

Section 2



LAND NAVIGATION

Key Points

- 1 Understanding Azimuths
- 2 Converting Azimuths and Determining the Grid-Magnetic Angle
- 3 Intersection
- 4 Resection
- 5 Polar Plot
- 6 Determining Distance on a Map
- 7 Understanding OAKOC

Being in the right place at the prescribed time is necessary to successfully accomplish military missions.

From Field Manual 3-25.26, Map Reading and Land Navigation

Introduction

In previous lessons, you learned how to read the topographic and other symbols on maps and how to plot grid coordinates. You also must be able to determine which direction you are facing and which direction you must go to arrive at your destination.

Direction is important to every Soldier in the field. It is not enough to know generally which direction is north, south, east, or west. You will need much more precision than that to get where you are going and avoid danger.

Picture an angle in your mind. At the vertex (where the sides come together), the two sides or rays of an angle are close together. The farther you go along either, however, the farther apart the sides are. This is what happens when you are not traveling in the precisely correct direction. The farther you move, the farther off course you will be.

This section will introduce you to additional concepts and skills you will need to navigate precisely and safely, to ensure that the above scenario doesn't happen to you.

In the middle of a battle, your ability to navigate is crucial if you are to direct reinforcements or call in artillery or air support. A sergeant proved this in 1967 in the Battle of Hill 823 at Dak To, Vietnam.

Reinforcing Company D

At the time when Company D [under attack from North Vietnamese regulars] had radioed its request for permission to follow an enemy communications wire, Captain [James J.] Muldoon [Company A] was monitoring the net. He was also in radio contact with Sergeant David Terrazas when the latter first came up on the tail of Company D, and he had directed the sergeant to join Company D temporarily.

A few thousand meters to the west, the men of Capt. William J. Connolly's Company C also labored to close on Company D. At 1400 Colonel [James H.] Johnson directed Connolly to clear the high ground above Captain [Thomas H.] Baird's embattled perimeter to relieve enemy pressure from the west.

A half hour later Johnson ordered Muldoon to reinforce Company D. At the time the captain was heading toward a selected night defensive position, but he turned and headed west toward the knoll where Baird's company was pinned down. From across the valley Terrazas kept his commander posted on what he could observe of enemy activity between the rear of Company D and the advancing Company A column.

Because the distant sound of automatic weapons, artillery, and air strikes appeared to have a retarding effect on the progress of the leading platoon of irregulars, Muldoon directed 1st Lt. Warren M. Denny to move his point fire team to the head of the column, following it with the balance of his platoon. The Montagnards [irregular anticommunist fighters] moved to the side of the torturous trail to allow the rest of the company passage and re-formed at the rear of the column.

As the company moved across the valley, it became increasingly necessary for the four-man point to break trail, frequently by hacking a way through clumps of bamboo. Captain Muldoon ordered his men to drop their rucksacks in order to lighten their loads, planning to return for them once his men had reached Company D and eliminated the enemy threat. Coming up from the valley onto higher ground, the point was in line and the going was somewhat easier.

Two point men, Spec. 4 Herman L. Slaybaugh and Pfc. Dennis T. Ridders, were the first to spot three North Vietnamese soldiers walking in file. Their attempt to stalk the enemy was frustrated when Lieutenant Denny, who had tried without success to reach his point by radio, shouted to them. Startled, the North Vietnamese ran for cover and the point had to open fire, prematurely, hitting only one of the three enemy soldiers.

From up on the ridge Terrazas heard the shots. Taking a compass azimuth toward the sound, he provided his company with an approximate back azimuth to Company D. Shortly thereafter, the point discovered the same enemy communications wire that had led their comrades into a fight, and the pace quickened.

Allan W. Sandstrum

Critical Thinking

At what azimuth would the 10 be? The 11? The 5?

Understanding Azimuths

Army Field Manual 3-25.26, *Map Reading and Land Navigation*, defines **azimuth** this way:

An azimuth is defined as a horizontal angle measured clockwise from a north base line. This north base line could be true north, magnetic north, or grid north. The azimuth is the most common military method to express direction. When using an azimuth, the point from which the azimuth originates is the center of an imaginary circle. This circle is divided into 360 degrees or 6400 mils.

Think of yourself as standing in the middle of a clock face. Think of the clock numeral 12 as at the north side of the clock face. If you face the 12 (north), the 3 is on your right (due east), the 6 is behind you (due south), and the 9 is on your left (due west).

Azimuths work in much the same way as the clock numerals, although with greater precision. Instead of 12 points to your compass, you have 360. Again, think of yourself standing on the clock face. The 1 is to your right front at an azimuth of 30 degrees. The 8 is to your left rear, at an azimuth of 240 degrees.

Determining a Grid Azimuth Using a Protractor

You can determine an azimuth using a map (a *grid azimuth*) or a compass (a *magnetic azimuth*).

To determine a grid azimuth, first identify your start point on your map. Use a sharpened pencil and mark your start point as Point A. Then identify your end point on your map. With that same sharpened pencil, mark the end point as Point B.

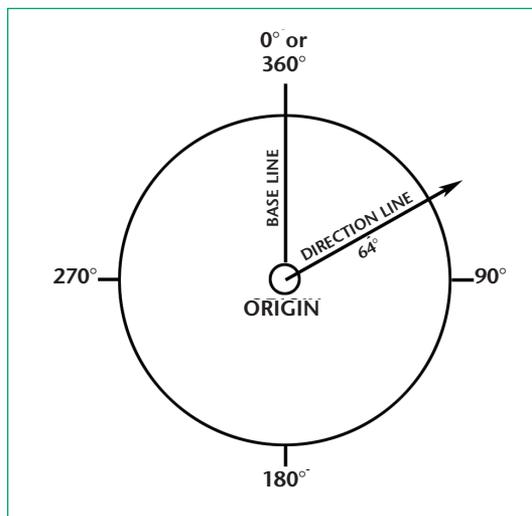


Figure 2.1 An Azimuth as a Horizontal Angle Measured Clockwise From a North Base Line

azimuth

the horizontal angle, measured clockwise, by degrees or mils, between a reference direction and the line to an observed or designated point—there are three base (reference) directions or azimuths: true, grid, and magnetic azimuths

Degrees and Mils.

This discussion will explore and measure azimuths in degrees. Mils—pronounced mills—become important in field artillery, tank, and mortar gunnery.

The terms azimuth and direction are interchangeable.

