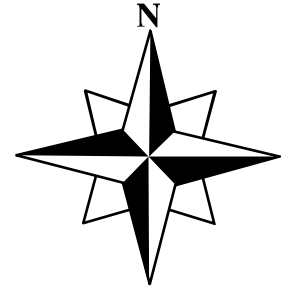




**Map and Compass  
for  
Eastern Michigan Region**



**Basic and Advanced Mountain Travel and Rescue**

Harry Frank

## MAPS

A map is any geographical image of the environment.

### **Cognitive (Mental) Maps**

Whenever we travel from one place to another (whether on an automobile trip across town or walking from one room to another) we make use of mental images that represent the route we intend to follow. These are called COGNITIVE maps. Cognitive maps are useful and functional, but our mental images of distances and direction don't always correspond to measured distance and direction. For example, ask yourself these questions<sup>1</sup>:

*What is the first foreign country you come to if you travel directly south from Detroit?*

*What direction do you travel if you take the Panama Canal from the Pacific Ocean to the Atlantic Ocean?*

*Guayaquil, on the west coast of Ecuador, is the most westerly large city in South America. If you travel directly north from Guayaquil, what is the first U.S. city you reach?*

### **Cartographic Maps**

Although cognitive, or mental, maps are useful enough for much of our everyday activity, other sorts of activities require EXTERNAL representations of the physical environment. These are called CARTOGRAPHIC maps. Many maps are *thematic*. These include political maps (that is, maps that show the borders of nations or states, etc.), demographic maps (that is, maps that show areas according to population characteristics--income, blood type, religion, etc.), hydrological maps, epidemiological maps, resource maps, and so on. For most recreational outdoor activity, the most useful type of map is designed to show the cultural and natural features of the land surface. These are called *topographic* maps.

### **Topographic Maps**

*National Topographic Map Series of the U.S. Geological Survey (USGS).* In the United States the most widely used "topo" maps are the Standard Quadrangle ("quads") series of maps published by the United States Geological Survey. A detailed explanation of USGS map symbols is available at <http://mapping.usgs.gov/mac/isb/pubs/booklets/symbols/index.html> on the web. A

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<sup>1</sup> Answers on page 11.

complete index of available USGS maps and locations where maps can be purchased are available at <http://mapping.usgs.gov/mac/findmaps.html> or write to

USGS Information Services  
Box 25286  
Denver, CO 80225

*Scale.* The most widely circulated USGS topo maps represent distance in two scales. Map scale is shown on the bottom margin of the map.

▶ 1:24000: 1 inch on the map equals 24,000 inches of actual distance, i.e., 1 inch equals 2,000 feet.

A map in this scale represents a 7.5 minute quadrangle. A circle is divided into 360 degrees. Each degree is divided into 60 minutes. The horizontal distance covered by a 7.5 minute quad map represents 7.5 minutes along a line of latitude (a line parallel to the equator). The vertical distance represents 7.5 minutes along a line of longitude (a meridian--a line from the north pole to the south pole).

▶ 1:62500: 1 inch on the map equals 62,500 inches of actual distance, i.e., 1 inch equals approximately 1 mile (a mile is actually 63,360 inches).

A map in this scale represents a 15 minute quadrangle.

*Features of a USGS topo map.* The standard quadrangle map has symbols, lines and numbers that represent a variety of features.

▶ Man-made constructions--buildings, churches, cemeteries, radio towers, dams, power stations, roads, trails, etc.

▶ Vegetation

▶ Rivers, streams, lakes, marshes

▶ Elevation: The most distinctive feature of a USGS topo map is representation of elevation and change in elevation.

*"Checked spot" elevation.* A number beside an "x" represents a point where elevation has been measured by precise surveying methods but where no marker has been placed.

*Benchmark.* A number beside a  $\Delta$  or the annotation "BM" (benchmark) represents a "recoverable" mark--a point where elevation has been measured by surveying techniques and where a marker (usually a brass plate) has been placed.

*Contour lines.* A pattern of lines drawn through points of equal elevation. (If these lines are drawn below sea level they are called bathometric contours.) The distance between lines (contour interval) usually appears on the bottom margin of the map. On the most current 7.5

minute quads, the contour interval is 20 feet, but maps of mountainous regions may use a 40 foot contour interval.

