Navigating with Map and Compass

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Introduction

There are many types of maps and many types of compasses. We will focus on the types of maps and compasses most commonly used in search and rescue work. We will discuss map reading and the proper use of the compass. We will also discuss measurement systems and the two primary coordinate systems used in search and rescue. Finally, we will do a number of practice problems in the field.

No single class or book can make a person an expert with map and compass. The key to becoming proficient is practice in the field. Practice, practice, practice!

Maps

A good map is the most important tool you can have to orient yourself in the field. If you can see and recognize land features and find them on the map, you can navigate fairly well even without a compass. It is easiest to correlate geographic features to the map if you orient the map correctly (map N to true N).

The most frequently used maps for search and rescue work are topographic maps that show elevation contour lines. The most commonly used topographic maps are based on the USGS 7½ minute series. This is the type of map we will use in this class. The scale of a USGS 7½ minute map is 1:24,000 (1" = 2,000').

Map reading:

Become familiar with the legend and data at the bottom of the map, especially scale, declination information and UTM grid zone. The USGS topographic map color codes are:

Red: Major roads and survey data
Blue: Rivers, lakes, streams, springs, etc.
Green: Areas of heavy forest or vegetation
Brown: Contour lines (except blue contour lines for permanent snow and ice fields)
Purple: Revisions or additions to the original map
Black: Minor roads, trails, railroads, power lines, buildings, dams and other man-made features; also latitude/longitude, UTM grids, place names, borders and other data

When out in the field, compare actual terrain features with how they are represented on the topographic map. Learn to recognize how features such as peaks, valleys, saddles or passes, drainages, streams, cliffs and gentle slopes look on the map. With practice, seeing the contours of the land on topographic maps can be almost as good as looking at a 3-dimension relief map.

Coordinate systems:

USGS topographic maps have four different coordinate systems. They are:

California Coordinate System: in feet northing and easting, used by surveyors.
Township, Range & Section: used to describe property; a section is about a mile square.
Latitude/Longitude: Degrees, Minutes, and Seconds. A minute of latitude is about 1nautical mile.
UTM (Universal Transverse Mercator) used by military and SAR. Metric system (meters/kilometers).

Reading coordinates:

Latitude/Longitude: Latitude and Longitude are angular measurements from the center of the earth. Latitude starts at the equator and is measured North and South 90°. Longitude starts at the Prime Meridian and is measured East and West 180°. In the US we read the map up (N latitude), then left (W longitude). For example: the Nevada County Sheriff's office is at 39° 16' 13"N, 121° 01' 30"W.

Note that the lines of longitude are not parallel. They converge on each other as they approach the poles. At the equator, a minute of latitude and longitude are both about 1 nautical mile. But, at our latitude one minute of longitude is only about 3/4 of a nautical mile. The Lat/Long system is widely known and used, but it is difficult to describe an exact location and to transcribe accurately over the radio.

UTM: A metric coordinate system developed by the US military. The earth is divided into 60 zones, each 6° wide, beginning at the 180th meridian and numbered from west to east (we are in UTM zone 10). Each zone is then gridded into kilometers and meters. The grids in each zone are read from left to right (W to E), then from the equator up in the Northern Hemisphere. In the Southern Hemisphere, we also read left to right, and then up from 80°S. Always "**read right up**". The UTM system is easy to use, and locations can be described with fewer words and numbers and less chance of error.

The UTM grids are always the same size: 1 km square. However the grid does not align exactly with true north except at the equator and along the north-south centerline of each zone. Unless you are at or near the center of the zone, you should not use the UTM grid lines to determine north on the map. USGS maps tell you how much the UTM grid (grid north) varies from true north in the center of that particular map.

Using "Handrails":

Visible features such as roads, ridges, valleys, streams or power lines can often be used as "handrails' to follow when navigating. Search areas often use such features to identify one or more of the boundaries. If you are on such a feature that is shown on your map, you may be able to determine your exact position by sighting on only a single distant object (triangulation).

Measuring systems

Distance: measured in inches, feet, yards, miles, nautical miles, meters, or kilometers. Learn the relationship between yards and meters and miles and kilometers.

