Chapter 6 - The Compass

Upon completion of this chapter, you will be able to:

- Explain the use of the 360 degree system in defining direction.
- Identify the parts of a compass, i.e.:
  - base plate
  - magnetic needle
  - orientation arrow
  - sight and sighting line
  - graduated dial
  - meridian lines
- Distinguish between magnetic north, true north and grid north.
- Adjust a declination adjustable compass for magnetic declination.
- Use a compass to take a bearing and to locate a given direction.
- Use a compass to take a back bearing.
- Explain factors affecting a compass, i.e.:
  - electrical currents
  - magnetic fields
  - ferrous metals
- Navigate around obstacles.
- Use aiming off to navigate to a point on a baseline.
- Make approximate measurements of distance through pacing and other techniques and know the limitations of these methods.

To better understand the information presented, have a compass and topographic map available to examine and use as each function and technique is described.

The Degree System

Before discussing the use of a compass, it is necessary to make clear the degree system of defining direction. A circle can be divided into 360 degrees. If one thinks of a person standing at the centre of a circle, the possible directions that a person can face can be defined in terms of 360 degrees. By convention, the direction of **True North** is 0° or 000 (also 360°), East is 90° or 090 (pronounced ZERO-NINE-ZERO), South is 180° or 180 (ONE-EIGHT-ZERO) and West is 270° or 270. A direction of Northeast, being halfway between North and East would be 045.

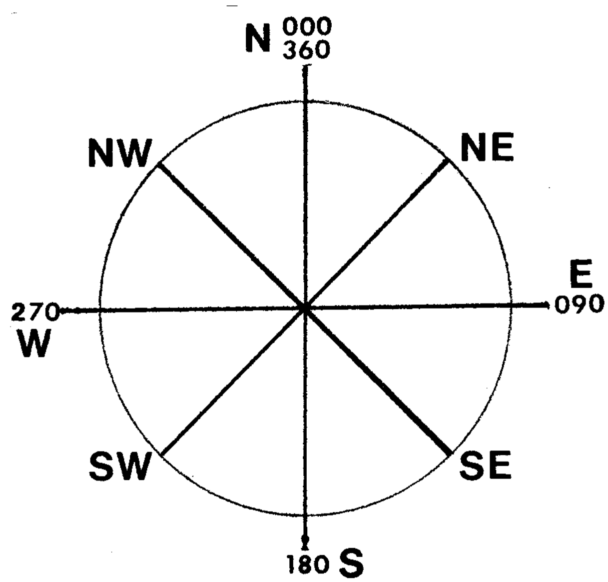

Figure 6.1

Directions defined in this way are called **bearings**. In theory each degree can be subdivided into minutes and seconds as well, but no situation in basic search and rescue will require such precision. In the discussion that follows, all bearings will be rounded off to the nearest degree.

Be aware that the Canadian Military use mils instead of degrees. Instead of dividing a circle into 360 degrees it is divided into 6,400 mils.

The Compass

PEP recommends the use of a declination adjustable compass for use in SAR work. Once the declination has been adjusted on the compass no calculations are required (declination is described on page 6-5). Several manufacturers make this type of compass. These compasses also have a hinged lid with a mirror as well as a transparent base plate.

Take your compass in hand and find each feature shown in Figure 6.2. The compass needle has a red and white end. The red end points in the direction of **Magnetic North** since the magnetic needle aligns itself with the magnetic field of the Earth and the magnetic field of the Earth focuses at the magnetic north pole. The compass housing is black (aluminum in older models) and can be rotated.

The compass needle is used to take bearings in the field and, as we will see in the map and compass chapter the meridian lines are used to take bearings from a map.

The use of the different parts of this compass will be explained in the sections that follow.