When contour lines are close together on a map, the slope is steep. When contour lines are far apart, it ordinarily means that the slope is gradual. This principal, however, applies strictly to distances between the *primary* contours, which are shown as heavier lines with numbers indicating elevation. Primary contours are plotted by a technique called *photogrammetry*, which uses overlapping aerial photographs viewed through a stereoscope to give a three-dimensional bird's-eye view of the terrain. The viewer plots points of apparent equal elevation, and a pen mechanism connects the points. The thinner *secondary* contours are plotted by dividing the distance between primaries into five equal parts. This means that on a map with a 20-foot contour interval, a section of trail that drops gradually for 100 feet between primary contour lines might look the same as a vertical cliff face.

► Grid coordinates. Along the borders of your map you will see numbers marked beside (usually) blue "tick" marks. The numbers get bigger as you go from west to east (left to right) and as you go from south to north (bottom to top). These are grid coordinates in the UTM (Universal Transverse Mercator) system. The distance between ticks is 1000 meters. For example, the number <sup>5</sup>154 on the left or right border of a map indicates a line 5,154,000 meters (5,154 kilometers) north of the equator. If you divide the distance between any two ticks into tenths (either with a ruler or just by eyeball), they can be used to describe the position of any point on the map to within 100 meters, which is usually close enough to call in a rescue team.

To describe the position of any point on the map, first give the map name, which usually appears at the top of the map (e.g., Marquette Quadrangle). This allows you to ignore the little numbers (which are like a zip code and therefore unnecessary to find a particular address once you know you're in the right neighborhood).

Coordinates are given as a six-digit number, ABCDEF. The first three numbers (ABC) indicate the east-west location, and the next three (DEF) indicate the north-south location. The point ABCDEF is C tenths of the distance from the grid line numbered AB to the next east-west grid line and F tenths of the distance from grid line DE to the next north-south grid line. Remember that your coordinate "address" reads from left to right and bottom to top. Like Mae West said to W.C. Fields when he finally took her up on her famous offer, "Go right on up, big boy."

To find the coordinates of any point on the map, first draw a line from the point to the bottom (or top) of the map. Most of the time your line will intersect the bottom of the map between two grid lines. For example (see Figure 1), suppose your pencil line crosses the bottom of your map  $\frac{3}{10}$  of the distance from <sup>4</sup>65 to <sup>4</sup>66. Find the nearest grid coordinate to the left of

your line. the BIG numbers are the first two digits of your location. The third digit is the fraction of distance from <sup>4</sup>65 to <sup>4</sup>66. the first three digits in this example would be 653.

Next, draw a line from the point on the map to the right (or left) side of the map. Find the nearest grid coordinate below your line. The BIG numbers are the next two digits of your location. The third digit is the fraction of distance to the next coordinate. In Figure 1, the (dotted) pencil line crosses the side of the map 8/10 of the distance from <sup>51</sup>56 to <sup>51</sup>57, so the last three digits would be 568.

In this example, you would report your position as 653568 on the Marquette Quadrangle.