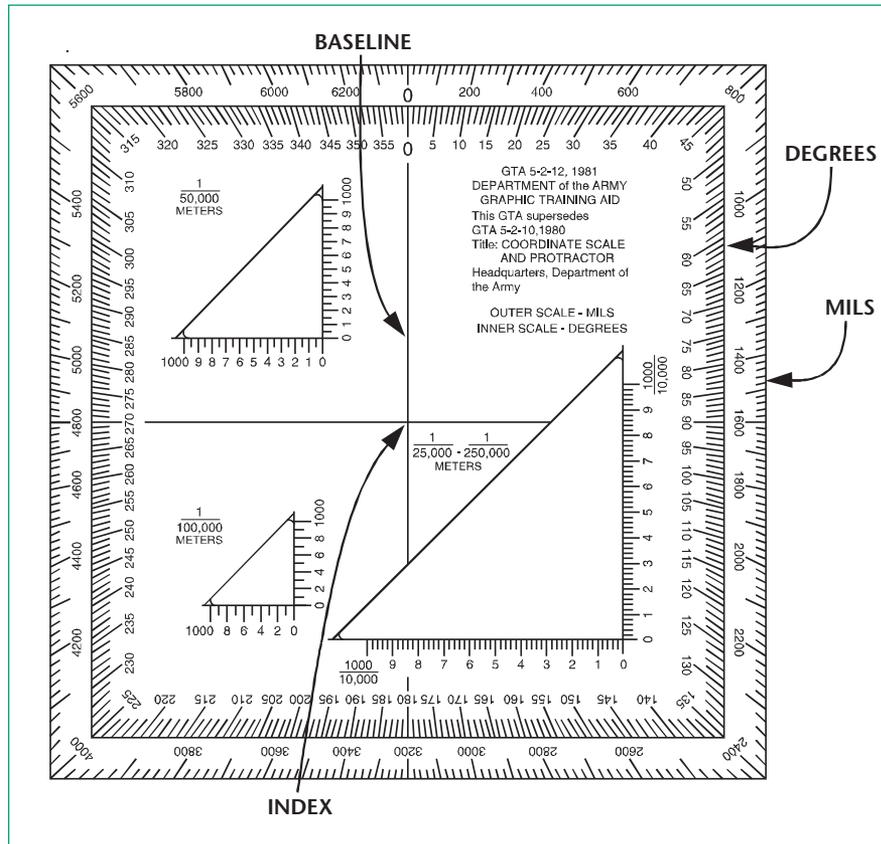


Figure 2.2 Army Protractor (GTA 5-2-12, 1981)

Be sure to note whether you are looking at the degree scale or the mil scale on the protractor.

Use the edge of your protractor (see Figure 2.2) to draw a straight line between Points A and B. That line is your azimuth. (You may want to extend the line to make it long enough to allow you to use the protractor.) Now you must determine the grid azimuth of that line—the angle between the line and grid north.

Make sure the 0 or 360-degree mark of your protractor is toward the top (or north) of your map. Make sure the 90-degree mark is toward the right (or east) of your map. (Because the protractor is made of clear plastic, it is easy to make a mistake and orient the protractor in the wrong direction.)

To determine your grid azimuth:

1. Place the index (cross hairs) of your protractor (where the etched vertical line and the etched horizontal line meet) at the point where the line you drew crosses a vertical, north-south grid line.
2. Keeping the index at this point, line up the 0-to-180-degree line, or *base line*, of the protractor on the vertical, north-south grid line.
3. Read the value of the angle from the scale: This is your grid azimuth from Point A to Point B.

You would use the same steps as above if you needed to plot an azimuth, such as if you received an order to move in a certain direction from your present location with no end point specified or for an undetermined distance.

Critical Thinking

What would be the back azimuth of 180 degrees—due south?

Determining a Back Azimuth

A *back azimuth* is the opposite direction of an azimuth. If your azimuth is less than 180 degrees, add 180 degrees. If your azimuth is more than 180 degrees, subtract 180 degrees. For example, the back azimuth of 38 degrees is 218 degrees. The back azimuth of 315 degrees is 135 degrees.

You should exercise extreme care when adding or subtracting 180 degrees. A simple mistake in arithmetic could lead to disaster.