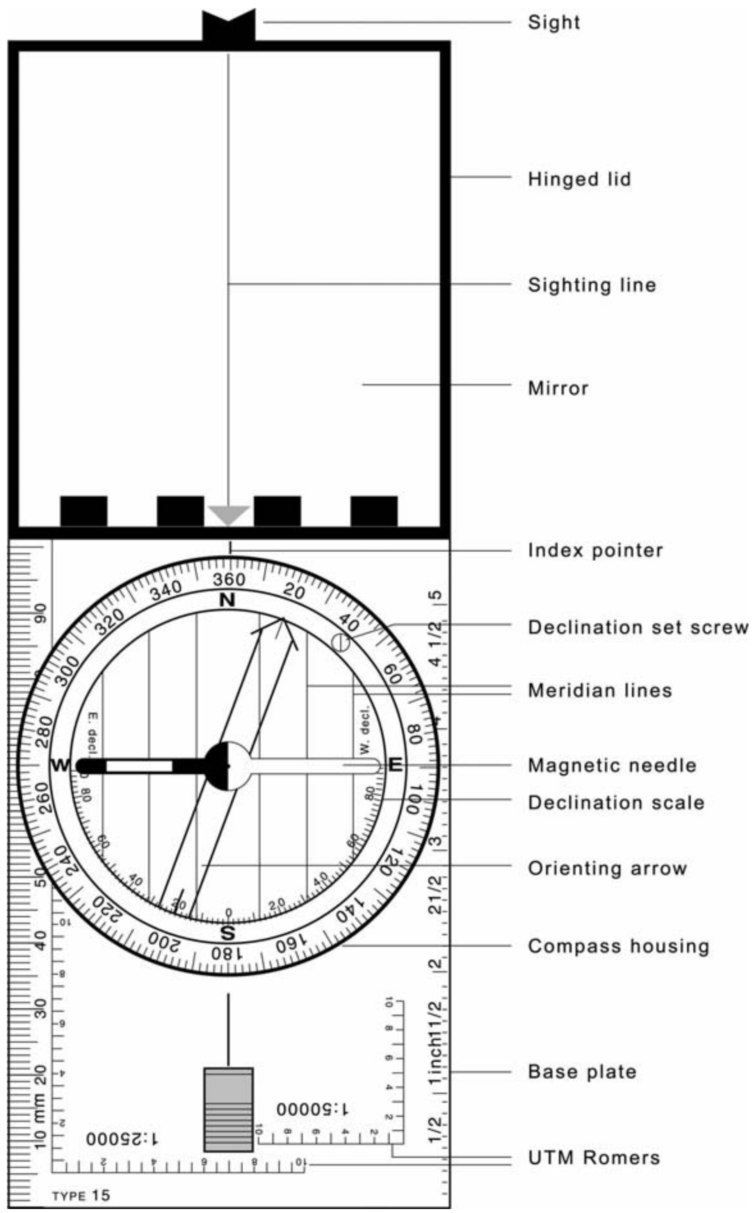

Figure 6.2 Features of the typical Search and Rescue Compass

Use of a Compass to Fix Direction

In the chapter “Maps”, we talked about true north, magnetic north and grid north. To review, **True north** is the earth’s geographic north pole. It is the point where the lines of longitude meet. The needle on a magnetic compass points to, and therefore establishes, the direction of **Magnetic North**. **Grid north** is the north direction in which the grid lines on your map point towards. True north, magnetic north and grid north are not in the same position.

Magnetic Declination

In order to fix other directions, the bearing of Magnetic North must be known. This bearing can be found on most maps and is the angle between True North and Magnetic North, known as the **magnetic declination**.

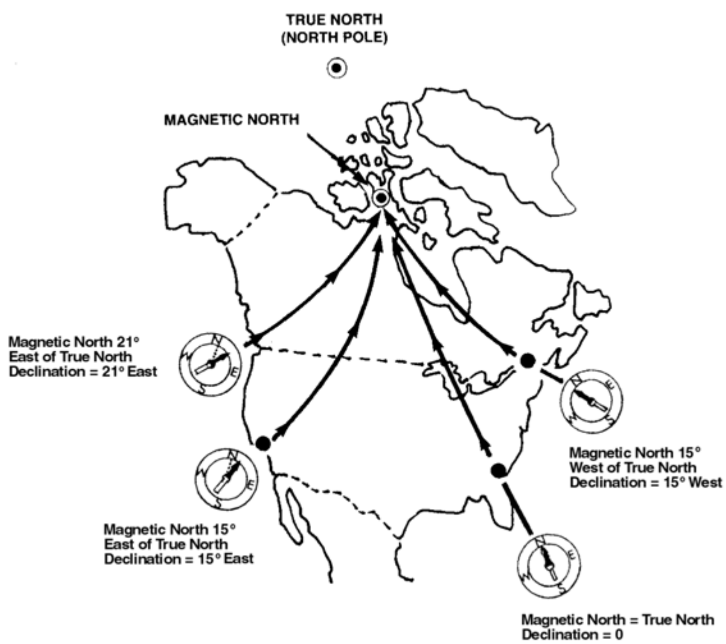

Figure 6.3a Magnetic Declination

Although this angle gives the theoretically correct value, the angle between Magnetic North and Grid North turns out to be much more important when using a compass in conjunction with a gridded map.

The data necessary to determine either angle is given in the information on the right margin of 1:50 000 maps. The grid bearing of Magnetic North is given directly, but the true bearing requires a subtraction or addition to be made. As all work done by ground searchers is likely to be in conjunction with a gridded map, **Grid North and the associated bearings will be used almost exclusively**.

However, the difference between True and Grid North must be remembered if talking to a pilot who understands North as True North.