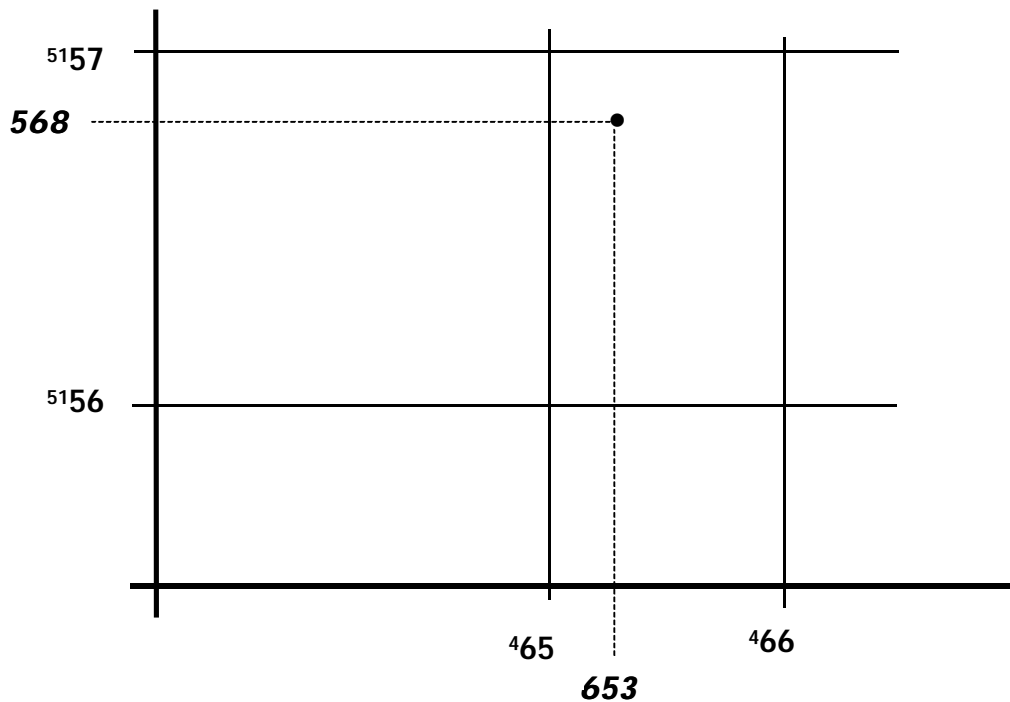


Figure 1. Schematic of Marquette Quadrangle.

## COMPASS

Get acquainted with your compass. Look at it, play with it, fondle it. It has several important parts: card, capsule, direction ring (or bezel), capsule lines or orienting arrow, direction of travel arrow, dummy cord (a piece of string with the compass one end and a dummy on the other), a magnetic needle, and an index mark.

## Reading Your Compass

Land navigation compass readings are usually given in one of two ways, *azimuths* or *bearings*. The more common is the azimuth, which is expressed in degrees (0 to 360) with 0 degrees corresponding to north.<sup>2</sup>

### Taking a Reading on a Landmark

- ▶ Point the direction-of-travel arrow at the object.
- ▶ Rotate the capsule until the needle is aligned with the orienting arrow or with the capsule lines. (If your compass has no orienting arrow, be especially careful that the NORTH end of your needle is pointing in the same direction as the NORTH ends of your capsule lines. The north ends of the capsule lines will be identified by color or by some sort of marking on your capsule.)
- ▶ The direction (azimuth) of the landmark is the number on the direction ring at the index mark.

If the numbers are on the capsule or if the direction ring rotates, you have a **DIRECT** read-out compass. The numbers increase as you read clockwise around the ring, so east corresponds to 90. On a compass of this type, the index mark does not rotate; it may be on the card or in the direction ring, but it is fixed.

If the numbers are on the card or if the direction ring doesn't move, you have a **REVERSE** read-out compass. That is, the numbers increase as you read counterclockwise around the ring, so east seems to correspond to 270. On a compass of this type, the index mark is on the capsule and rotates.

### Setting a Course

- ▶ Rotate the capsule until the direction (azimuth) you want to travel lines up with the index mark.
- ▶ Hold the compass in the palm of your hand and turn *yourself* around until the magnetic needle lines up with the orienting arrow or capsule lines.
- ▶ Travel in the direction indicated by the direction-of-travel arrow. This is easier said than done, especially on skis. Find some landscape feature that lies in your direction of travel and head toward it.

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<sup>2</sup> A bearing is always a number between 0 and 90 and must specify whether it is given in reference to north or south. An azimuth of 120 degrees would be given as a bearing of S 60 degrees E, meaning 60 degrees east of magnetic south.

## USING THE COMPASS WITH THE MAP

### Where is North?

All azimuth readings are in reference to north, but unlike a rose, it is not true that north is north. Some topographic maps give three different directions for north, and all USGS topo maps give at least two. These are shown at the bottom of your map as arrows labeled GN and MN. GN is geographic north (or "true" north). The geographic north and south poles are defined by the axis about which the earth rotates. On large-scale maps like the USGS quadrangle series maps, the north-south grid lines are oriented to true north. If you stood a camera on the geographic north pole and pointed it straight up and left the shutter open for 24 hours during the winter, all of the stars would show up as concentric rings with the north star at the center. On a world globe, the geographic north pole is that point where all the meridian lines intersect.