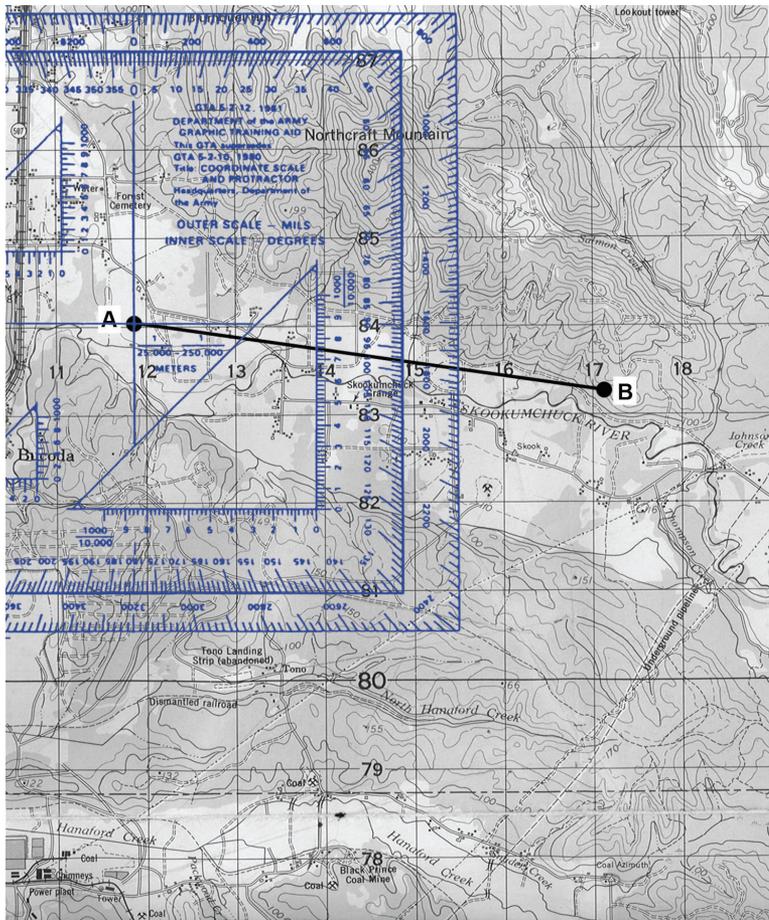


Figure 2.3 Measuring an Azimuth

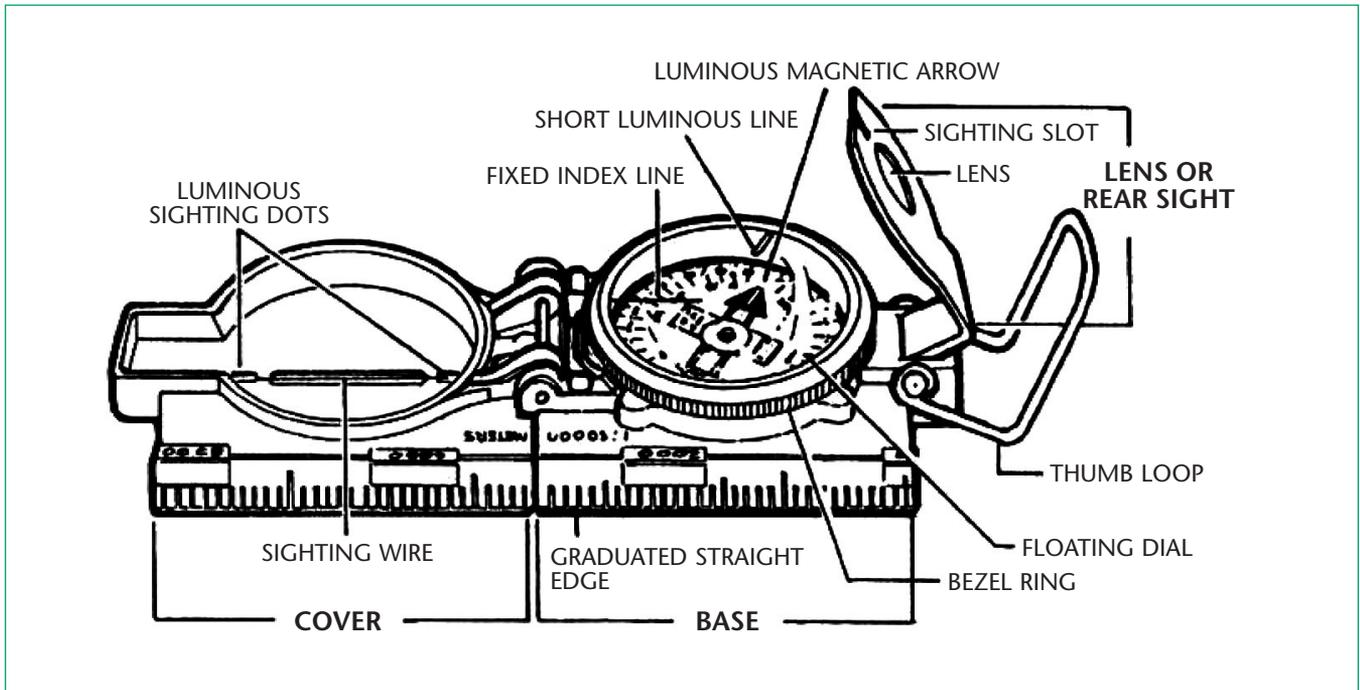


Figure 2.4 Lensatic Compass

Determining a Magnetic Azimuth Using a Compass

A *magnetic azimuth* is an azimuth determined using magnetic instruments, such as a compass. The Army uses several different kinds of compasses—this discussion will focus on the *lensatic* compass, pictured in Figure 2.4.

You can determine a magnetic azimuth using these five steps:

1. Open your compass so the cover forms a straight edge with the base. Move the lens (the rear sight) to the rearmost position. The dial will float freely.
2. Place your thumb through the thumb loop, form a steady base with your third and fourth fingers, and extend your index finger along the side of the compass.
3. Place the thumb of your other hand between the lens (rear sight) and the bezel ring; extend your index finger along the remaining side of the compass, and your remaining fingers around the fingers of your other hand. Tuck your elbows into your sides. The compass will be between your chin and your belt (see Figure 2.5).
4. Turn your body toward the object, pointing your compass cover directly at the object. You may have to glance up and down several times to make sure you are accurate.
5. Look down and read the azimuth from beneath the fixed black index line on the compass face.

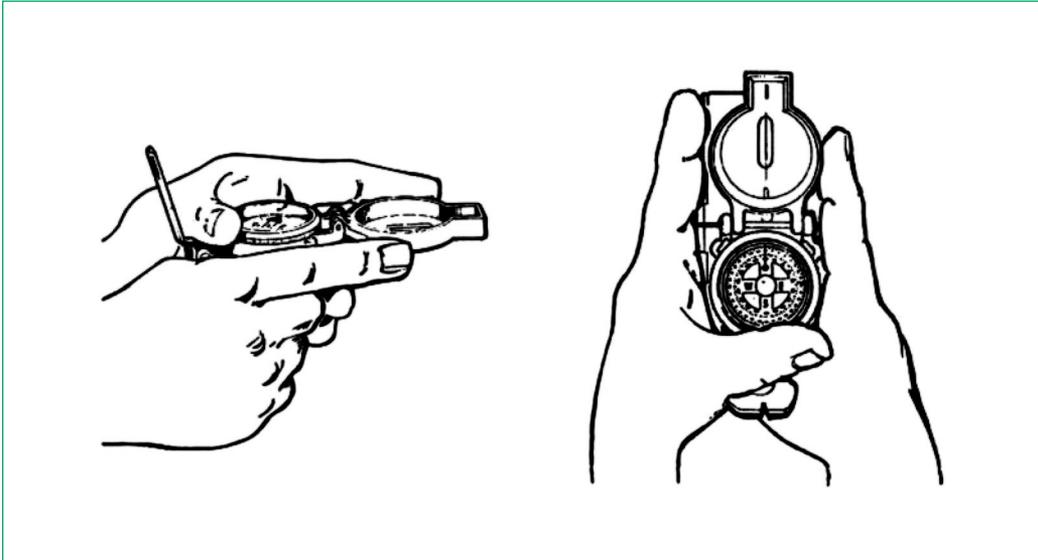


Figure 2.5 Centerhold Technique With a Lensatic Compass

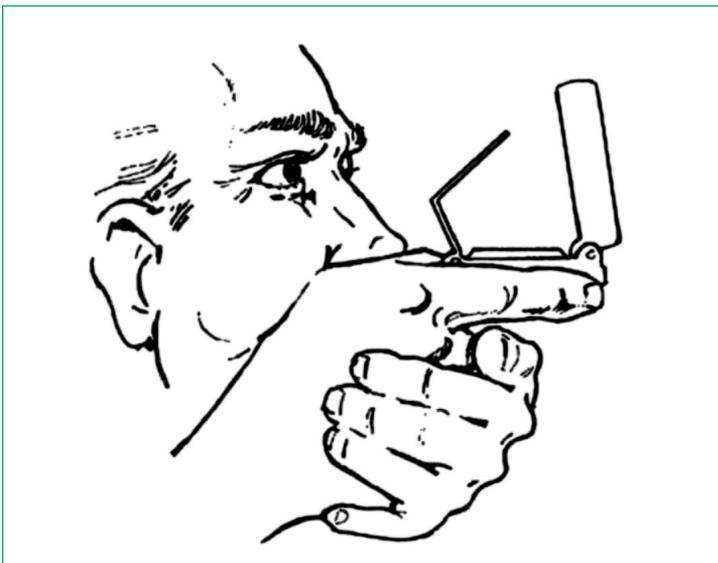


Figure 2.6 Compass-to-Cheek Technique

Some Cadets find the *compass-to-cheek* or *sighting* method more accurate at first. In this method, you fold the cover of the compass containing the sighting wire to a vertical position; then fold the rear sight slightly forward. Look through the rear-sight slot and align the front-sight hairline with the desired object in the distance. Then glance down at the dial through the eye lens to read the azimuth (Figure 2.6). While this method may be easier in the beginning, you will soon find the centerhold technique to have more advantages.

Converting Azimuths and Determining the Grid/Magnetic Angle

Two problems complicate your easy use of map and compass:

First, the surface of the earth is curved, while the surface of your map is flat. This creates problems between what your map shows as north (grid north) and what is really north (true north).

Second, the earth's magnetic pole is not the same as the earth's axis. This creates a difference between what your compass shows as north (magnetic north) and what is really north (true north).

declination

the angular relationships between true north, grid north, and magnetic north

As you learned in Section 1, the **declination** diagram in your map's legend gives you the information you need to compensate for the differences—declination—between grid north, true north, and magnetic north.

The declination diagram shows you the angle between any of these norths. If you have a map (showing grid north) and a compass (showing magnetic north), your primary concern is the difference between grid north and magnetic north.

On larger maps, the declination diagram is usually in the lower margin. On medium-scale maps, the declination information is usually in a note in the map margin.