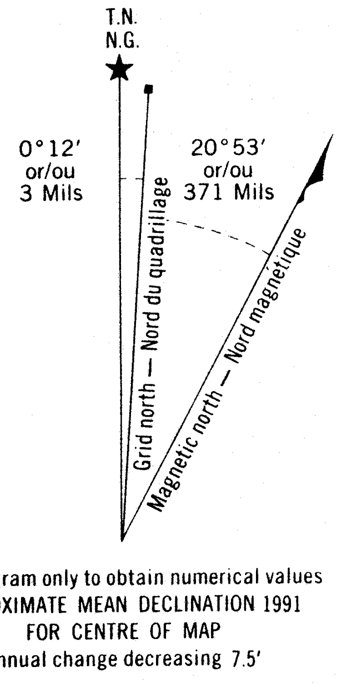

Figure 6.3b Map Declination Information

The amount of declination changes from year to year so a correction for annual variation of the declination must be made. A particular map might have the declination diagram shown above. The magnetic declination of Magnetic North relative to Grid North was 20° 53' in 1991. As this angle is decreasing by 7.5' annually, it has decreased by 52.5' (7.5' X7) by 1998. Converting 52.5' to minutes and seconds gives 52' 30". Thus, the 1998 declination would be 20° 00' 30" or a bearing for Magnetic North of 020 (accuracy down to 30" is extremely difficult with a compass). Various web sites are available that correct for magnetic declination.

Knowing that 020 is the direction in which the compass needle points, all other directions are fixed as shown in Figure 6.4.

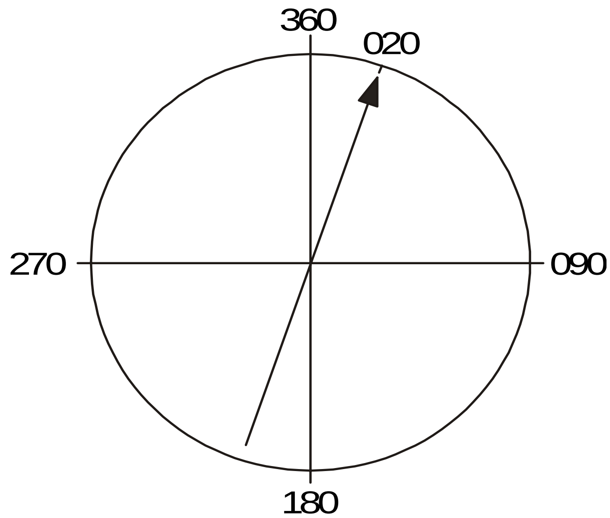

Figure 6.4 Magnetic Declination Fixes all Other Points

Although information is given to allow declination calculations to the nearest minute, rounding off to the nearest degree gives more than sufficient accuracy for most applications in SAR.

Websites are also available which will calculate the magnetic declination for a given point. One of them is maintained by National Resources Canada and is located at:
http://www.geolab.nrcan.gc.ca/geomag/e_cgf.html

Setting the Declination

A declination adjustable compass is designed to greatly simplify the problem of the difference between True/Grid North and Magnetic North. Once you set the declination for your area on the compass you do not have to pay any attention to it unless you move to a new map area.

In the inner circle of the compass, a scale that runs from 90° W decl. to 90° E decl. can be seen. If the setscrew in the compass housing at the NE position is turned with the attached screwdriver, the orienting arrow will move against this scale.

To correctly set the declination, the screw should be turned until the tiny mark in the **base** of the orienting arrow points to the known declination. In making this adjustment, it must be noted that the divisions on both the declination scale and the compass housing are 2°, not 1°, so a setting of 23° would be halfway between two divisions. When correctly set for a declination of 20° E, the orienting arrow and declination scale should appear as in Figure 6.5. The compass housing will be correctly oriented for Grid North.

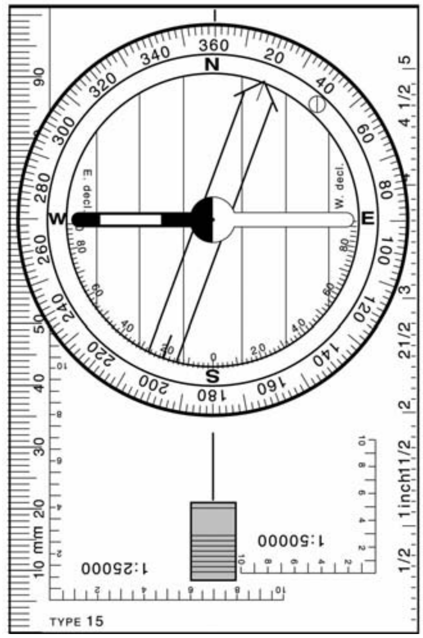

Figure 6.5 Declination Set for 20° on Newer Compasses

On some compasses (especially older models) the arrow end of the orienting arrow is adjusted until it points to the declination scale. The setup would appear as in Figure 6.6.

