

## Section 1

# MAP READING I

## Key Points

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- 1 Marginal Information
- 2 Topographic Symbols
- 3 Elevation and Relief
- 4 Map Coordinate Systems
- 5 Measuring Distances on a Map

## Introduction

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War has three basic tenets: *move*, *shoot*, and *communicate*. It is no accident that *move* is the first. Every Soldier must be able to read and understand a map. A thorough knowledge of map reading is essential to your military career. Only through mastery of the skills this chapter presents can you hope to understand the more complex instruction that follows. Once you can get yourself from Point A to Point B, you can begin to incorporate the many other variables involved with moving troops and equipment (FM 3-25.26).

A map depicts three-dimensional natural and man-made objects on a two-dimensional surface. It indicates variations in terrain, heights of natural features, and the extent of vegetation cover. With military forces dispersed throughout the world, maps are necessary to provide information to our combat units and to carry out logistical operations far from our shores. Soldiers and materials must be transported, stored, and deployed at the proper time and place. You need maps to do much of this planning. Therefore, any operation requires a supply of maps. But the finest maps available are worthless unless the map user knows how to read them.

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### The 507th Maintenance Company

In the early morning hours of 20 March 2003, US Army, US Marine Corps, and coalition ground combat forces crossed from Kuwait into southern Iraq and attacked northward, beginning the ground phase of Operation Iraqi Freedom. By dawn on 23 March, major US ground combat units had advanced more than 200 miles into Iraq and were approximately 130 miles north of An Nasariyah. The rapid advance of coalition troops in thousands of vehicles and hundreds of aircraft was made possible by the determined, aggressive support of scores of logistics, medical, and maintenance units. Many moved constantly to maintain contact with the units they were supporting. One such unit was the 507th Maintenance Company.

CPT Troy King, commander of the 507th, was supposed to follow “Route Blue” on the map to a rendezvous point farther north called “Objective Ram.” When he reached an intersection south of the southern Iraqi city of Nasariyah, which required a left turn to stay on “Route Blue,” he directed the convoy straight north instead. This route took the Soldiers into the outskirts of the city and then straight into an ambush. As the convoy drove through Nasariyah it passed armed Iraqis manning checkpoints. But the Iraqis did not fire their weapons at this point. The US Soldiers held fire—the rules of engagement required the enemy to show hostile intent. When the convoy reached the northern edge of the city, CPT King realized for the first time that he had veered from the designated route. He had the company make a U-turn and head back into the city and ordered his troops to “lock and load” their weapons. The Soldiers again missed the required turn and had to make a second U-turn. Around this time, the 507th came under fire from grenade launchers and rifles. An intense 60- to 90-minute firefight marked by chaos and bravery ensued, with the convoy broken into three groups.

Once engaged in battle, the Soldiers of the 507th Maintenance Company fought hard. They fought the best they could until there was no longer a means to resist. They defeated ambushes, overcame hastily prepared enemy obstacles, defended one another, provided life-saving aid, and inflicted casualties on the enemy.

In the end, nine 507th Soldiers and two other Soldiers traveling with it were killed; six were taken prisoner, including PFC Jessica Lynch, who was rescued from a Nasariyah hospital eight days later by US special-operations forces. Sixteen Soldiers, including CPT King, managed to escape from the ambush when Marines came to the rescue.

Scarborough (2003); US Army Official Report on 507th Maintenance Co.