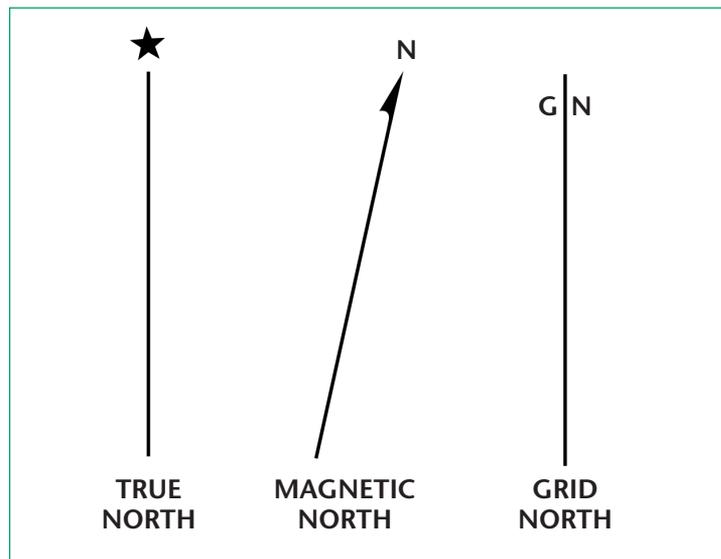


Figure 2.7 True, Magnetic, and Grid North

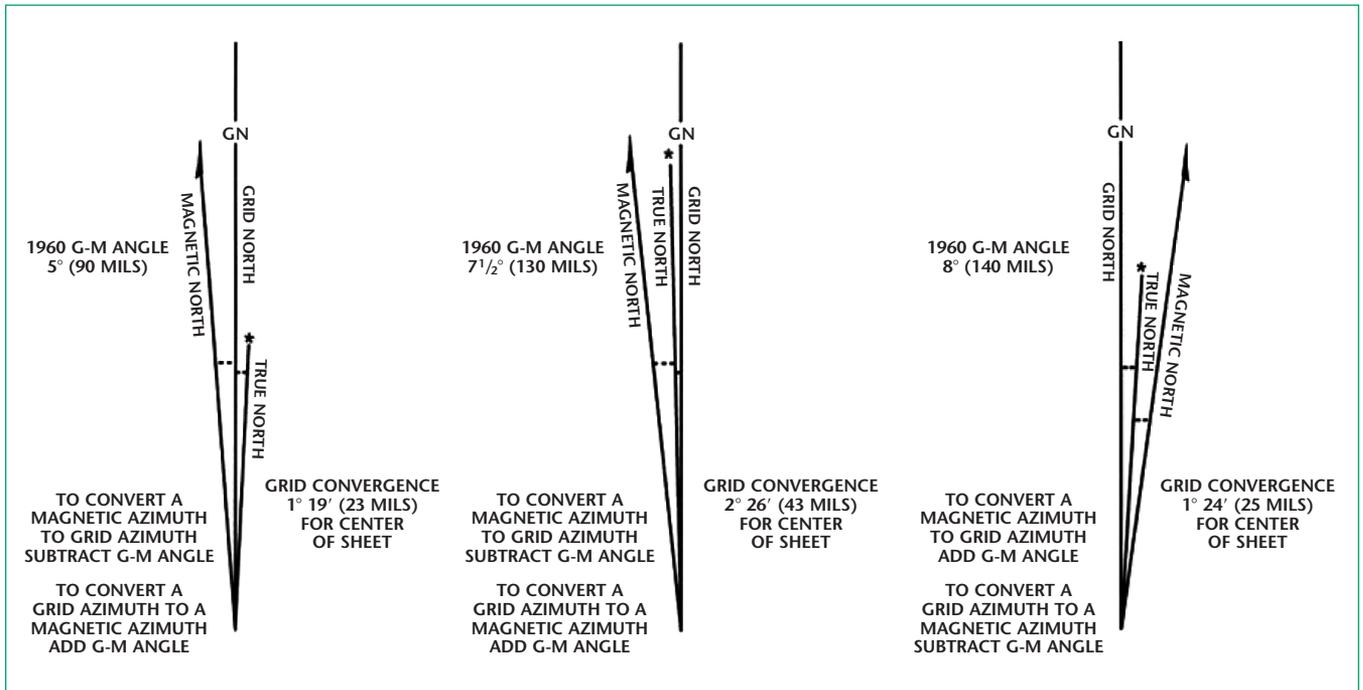


Figure 2.8 Map Declination Diagram

Adjusting for the Grid-Magnetic (G-M) Angle

The G-M angle value is the size of the angle between grid north and magnetic north. You will see it as an arc, indicated by a dashed line, connecting the grid-north and magnetic-north prongs.

The G-M angle is important because if you don't adjust for the G-M angle, azimuths translated between map and ground (and vice versa) will be wrong by the size of the angle. In other words, if your G-M angle is 8 degrees *and you don't adjust for that angle*, your azimuth will be off by 8 degrees. The farther you move away from your start point on your incorrect azimuth, the farther off you will be from your objective. You could totally miss your intended objective, or worse, walk right into the enemy.

Look at the notes that accompany the G-M angle diagram (Figure 2.8). One note tells you how to convert your magnetic azimuth to a grid azimuth; another tells you how to convert your grid azimuth to a magnetic azimuth.

A typical note may read, "To convert a magnetic azimuth to grid azimuth, subtract G-M angle." If you have a magnetic azimuth of 315 degrees, and the G-M angle is 8 degrees, your grid azimuth will be 307 degrees.

The conversion (whether to add or subtract) is governed by the direction of the magnetic-north prong relative to that of the grid-north prong.

intersection

a method to determine an unknown point on a map by occupying two or more known positions and map sighting on the unknown location

resection

a method to determine your position on a map using two or more azimuths

polar plot

a method to plot an unknown position from a known point by giving a direction and a distance along that direction line

Intersection

Understanding how to determine azimuths gives you a powerful tool for plotting unknown points on your map. Depending on the circumstances, you can use **intersection**, **resection**, or **polar plot**.

Intersection is locating an unknown point by using at least two known points. You can use intersection to locate or plot positions to places you can't get to, such as enemy targets or danger areas. You have two options for intersection: the *map-and-compass method* and the *straightedge method*—which you use when you don't have a compass.

Using the Map-and-Compass Method

1. Orient the map using the compass (Figure 2.9).
2. Locate and mark your position on the map.
3. Determine the magnetic azimuth to the unknown position using your compass.
4. Convert the magnetic azimuth to a grid azimuth.
5. Draw a line on the map from your position on this grid azimuth.
6. Move to a second (or third) point and repeat Steps 1 through 5.
7. The unknown position is located where the lines cross (intersect) on the map.
8. Now you can determine the grid coordinates to the accuracy you need.