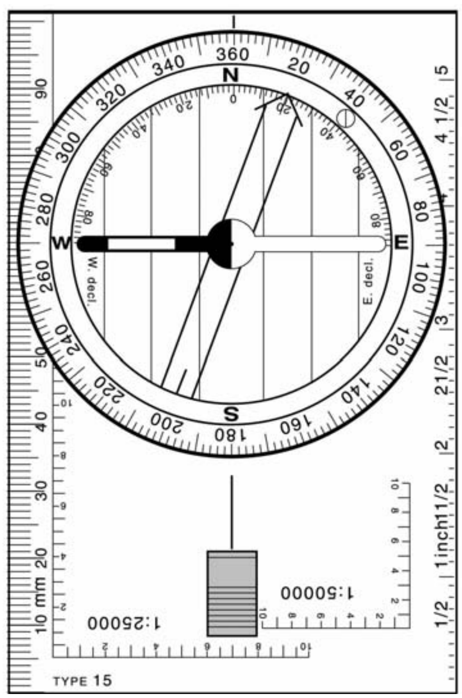

Figure 6.6 Declination Set for 20° on Older Compass

Bearing Relative to Grid North

Once the declination is set any bearings that are taken are relative to Grid North.

Taking a Bearing

On a search you may want to determine what the bearing is to a familiar landmark such as a mountain peak, from where you are located To take a bearing:

1. The compass has to be aimed towards the object that you want to take the bearing on. This can be done two ways.

   a) The quicker but less precise way is to hold the compass opened out flat and level at waist height with the mirror end away from you, and point the sighting line at the peak.

   b) Increased accuracy can be obtained by using the sighting method.

      i) Hold the compass at eye level and adjust the cover to approximately 45° so that the mirror reflects a top view of the compass dial. See Figure 6.7.

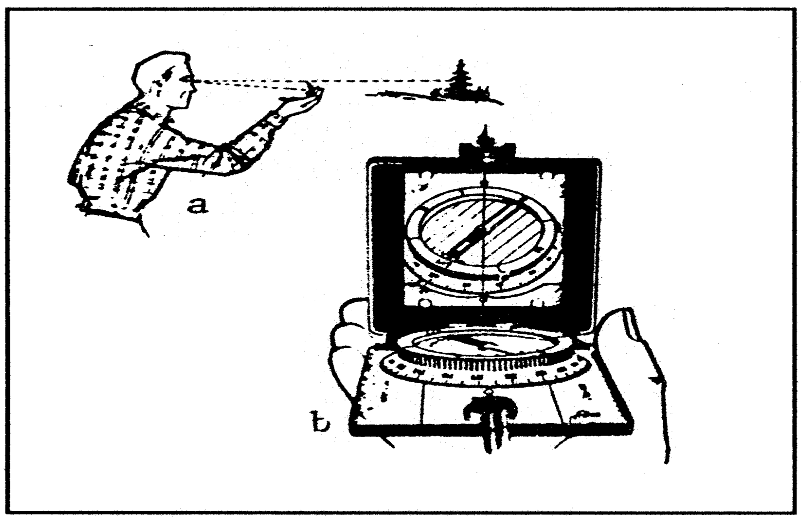

Figure 6.7 Sighting Method of Taking a Bearing

      ii) While looking in the mirror, move your sighting eye sideways until you see the sighting line intersect the two luminous points as in Figure 6.8.

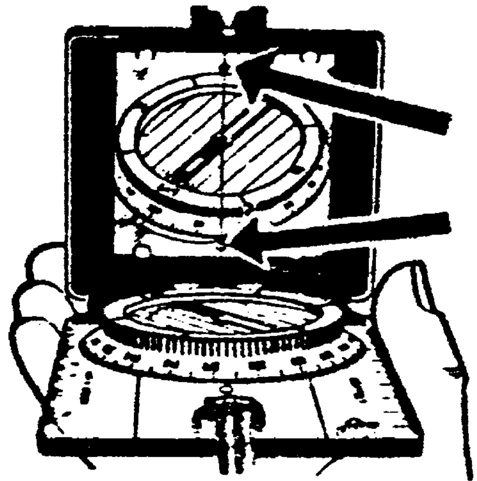

Figure 6.8 Sighting Line Oriented Correctly

2. While keeping the compass aimed toward the object turn the compass housing until the red end of the needle lies within and parallel to, the red end of the orienting arrow. Make sure the compass is level as the compass needle can “bind” and not move to the correct position if the compass is tilted.

3. The reading at the index pointer is the bearing of the object. Now that you know how to do it, step outside and take bearings on objects in all directions. Take the bearing both with the compass at waist height and with the sighting method. Remember that with the declination set these bearings are taken relative to Grid North.