The arrow labeled MN at the bottom of the map is magnetic north. Because the core of the earth is primarily iron, its rotation creates a geomagnetic field. The north pole of this magnetic field lies about 900 miles south of the geographic pole (Prince of Wales Island). This is the north pole toward which your compass points.

### Declination

The difference between true north and magnetic north is called declination. The amount of declination is the angle between the arrows indicating GN and MN on your map. It varies from one part of the country to the other. If you draw a line from the geographic north pole through the magnetic north pole, declination will be 0° for all points that lie along this line. This is called the AGONIC LINE, and in the U.S. it runs roughly from the east coast of Florida through the southwest corner of Michigan. Remember: Your compass needle is attracted toward the agonic line (All roads lead to Rome, and all compasses point to Muskegon!). So, if you are east of the agonic line your needle is said to "decline" to the west; if you are west of the agonic line it declines to the east.

The further to the east or west you are from the agonic line, the more extreme is the declination. Also, the further north you are the more extreme the declination.

### Correcting for Declination

► The hard way. Learn all sorts of little rules for adding or subtracting a correction. "West is Best." Let's see, that means that if I have a western declination, I add a correction to my reading, and if I have an eastern declination I subtract the correction from my reading. O.K. I'm east of the agonic line, so I subtract . . . Wait, that's not right. If I'm east of the agonic line, it's a western declination, so I add. O.K. the map says fifteen degrees. If I add the correction . . .

Oops, no. I don't add it to the reading on the map, I add it to the reading I take on the landmark. . . . But isn't that the same as *subtracting* it from the reading on the map? No, you only subtract an eastern declination . . . . Try doing this after being out for 3 hours at 20 degrees, and you will learn why the string on your compass is called a dummy cord.<sup>3</sup>

►The expensive way. Buy a compass with a declination adjustment. In the warmth and comfort of your kitchen the day before your trip, read the declination on your map, and take 3 seconds to adjust your compass. Of course, if you are going on a trip that covers a lot of territory, you will have to do this several times. It's easy to forget and (outside the comfort of your nice warm kitchen) easy to make mistakes.

►The easy way (called the KISS method--Keep It Simple, Stupid!). Take a yardstick and extend the MN line on your map. Then draw a lot of lines parallel to it. That is, re-grid your maps so they are oriented to magnetic north. Then forget all about declination!

However you decide to correct for declination, it must be understood that every system has its drawbacks. Declination adjustments on compasses are seldom accurate to less than 2 degrees, and a couple of degrees can add up a big error over a long distance. Likewise it's easy to introduce a degree or two of error with your yardstick if you're regriding your map. It should also be emphasized that declination changes over time. Depending on how close you are to the agonic line, you should update your compass or maps every 2-5 years. Declination calculation programs are available for PCs and handhelds, and several websites allow you to punch in the location of interest (latitude and longitude) and the current date and return current declination. See, for example, <http://www.ngdc.noaa.gov/cgi-bin/seg/gmag/fldsnt1.pl> or [http://www.geolab.nrcan.gc.ca/geomag/e\\_cgrf.html](http://www.geolab.nrcan.gc.ca/geomag/e_cgrf.html).

### Getting from Here to There

The most basic skill with map and compass is figuring which direction to travel in order to get from point A to point B.

If you've taken the time to prepare your map by drawing MN lines all over it, it is very easy. Unless you're going to report your direction of travel, you don't even have to read an azimuth.

►Draw a line on your map from A to B.

►Lay the side of your compass card along this line with the direction- of-travel arrow pointed toward B.

►Rotate the capsule until the orienting arrow or capsule lines are parallel with the MN lines you drew (Be sure the NORTH ends of your capsule lines point north on your map!).

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<sup>3</sup> For every hour under these conditions, you lose a pint of water, an ounce of body fat, and 10 IQ points. By the end of the day you have the functional intelligence of a pet rock.

▶ To GET from A to B keep the needle of your compass lined up the orienting arrow (or capsule lines) and follow the direction of travel arrow.