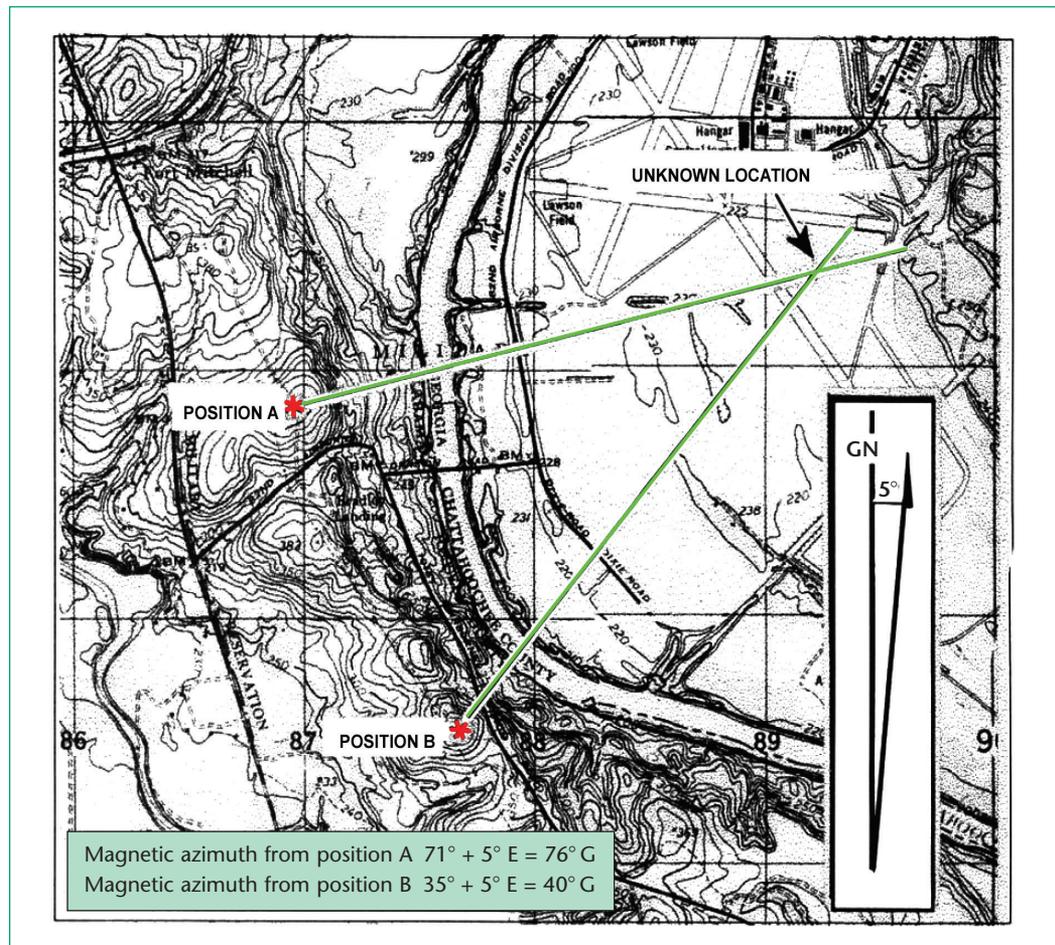


Figure 2.9 Intersection Using a Map and Compass

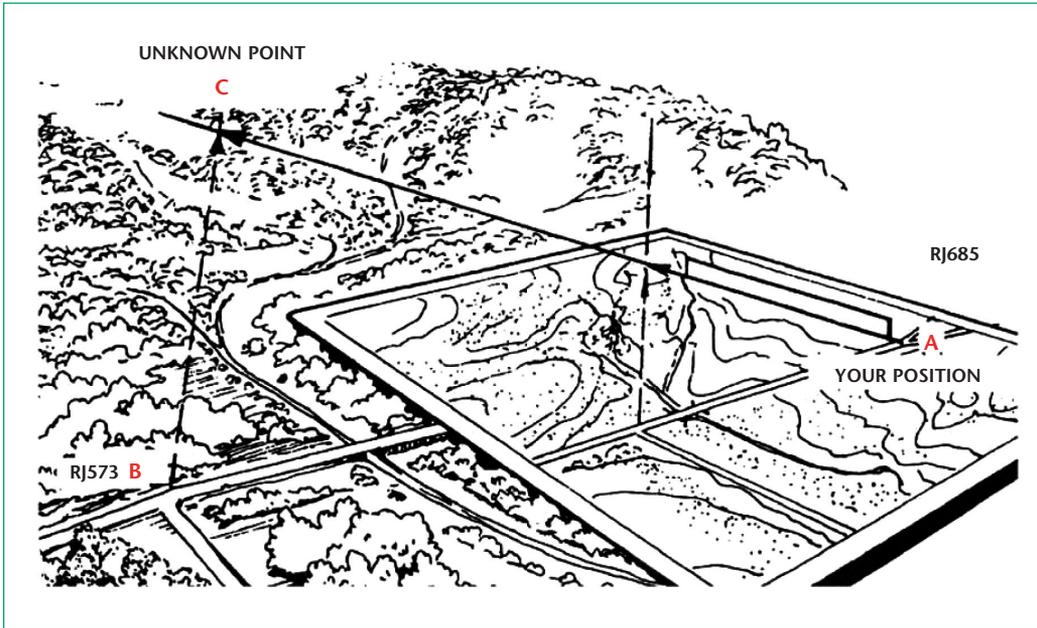


Figure 2.10 Intersection Using a Straightedge

Using the Straightedge Method

1. Orient the map on a flat surface by the **terrain-association** method (Figure 2.10).
2. Locate and mark your position on the map.
3. Lay a straightedge on the map with one end at your position (A) as a pivot point. Then rotate the straightedge until you sight the unknown point along the edge.
4. Draw a line along the straightedge.
5. Repeat the above steps at a second position (B) and check for accuracy.
6. The intersection of the lines on the map is the location of the unknown point. Now you can determine the grid coordinates to the accuracy you need.

terrain association

a technique of orienting a map in which you compare what you see on the map to what you see on the ground—this technique requires that you know your approximate starting location

Resection

Resection is the method of locating your unknown position on a map by determining the grid azimuths to at least two locations that you can pinpoint on the map. (It's better to use three or more locations for greater accuracy.) As with intersection, you can use the map-and-compass method or the straightedge method.

Using the Map-and-Compass Method

1. Orient the map using the compass (Figure 2.11).
2. Identify two or three known locations on the ground and mark them on the map.
3. Measure the magnetic azimuth to one of the known positions from your location using your compass.
4. Convert the magnetic azimuth to a grid azimuth.
5. Convert the grid azimuth to a back azimuth. Using your protractor, draw a line for the back azimuth on the map from the known position back towards the unknown position.
6. Repeat Steps 3, 4, and 5 for the second and third positions.
7. You are located where the lines intersect. Now determine the grid coordinates to the accuracy you need.

