illustrator on a Macintosh. The PDF files can be opened and edited in Illustrator running either on a Mac or Windows platform.

Maps come in all different scales. We have tried to include tools that work with the scales we use most frequently in ground search and rescue work here in the US. You may find that you need other scales. To scale an existing map tool to a different scale you should select a tool that is close to the scale you need, and then determine how much to scale it by. For example to turn a tool intended for a 1:24,000 scale map into one that would work with a 1:25,000 scale map.

24,000 / 25,000 * 100 = 96%

You can use Adobe Illustrator, the Acrobat Reader, your printer software, or a photocopier to print at 96% of original scale. Always double check your results against the map to make sure you get the correct results.

Get Acrobat to view and print these PDF files.

UTM Coordinate Tools
Estimating the size of an area
Scales & Rules
Latitude & Longitude Tools
Compass Roses