How might you use this in SAR? If you were in the bush, and needed to know where you were, you could take bearings on recognized landmarks and triangulate your position. Triangulation will be covered in the chapter “Map and Compass”.

Taking a Back Bearing

A back bearing is the bearing from a landmark to where you stand. It is 180° opposite of the bearing from where you stand to the landmark. It is used in several procedures such as triangulation, returning back the way you came and in looking for magnetic anomalies. There are two ways to take a back bearing.

One way is to take a bearing on the object but instead of reading the bearing at the index pointer read the back bearing at the luminous line that is 180° opposite to the index pointer.

The other way to take a back bearing is to sight the compass at the landmark but line the white end of the compass needle over the red end of the orienting arrow (this is opposite of what you would do to take a bearing). Then read the back bearing at the index pointer.

Following a Bearing

Suppose your Ground Search Team Leader assigns you to be the compass bearer for a grid search, and says that you must follow a bearing of 135° (SE) for 300 m. To use your compass to follow a bearing of 135° you would:

1. Set the given bearing at your index pointer. In this case the compass housing is rotated until the index pointer between the mirror and the housing points to 135°.

2. Hold the compass level and turn your whole body around until the red end of the magnetic needle falls within the red end of the orienting arrow. The sighting line on the mirror now points in the135° direction. Figure 6.9 shows how the compass would appear when aligned in the direction of 135°.

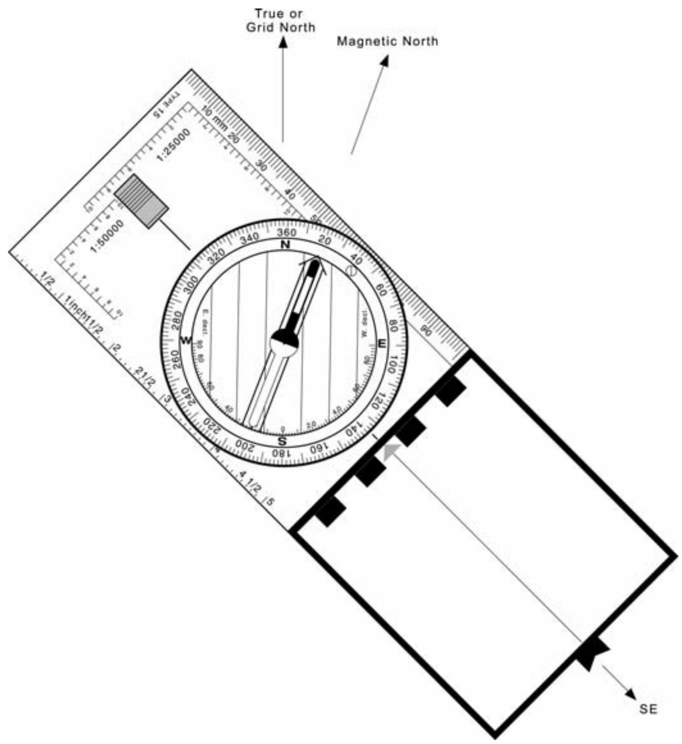

Figure 6.9 Appearance of Compass when Aligned for a Direction of Travel of 135° (SE)

3. Holding the needle exactly this way, find an identifiable object on the bearing that you can walk toward. This is often a tree, but it may be a rock, a bush, a peak, even a bend in the river or the end of a lake. The important thing is that you must not lose sight of it as you walk. If that could be a problem, choose something closer.

4. Once you have picked out an object at that bearing, walk to it. You don't need to look at your compass again until you have reached it. It is not necessary to climb over difficult obstacles: as long as you reach the object, you will be following the course.

5. When you reach it, sight again, and find a new object on that bearing to walk to. Keep repeating this process to continue along the bearing.

Lateral Drift

If you lose sight of your intermediate landmark and want to make sure you are still headed towards it, turn around and take a back bearing to your starting position. You will have to move one way or the other to line up the back bearing to your original starting position. Then turn around and take another bearing in your original direction. If you do not check your alignment when an intermediate landmark is lost, lateral drift can occur putting you off on a parallel course.

Considerable practice is essential if accurate bearings are to be consistently achieved. Setting and taking bearings using a compass without declination adjustment is described in map and compass books.

How Far off Course

For each degree of error you will be about 17.5 m off for each kilometre you travel. Therefore, if you are off 5 degrees on a 5 km hike, you will be 5° X 5 km X 17.5m = 437.5m. If you are thinking in miles and feet, then figure that you will be off about 92 feet each mile for every degree of error.

Problems in Following Bearings

Dense Bush In open country following a bearing will be easy. In dense bush, you may have to take repeated bearings at trees, or even individual branches, only a few meters ahead. And if you take your eyes off the bearing point for a moment, you may lose it. Remember, if you lose your intermediate landmark you are subject to lateral drift (see above).