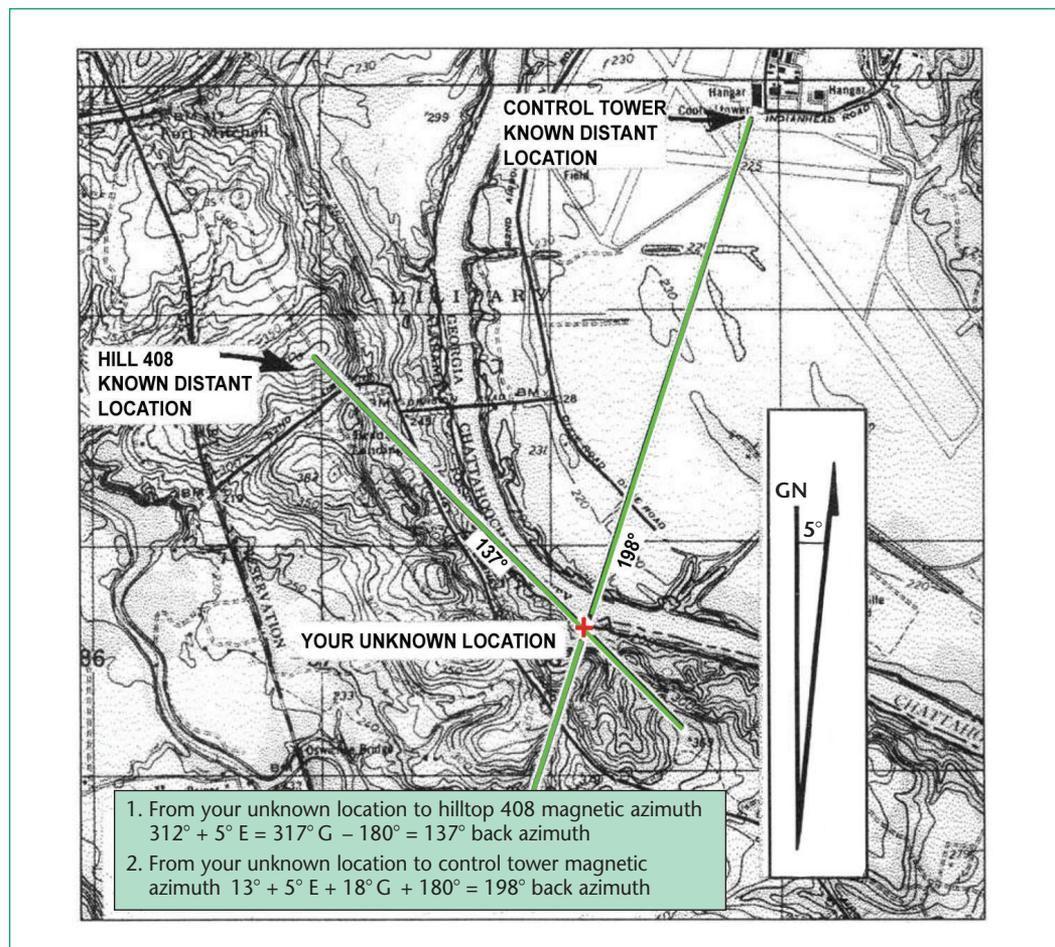


Figure 2.11 Resection Using a Map and Compass

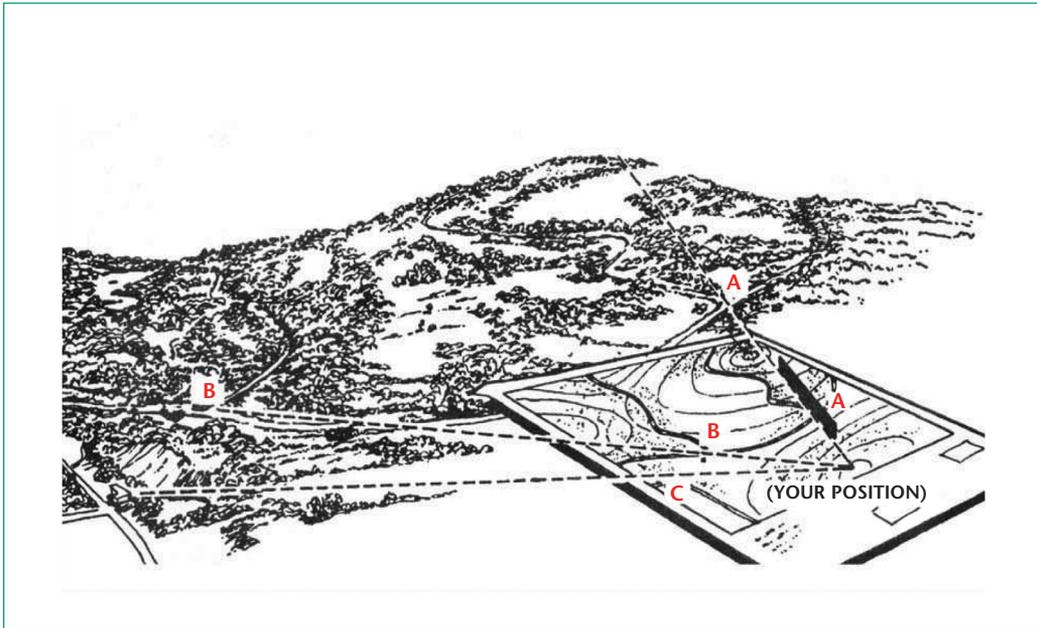


Figure 2.12 Resection Using a Straightedge

Using the Straightedge Method

1. Orient the map on a flat surface by the terrain-association method (Figure 2.12).
2. Locate at least two known distant locations or prominent features on the ground and mark them on your map.
3. Lay a straightedge on the map using a known position as a pivot point. Rotate the straightedge until the known position on the map is aligned with the known position on the ground.
4. Draw a line along the straightedge away from the known position on the ground toward your position.
5. Repeat Steps 3 and 4 using a second known position.
6. The intersection of the lines on the map is your location. Now determine the grid coordinates to the accuracy you need.

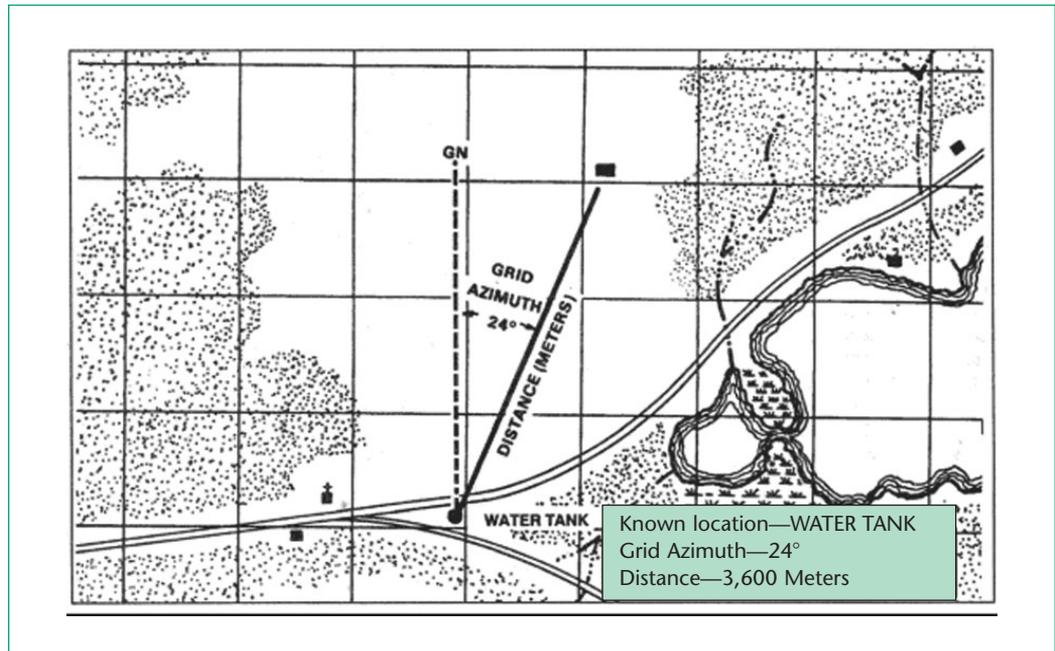


Figure 2.13 Polar Plot

Polar Plot

A polar plot is a way to locate or plot a target or position that is not identified on the map. All you need to determine the exact location of the target is the azimuth from your known position to the target and an accurate estimate of the distance along the azimuth to the target (Figure 2.13). To use a polar plot, you must know:

- Your present location on the map
- The azimuth (grid or magnetic) to the target or unknown position
- The distance (in meters) to the target or unknown position.

You will be more accurate in plotting the unknown position's location if you use a laser range finder to determine the range from your position to the target or unknown position.

Determining Distance on a Map

When planning your movement, you need to know how far you must travel. You can use your map's graphic scale—located in the marginal information—as a ruler to convert distances on the map to distances on the ground.