### **Where *IS* Here?**

- ▶ Take a reading on a landmark you can locate on your map.
- ▶ Lay compass on map with the edge of the card on the landmark and the capsule lines parallel to MN.
- ▶ Draw a line along the edge of the card through the landmark.
- ▶ Repeat for a second landmark (and maybe confirm with a third).
- ▶ Your location is where the lines intersect.

### **USING THE COMPASS WITHOUT A MAP: THE P.A.U.L. SYSTEM**

Traditional techniques for using map and compass work best in varied terrain with prominent features (mountain peaks, escarpments, headlands, etc.) that can be identified on a map. Most of the lower peninsula of Michigan is what the U.S. Army classifies as featureless terrain. In addition, much of our camping, mountain biking, ski touring and hunting takes place over areas that are too small for even 7.5-minute quadrangle maps to be very helpful. Sometimes it may therefore be easier to use a mapless system devised by Special Forces Staff Sgt. Don Paul and described in his book, *The Green Beret's Compass Course: The New Way to Stay Found (Not Lost) Anywhere* (7th ed., 1991. Woodland, CA: Path Finder Publications).

The P.A.U.L. (positive azimuth, uniform layout) system requires only a compass, a watch, and a notebook. Basically, you shoot an azimuth every time you change direction, record the azimuth in the notebook, and record the length of time traveled in that direction. When you are ready to go home, you make a model of your route (the P.A.U.L. diagram, see Figure 2), using sticks, or string, or lines in the snow, letting one boot-width or other standard unit represent a fixed length of time (five minutes, 10 minutes, etc.). When you're done, you shoot an azimuth from the point on your model that represents where you are now (A) to the point representing your starting point (B). This gives your dead-reckoning azimuth. Then you step off the distance from A to B in boot-widths and multiply the number of boot-widths by the time interval that each boot-width represents. This gives you an estimated time of travel.

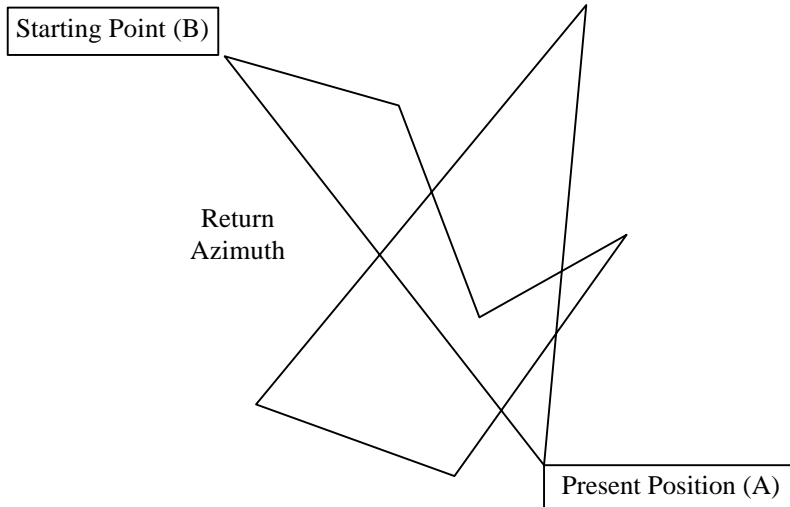


Figure 2. P.A.U.L. Journey Diagram

If you travel the calculated time along your azimuth and don't find your starting point (car, camp, orienteering stake, etc.), you can *box* your compass. Use a hat or some other object to mark the place where you begin and make a right-angle spiral around the spot, recording your travel time on each vector (See Figure 3).

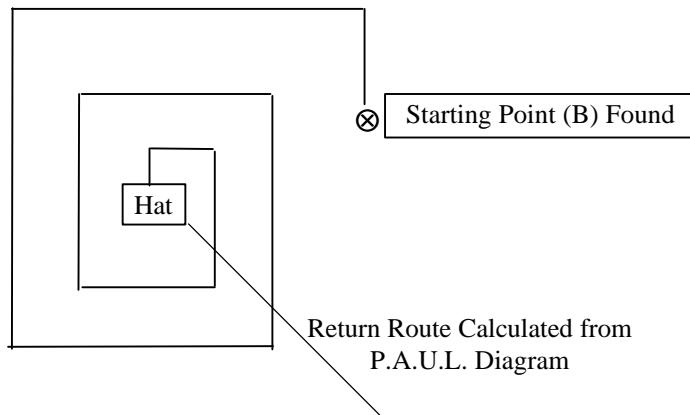


Figure 3. Boxing a compass at the end of your return route.