1 nautical mile = approx. 1.15 miles	1 meter = approx. 1.09 yds. (3'-3.375")
1 mile = approx. 1.61 kilometers	1 kilometer = approx. 0.62 miles
1,760 yards = 1 mile	1,000 meters = 1 kilometer

You can learn to estimate distances by pacing and by looking at objects at a known distance.

Angular: degrees, minutes, seconds are used both for headings and lat/long coordinates. Learn to estimate angles in degrees (0-360) by the compass and clock face (1hr = 30° on a 12 hour clock).

Compasses

There are many types of compasses including surveyors, mapping, marine and lensatic. For SAR use, we generally use bearings from 0 to 360° (don't buy a surveyor's "pocket transit" or "quad" compass). I recommend a mapping compass, calibrated 0 to 360°, with a clear base, rotating bezel and adjustable declination. A mapping compass that includes a sighting mirror allows more precise field bearings.

Declination:

The most important thing you must know about all compasses is that the needle does not point toward the North Pole. Rather, the north end of the needle points toward the magnetic north pole, which slowly moves. The magnetic north pole is now around Baffin Island, north of Hudson Bay in Canada. The direction our compass needle points is also affected by minerals in the earth's core and crust.

The angular difference between true north and the direction a compass needle points is called "declination". In this area the magnetic declination is now about 15° east. That means the compass needle points about 15° east of true north. USGS maps tell you what the declination was at the center of the map at the time the map was printed.

A good mapping compass will have a declination adjustment that allows you to set the declination for whatever area you are in. With the declination properly set, your compass will then give readings relative to true north. "Headings" or "bearings" are usually given relative to true north.

Using the compass:

To take a bearing in the field:

1. Hold the compass level, in front of you and away from radios or metal objects that could affect the needle.
2. If you are using a sighting compass with a mirror, hold it out at eye level with the mirror open about 45°. View the compass face in the mirror as you sight the compass. Be sure to align the indexing line on the mirror with the center of the compass (the needle pivot point or index marks on the base plate).
3. Rotate your body until the compass is pointing at the desired object (still keeping the compass level and the indexing line aligned with the center of the compass).
4. Rotate the bezel (compass housing) until the needle is aligned with the declination arrow. Be sure the north (red) end of the needle is at the north (pointed) end of the arrow. Note: If you are looking at the compass needle at an angle or through the sighting mirror, the needle may not appear to be centered over the declination arrow, but it is very important that the needle and arrow are parallel.
5. Read the bearing at the index mark on the base plate.

To follow a compass bearing in the field:

1. Set the desired bearing at the index mark on the base plate.
2. Hold the compass level in front of you and rotate your body until the compass needle is aligned with the declination arrow.
3. Sight on a distant object that is in the direction the compass is pointing and walk toward it.

To read a bearing from the map:

1. Draw a line between the two points of interest on the map.
2. Place the compass with one edge aligned with the line connecting the two points and the compass pointed in the direction of travel.
3. Rotate the bezel to align the north-south lines on the bezel with a north-south line on the map. Be sure that north on the compass bezel is toward the north edge of the map.
4. Do not be concerned with the direction of the compass needle or the declination arrow.
5. Read the bearing at the index mark on the compass base plate.

To plot a bearing on the map:

1. Set the desired bearing at the index mark on the base plate.
2. Place one edge of the compass base plate on the desired starting point.
3. Rotate the entire compass around this point until the north-south lines on the bezel line up with a north-south line on the map. Be sure that north on the compass bezel is toward the north edge of the map.
4. Do not be concerned with the direction of the compass needle or the declination arrow.
5. Draw the bearing line along the edge of the compass in the desired direction.

Triangulation:

By taking bearings on two (or more) identifiable geographic features such as mountain tops, passes, or lakes and plotting them on the map, you can pinpoint your location quite accurately. Triangulation works best if the identifiable features are approximately at right angles when viewed from your position.

Follow the steps above for taking a bearing in the field on the first point and for plotting that bearing on the map. Do the same for the second point. Your location will be where the lines cross. Using more than two points can improve accuracy.

Practice problems:

1. Read the coordinates of points on the map in both Lat/Long and UTM.
2. Plot a bearing on the map.
3. Determine the bearing between two points on the map.
4. Determine the number of paces you take to walk 100 yards and 100 meters.
5. Identify and take a bearing on a distant object.
6. Follow a compass course in the field by following given bearings and pacing off given distances.
7. Determine your position on the map by triangulation.

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