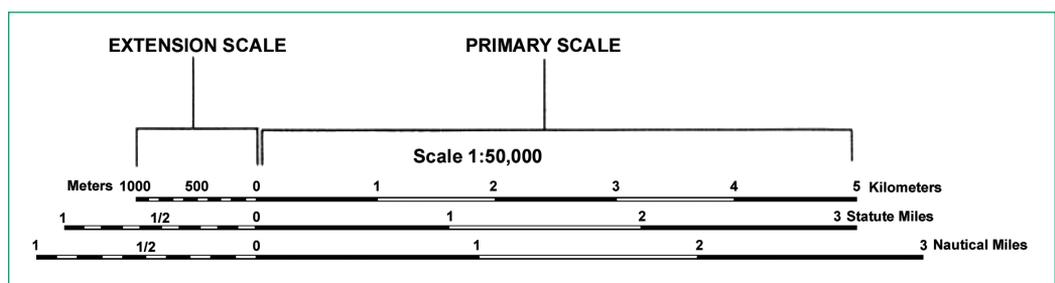


Figure 2.14 Using a Graphic (Bar) Scale

The graphic scale is divided into two parts. To the right of the zero, the scale is marked in full units of measure and is called the *primary scale*. To the left of the zero, the scale is divided into tenths and is called the *extension scale*.

Most maps have three or more graphic scales, each with a different unit of measure. When you use the graphic scale, be sure to use the correct unit of measure.

Determining Straight-Line Distance

Straight-line distance on a map is important in many ways. You can use straight-line distance to determine the range of your weapons—and the range of your enemy's weapons. Or, as with the previous example, you can use straight-line distance to conduct a polar plot to identify the location of objects not depicted on a map. The most frequent use for straight-line distance is to determine distance when navigating from one point to another. Determine the straight-line distance between two points on your map using these three steps:

1. Lay a straight-edged piece of paper on the map so the edge of your paper touches both points and extends past them.
2. Make a tick mark on the edge of the paper at each point.

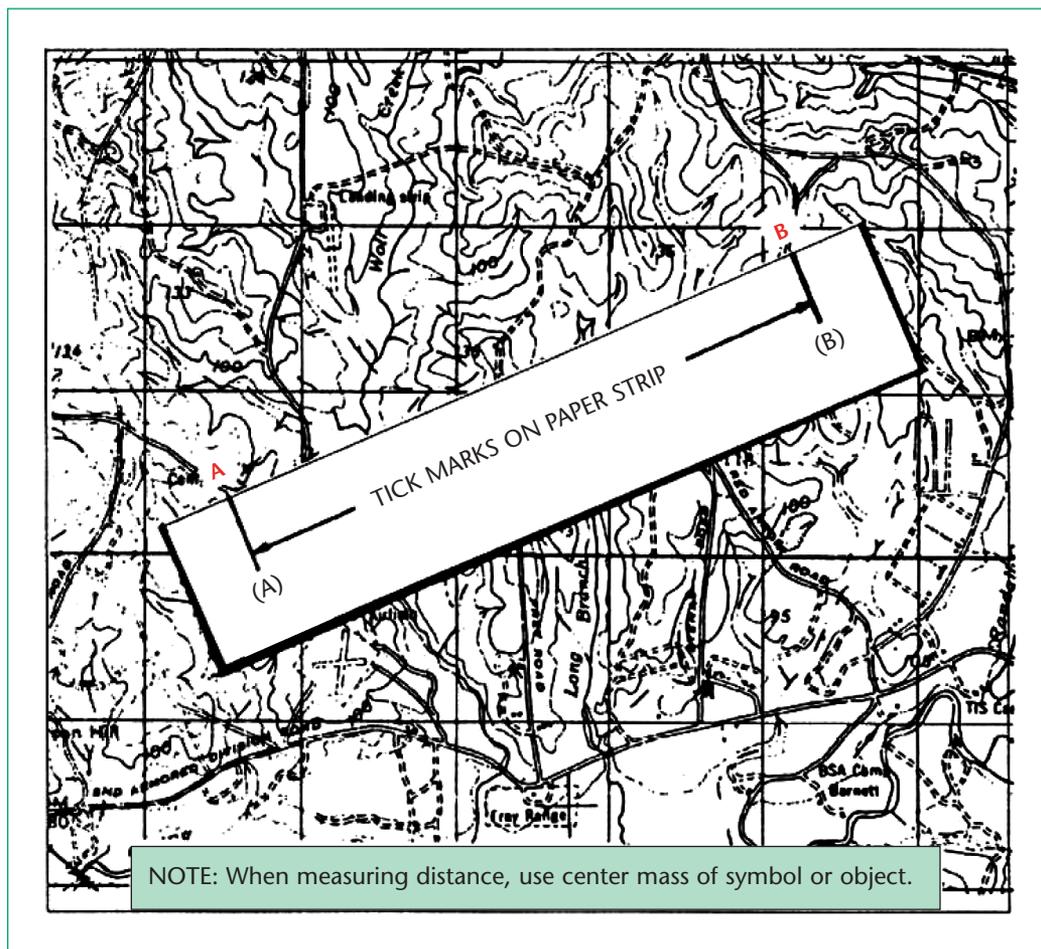


Figure 2.15 Transferring Map Distance to Paper Strip

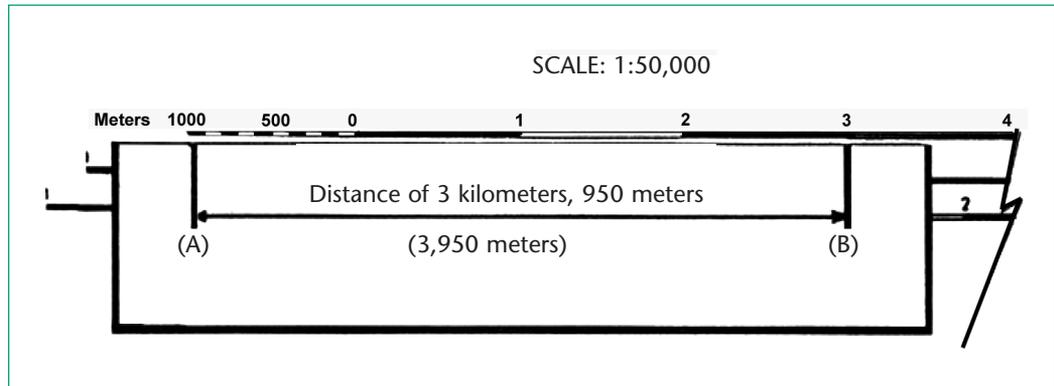


Figure 2.16 Measuring Straight-Line Map Distance

3. Then move your paper to the graphic bar scale, and use the scale to measure the distance between the two points. Be sure to align the tick mark on the right with a printed number in the primary scale so that the left tick mark falls within the extension scale.

Determining Curved-Line Distance

Curved-line distance on a map is important in determining how far you have to travel on a road, trail, or waterway identified on your map. Determining distance along a relatively straight line—Interstate 80 across Nebraska, for example—is easy. Determining distance along a curved line—a mountain road, a streambed, or a ridge, for example—is another matter. Nature has few straight lines.

You can determine curved-line distance using these four steps:

1. Put a straight-edged piece of paper on your map with the edge next to your starting point. Place a tick mark on the paper and on your map.
2. Line up the straight edge of the paper with the straight portion of your measured distance. Make a tick mark on both map and paper when the edge of the paper leaves the straight portion of the line you're measuring. (See View A in Figure 2.17.)
3. Pivot the paper until another straight portion of the curved line lines up with the edge of the paper. Continue in this manner until you have completed the distance you want to measure. (See View B in Figure 2.17. Notice the number of small ticks on the edge of the paper.)
4. Move the paper to the graphic scale to determine the ground distance. The only tick marks you need to measure are Tick Marks A and B. (See View C in Figure 2.17.)