Local Magnetic Attraction Your compass needle is magnetic, and may waver toward any large iron or steel object, or respond to local magnetic fields. If you are near a car, snowmobile, or outboard motor – especially if they are running – the needle may be way off. Inside a building, the wiring creates magnetic fields which attract the needle. If a rifle, knife, radio, battery powered watch, batteries, belt buckles or pacemaker is too close, it will affect the compass. Being near railroad tracks or power lines can also deflect the compass needle.

On land there are many places where magnetic anomalies occur due to magnetic ore deposits. The best test for influence by magnetic rocks or localized fields is the "**back bearing"** technique. When the compass bearer reaches the object that was sighted on the desired bearing, he may turn around and sight at the starting point. If the sighting has been done correctly and local magnetic attraction is not present, **the white end of the compass needle should be aligned over the orienting arrow.** If not, a more careful analysis will be necessary.

Fog and Snow In dense fog or heavy snow there may be no natural objects to take a bearing on. Mountaineers on snowfields have a method of following a bearing without reference points. On glaciers one person sights along a bearing, the other walks along the bearing until he is just at the limit of visibility. That person then acts as a target and the compass bearer can tell him to move right or left until he is exactly in line. The accuracy of the bearing can be improved by having the target person take a back bearing on the compass bearer and adjust for any error. The compass bearer moves to the target person then the target person moves out on the bearing again.

Navigating Around Obstacles

Often as you travel on a bearing you will reach an obstacle such as a lake, river or canyon that you need to go around. There are two ways to go around the obstacle.

If you can see across the obstacle, take a bearing on an obvious landmark on the other side. Before going around the obstacle make sure you can identify where your starting point is or mark the point with flagging tape (preferably biodegradable) or by breaking a branch. Walk around the obstacle to the landmark. Take a back bearing on your starting point to confirm that you are still on course.

If you cannot see across the obstacle then you will have to use another technique. Turn 90° from your bearing and follow this new bearing counting your steps until the obstacle is passed. Return to the original bearing and walk past the obstacle. Now turn 90° in the opposite direction from your original bearing and walk the same number of steps so that you return to your original course. Once the correct number of steps have been counted turn back onto the original bearing. This is outlined in Figure 6.10.

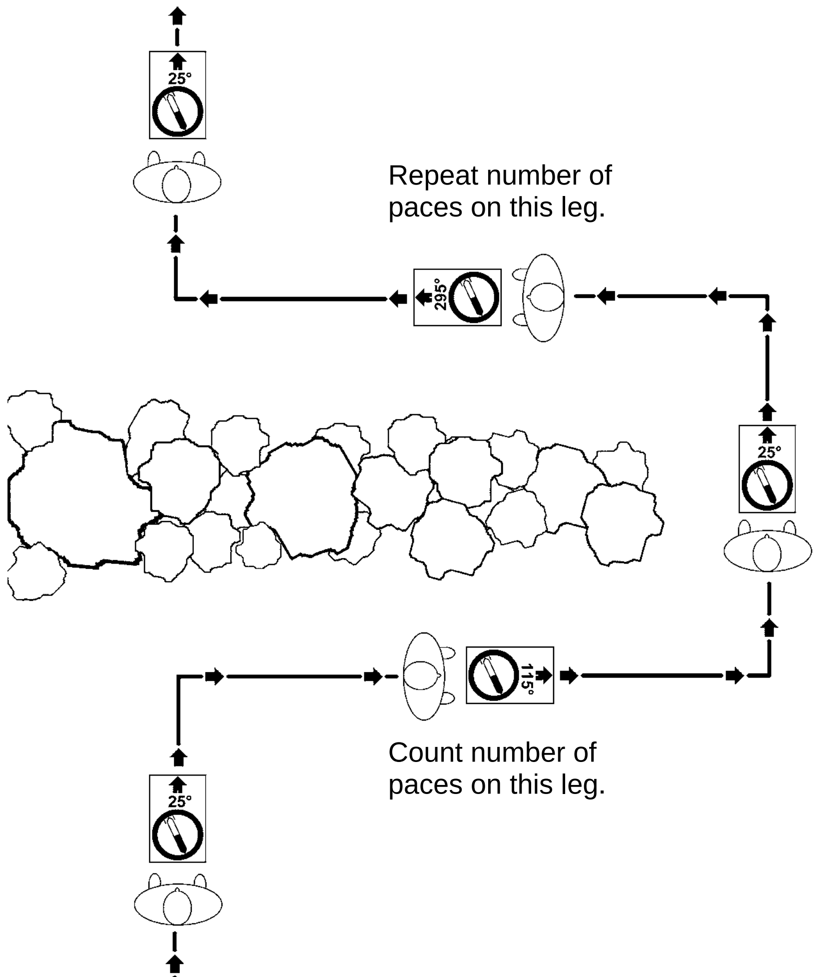

Figure 6.10 Navigating Around an Obstacle

Aiming Off (Deliberate Error Reckoning)

On occasion, a searcher may have to follow a bearing away from a baseline (also called a handrail) such as a road, trail, or shore, then return to the point of origin following a back bearing.