Don't worry about losing your hat. You can construct a P.A.U.L. diagram to get back to where you put it.

The basic assumption of the system is that *on the average*, 10 minutes (or 20 minutes or 30 minutes) of travel in any one direction covers about the same distance as 10 minutes (or 20 minutes or 30 minutes) in any other direction. This does not assume a uniform rate of travel. It assumes only that the terrain on any one leg of your route has about the same amount of uphill

travel, downhill travel, travel through heavy brush, flat unobstructed travel, and so on, as any other segment of your route. In relatively flat or rolling featureless terrain, this assumption is very reasonable, even for short travel segments. In more varied terrain, the assumption holds up better the longer each segment. Even in terrain with extreme and widely spaced changes in elevation (or density of ground cover or other features that affect speed), errors can be minimized by increasing the number of direction changes (e.g., zigzagging up a long incline and zigzagging down the other side). If the terrain requires long uphill or long downhill legs (as in negotiating a narrow mountain trail) or long stretches with other features that affect speed, the system can be fine-tuned to adjust the horizontal distance represented on the P.A.U.L. diagram.

In addition to errors that involve time and distance, calculations can also be thrown off by errors in reading or recording your azimuth. Noting the direction of each turn (right or left) is a good safeguard against accidentally recording your back-azimuth (e.g., 90 degrees instead of 270 degrees). Errors produced by simple lack of precision are essentially random and tend to cancel each other out if you make enough direction changes.

### GENERAL TIPS

▶ Don't lay a course directly for your objective. Pick out a "handrail," a prominent landscape feature that crosses your course--a treeline, a ridge, a fence, a contour line (if you have an altimeter) and set a course that is clearly to the right or the left of your objective.

▶ In flat or featureless terrain it is difficult to keep a direction-of-travel landmark in sight. Send one member of the party ahead to a preselected point. Use hand signals to keep him or her on the line of travel.

▶ Take periodic back azimuths--that is readings on an object that is 180° from your direction of travel, or a team member who remains at the spot from which you took your last reading.

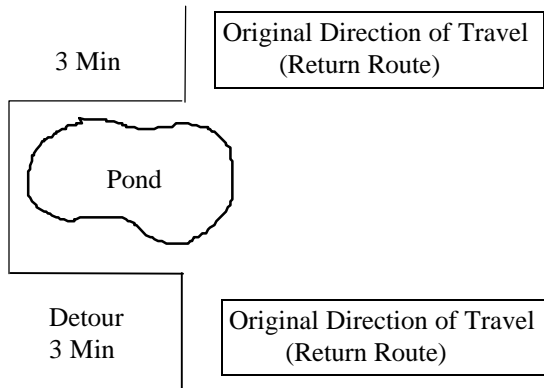
▶ Use a watch to keep track of distance. If you don't know your pace (which is the usual situation on skis) record the time it takes you to cover the distance between two landmark features you can find on your map and calculate your average speed. In featureless terrain, use time *instead* of distance.

▶ Vegetation can give you information. Tree species indicate changes in elevation, approach to drainages, etc.

▶ In many situations, the shortest route in time and effort is not the most direct route. It may be easier to head for some recognizable land feature *that is on the same contour line* as your objective and then follow the contour to your objective, as indirect as that course may be.

▶ In some situations, the most direct route may not be possible. Ponds, quarry pits, fences, dense stands of vegetation, and so on can get in the way. Box your obstacle, as shown in

Figure 4: Shoot an azimuth  $90^\circ$  to your direction of travel. Record the time traveled on that detour. When you are clear of the obstacle, resume your original direction of travel. When you have bypassed the obstacle, shoot an azimuth  $180^\circ$  to your detour. Travel in that direction for the same amount of time you detoured. Resume your original direction of travel.



*Figure 4.* Boxing an obstacle.

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