Knowing a few tricks of the trade will allow you to determine curved distances more accurately. First, the sharper your pencil and the more tick marks you make along a curve, the more accurate your distance will be when you move your paper to the distance bar graph. Second, when measuring roads or waterways, always stay on the same side of the road or waterway when making your tick marks. Measuring and making tick marks from different sides of the road or waterway increases your error when you calculate curved-line distance.

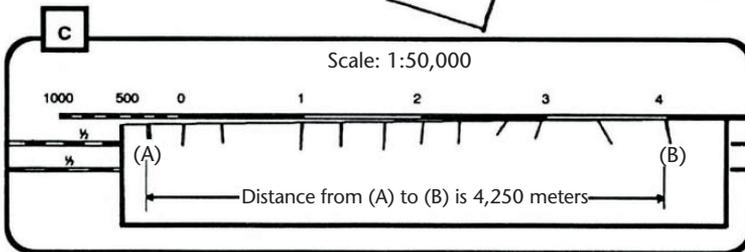
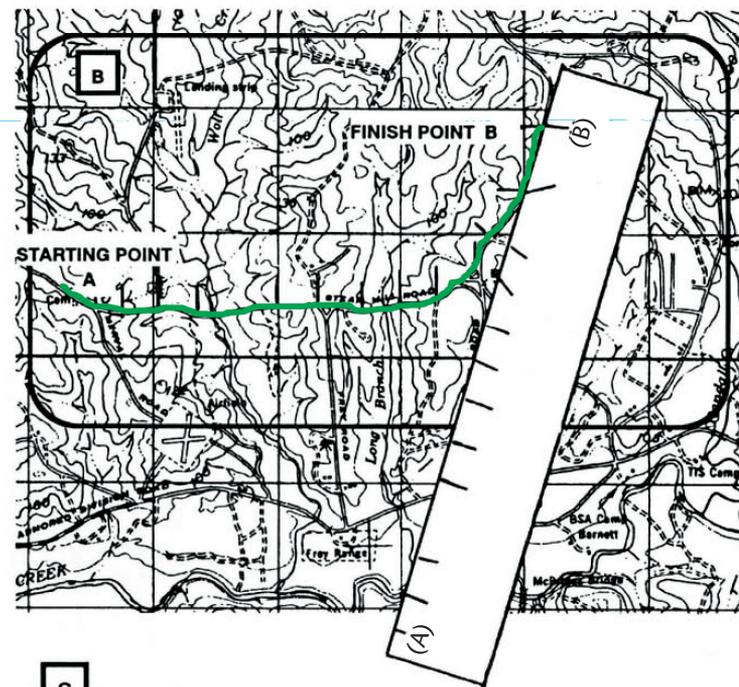
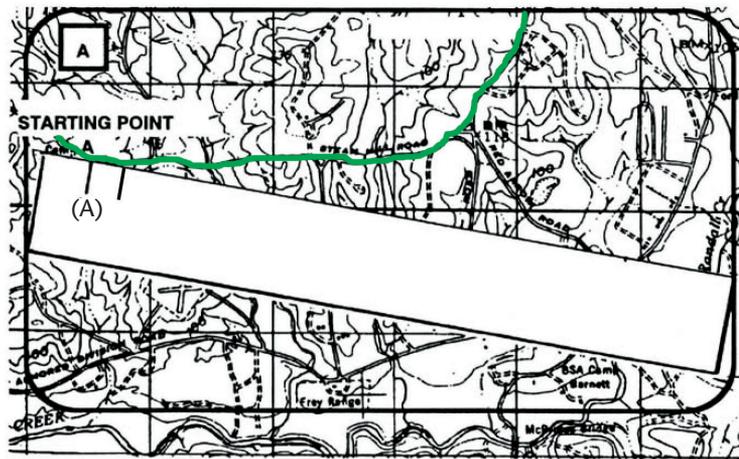


Figure 2.17 Measuring a Curved Line

Understanding OAKOC

OAKOC

an Army acronym used for planning operations—it stands for Observation and fields of fire, Avenues of approach, Key and decisive terrain, Obstacles, and Cover and concealment

Your map becomes critical in both the attack and in the defense because much of your plan depends on your terrain—and how the terrain affects military operations for both you and the enemy. You must analyze the terrain as you decide the best or safest way to travel from Point A to Point B. You can use the acronym **OAKOC** to evaluate the effects of terrain on your operations plan. You will encounter this acronym often, so become familiar with it now.

- O** *Observation and fields of fire.* What can you see throughout your area? What fields of fire will you have in terms of maximum effective range, grazing fire, and the arming range and time of flight for anti-armor weapons? How will the weather affect your visibility? The enemy's visibility?
- A** *Avenues of approach.* An avenue of approach is a route to an objective or key terrain. If you are attacking, which avenues of approach will give your Soldiers their greatest protection? Which avenues of approach will place you and your Soldiers at your enemy's most vulnerable spot? How will the weather affect your ability to move along your preferred avenue of approach?

If you are defending, which avenues of approach will your enemy most likely use to attack your defensive position? How might you position your key weapons to address the enemy's most likely avenues of approach to your defense? Anticipate what the enemy may do. Ask yourself, "If I were attacking, how would I do it?" How will the weather affect the enemy's ability to move?
- K** *Key and decisive terrain.* Which terrain can you seize or secure to give you an advantage? Where is the high ground? Where is the covered ground? Which terrain gives the enemy the advantage?

Critical Thinking

How does occupying or controlling high ground give you an advantage?

- O** *Obstacles.* If you are attacking, which terrain will restrict your ability to maneuver? If you are defending, which terrain will you use to defeat your enemy, protect your Soldiers, and hold your ground?

- C *Cover and concealment.* Which terrain will protect you and your Soldiers from direct and indirect fires (cover) and from aerial and ground observation (concealment)?

Critical Thinking

How is *observation* related to *concealment*?
How are *fields of fire* related to *cover*?

Critical Thinking

Have the OAKOC principles always been important? Would a Roman soldier in Gaul have considered observation and avenues of approach? Why or why not?



CONCLUSION

At one time or another, you may have heard Soldiers—especially infantry Soldiers—described as “ground pounders.” They pound the ground with their boots, their vehicles, and their bodies. Just as the air belongs to the Airman and the sea belongs to the Sailor, the ground belongs to the Soldier.

Because the ground is your territory, you must become intimately familiar with its napes and folds, its terrain and features. And you must become intimately familiar with maps—the graphic representations of the ground. You must be able to navigate from one point to another on that ground—using a map, compass, and protractor. You must know how to determine azimuths and convert from one type of azimuth to another. You must be able to plot known and unknown points.

Your profession of Soldier demands that knowledge. The success of your mission and your survival in the battle area depend on it.

Key Words

azimuth
declination
intersection
resection
polar plot
terrain association
OAKOC

Learning Assessment

1. Explain how to calculate a grid azimuth.
2. Explain how to calculate a magnetic azimuth.
3. Explain how to convert a grid azimuth to a magnetic azimuth.
4. Explain how to convert a magnetic azimuth to a grid azimuth.
5. Show how to measure the distance between two points on a map.
6. Define intersection, resection, and polar plot.
7. Give the five points of the acronym OAKOC.

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