Following the back bearing is easy; don't change the original bearing, just put the **white** end of the magnetic needle in the orienting arrow instead of the red. The difficulty comes in finding the exact point of origin.

For example, if you left a car on a road and followed a compass bearing to a peak, then tried to return exactly to the car, you might well be off a few degrees. Arriving at the road, the car might be out of sight, and you would not know which way to look for it, because you would not know which way you were in error. If, for example, you were about 5° off at the end of 5 km (not hard to do), you would be about 437m from your target, and if you couldn't see it, you might walk in the wrong direction to locate it.

To prevent this, take a bearing 5° off one way or the other from the direct back bearing. In other words, make an intentional error. Then, when you hit your baseline, you will know which way to turn even with the inevitable error in compass work. This is called aiming off or deliberate error reckoning.

Aiming off can also be used when travelling along a route. Identifying “handrails” which are well defined features that can be easily recognized and followed such as creeks, cut lines, and cliff bands. Aim off to the handrail and follow it to your desired destination.

It must be noted that aiming off only works if the point to be located is on a handrail (baseline). It does not work for locating a small point surrounded by non-descript terrain.

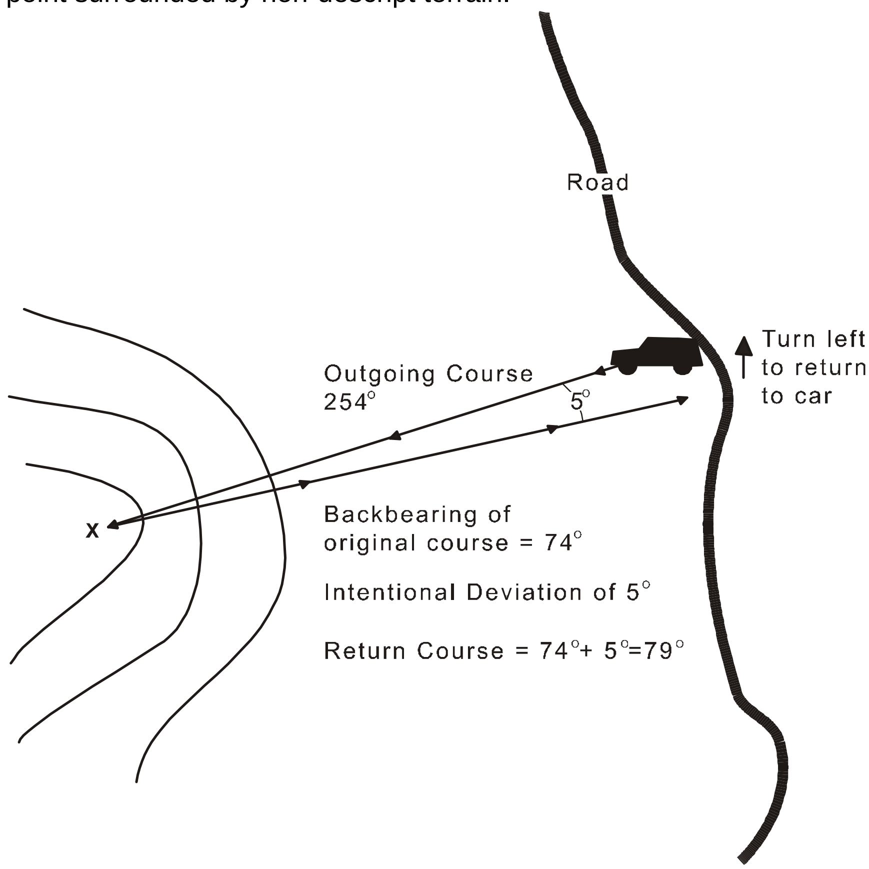

Figure 6.11 Aiming off to Return to a Baseline

Distance Measurement

Dead Reckoning: During early stages of a search, accurate measurement of distance is rarely needed. “dead reckoning”, or knowing your speed and elapsed time, is usually adequate to tell you how far you have traveled.

For example, if you estimate that you are moving one km every 20 minutes and you then walk for 40 minutes, you may reasonably expect to have gone about 2 km. This method is imprecise, but frees your mind for the search. When only a few searchers are in the field, as there is at the start of most searches, you may need every bit of attention for the search, rather than careful distance calculation.

Clearly, time will vary with the nature of the terrain and the vegetative cover. While you might travel 1 km in only 8 minutes on open ground, it might take 3 or 4 times as long in heavy bush or steep country. Elapsed time estimates improve with experience.

Frequent Position Fixing: By determining your exact position on the map whenever an opportunity presents itself, you can keep yourself oriented with respect to distance. A combination of Dead Reckoning and Position Fixing is often used, and makes it easier to spot landmarks. (Position Fixing with compass is described later). Increasing use of Global Positioning Systems (GPS) makes this much quicker and easier than position fixing with a compass.

Pacing

When accurate distance measurement is necessary, as in flagging grid search boundaries or plotting uncharted trails and maps on a Search Status Map, and no GPS is available, pacing is the most practical method.

How to Pace: Measuring distance accurately by pacing it requires considerable experience. Not only does every person have a different sized pace, but the size of a person's pace (or step) will depend on his speed and type of ground he is traversing. To obtain information about one's pace it is desirable to travel previously measured distances and count one's pace to travel these distances. The effect of varying speeds, of rough ground, and of slope should all be investigated. The figure that should be obtained in each case is the number of paces or steps that are required to travel 100 m. **The use of the pace (2 steps) or the single step as the counting unit is optional.** A person might find that on smooth, level ground, 122 steps (or 61 paces) are required to travel 100 m. Thus to walk 400 m at this rate would require counting 122 steps (or 61 paces) 4 times.

It is not necessary for all members of a search team to be proficient in pacing, and indeed, many of us do not have the mental math skills to calculate on the move. Some searchers carry tiny hand calculators to make the process easier.

In order to measure distance with reasonable accuracy by pacing, you must first find the number of paces, (or steps, whichever you prefer) is required to travel 100 m. over the type of county you will be measuring.

First, measure a course of 100 m over ground typical of what you will be walking. You can also measure a course of 50 m and multiply by two. Don't choose the smoothest or least vegetated ground – take something that fairly represents the real terrain.

Walk the course counting your paces or steps. It is critical that you take normal steps! Don't try to stretch them to an even meter. If you have walked out 100 m, walk and count it back again, and average the two if there is a difference.

You now have the number of steps it takes you, and you alone, to walk 100 m. If, now, your SAR Manager tells you to follow a compass course for 400 m, you simply multiply your 100 m step count by 4.

Odd distances are only slightly more complicated, but will probably require a pencil and paper. If you need to measure, for example, 170 m, then you simply multiply your 100 m step count by 1.7. If you need to measure 520 m, by 5.2, etc.

Using the Hip Chain

An excellent tool that is coming into increasing use in SAR is the hip chain. It is a device used by resource agencies and prospectors to measure distance and lay out lines on the ground. It is a plastic belt case containing a spool of thin string and a measuring device that registers as the string is paid out. The user simply ties the string at this starting point, and can then read his counter at any time to determine how far he has gone. This method is more exact than pacing if a reasonably straight line can be maintained.

In the US, some teams have developed a technique of encircling a high-probability search area with hip chain string. A helper follows the hip chain carrier and attaches paper arrows to the string that indicates the way out. If the search subject then runs into one of these, he is guided out.

The hip chain is also excellent for laying out lines for a closed-grid search, in place of flags. Biodegradable string is available and should always be used, as it is quite difficult to pick up all the string once laid.

Hip chains are not commonly carried by search teams at this point because their cost – around $100 – but are extremely useful. Obtaining hip chains would be a good target for SAR societies' fund raising events.

Additional Resources

Graydon, Don, and Hanson, Kurt. *6th Edition, Mountaineering, The Freedom of the Hills.* Seattle, WA: The Mountaineers, 1997.

Kjellstrom, Bjorn. *Be Expert with Map & Compass.* New York, NY: MacMillan General Reference, 1994.

Seidman, David. *The Essential Wilderness Navigator.* Camden, MD: International Marine/Ragged Mountain Press, 1995.

Declination calculation:
http://www.geolab.nrcan.gc.ca/geomag/e_cgf.html

Further references listed in the Bibliography.

Chapter Review

Please answer the following questions on a separate sheet of paper so that another student can use this manual. The answers to these questions are located at the end of the manual.

1. What is the difference between grid north, true north and magnetic north? Which ones are used in SAR?
2. Why are declination adjustable compasses used in SAR?
3. Is the declination adjustment scale on your compass at the point of the arrow or at the base of the arrow?
4. What are the two ways to aim the compass when taking a bearing? Which is more accurate?
5. What can cause local magnetic attraction?

Answer **True** or **False** to the following statements.

6. Back bearings are 90° from the bearing.
7. True north and its associated bearings will be used exclusively in SAR.
8. It is important to keep the compass level while taking a bearing.
9. Back bearings can be used to prevent lateral drift.
10. Declination is a constant, over time, in any given area.