## Marginal Information

The information contained in the margins (**marginal information**) explains how to read and use the map. All four margins can relay information, with the bottom margin usually containing the most. The following are just a few examples of what you might find:

### marginal information

any information located in the margins of a map—the map's instructions

- **Information Date.** The first step with any map is to find the date it was made or last updated. This is called the Information Date, found immediately below the word “LEGEND” in the lower left margin of the map. The more current the date, the more accurate the information on the map (buildings, roads, power lines, etc.) should be.
- **Sheet Name.** You'll find the sheet name in bold print at the center of the top and in the lower left area of the map margin. A map is generally named for the largest or most populated settlement it covers, or for the largest natural feature located within the area when the map was drawn.
- **Sheet Number.** The sheet number is found in bold print in both the upper right and lower left areas of the margin, and in the center box of the adjoining sheets diagram, located in the lower right margin. It is used as a reference number to link specific maps to overlays, operation orders, and plans.
- **Series Name.** The map series name is found in the same bold print as the sheet number in the upper left corner of the margin. The series name is generally that of a major political subdivision, such as a state within the United States or a European nation. A map series usually includes a group of similar maps at the same scale and on the same sheet lines or format that cover a particular geographic area. It may also be a group of maps that serve a common purpose, such as the military city maps.
- **Series Number.** You can find the series number in both the upper right margin and the lower left margin. It is a sequence reference expressed either as a four-digit numeral (1125) or as a letter followed by a three- or four-digit numeral (M661; T7110).
- **Edition Number.** The edition number is found in bold print in the upper right area of the top margin and the lower left area of the bottom margin. Editions are numbered consecutively; if you have more than one edition, the highest numbered sheet is the most recent. The National Geospatial-Intelligence Agency (NGA) now publishes most military maps, but the US Army Map Service may have produced older editions of maps. Still others may have been drawn, at least in part, by the US Army Corps of Engineers, the US Geological Survey, or other agencies, some nongovernmental.

- **Scale.** The scale is located both in the upper left margin after the series name, and in the center of the lower margin. The scale note gives the ratio of a map distance to the corresponding distance on the earth's surface. For example, the scale note 1:50,000 indicates that one unit of measure on the map equals 50,000 units of the same measure on the ground.
- **Index to Boundaries.** The index to boundaries diagram appears in the lower or right margin of all sheets. This diagram, which is a miniature of the map, shows the boundaries within the map area, such as county lines and state borders.
- **Adjoining Sheets Diagram.** Maps at all standard scales contain a diagram that shows the adjoining sheets. On maps at 1:100,000 and larger scales and at 1:1,000,000 scale, the diagram is called the "index to adjoining sheets." It consists of as many rectangles representing adjoining sheets as needed to surround the rectangle that represents the sheet you are looking at. The diagram usually contains nine rectangles, but the number may vary depending on the locations of the adjoining sheets. Sheet numbers identify all represented sheets. Sheets of an adjoining series at the same scale, whether published or planned, are represented by dashed lines. The series number of the adjoining series appears along the appropriate side of the division line between the series.
- **Elevation Guide.** This is normally found in the lower right margin. It is a miniature characterization of the terrain on the map. The terrain is represented by bands of elevation, spot elevations, and major drainage features. The elevation guide provides the map reader with a way to rapidly recognize major landforms.
- **Declination Diagram.** This is located in the lower margin of large-scale maps and indicates the angular relationships of true north, grid north, and magnetic north. On maps at 1:250,000 scale, this information appears in a note in the lower margin. In recent edition maps, a note indicates the conversion of azimuths from grid to magnetic and from magnetic to grid next to the declination diagram. (An azimuth is the horizontal angle of the observer's bearing in surveying, measured clockwise from a referent direction, usually north.)
- **Bar Scales.** You'll find these in the center of the lower margin. They are rulers that convert map distance to ground distance. Maps have three or more bar scales, each in a different unit of measure. You should exercise care when using the scales, especially in selecting the unit of measure that you need.
- **Contour Interval Note.** This note appears in the center of the lower margin normally below the bar scales. It states the vertical distance between adjacent contour lines of the map. When supplementary contours are used, the note indicates the interval. Recent edition maps give the contour interval in meters instead of feet.
- **Spheroid Note.** This note is located in the center of the lower margin. Spheroids (ellipsoids) have specific parameters that define the X Y Z axis of the earth. The spheroid is an integral part of the datum (point of reference).
- **Grid Note.** You'll see this note in the center of the lower margin. It gives information about the grid system used and the interval between grid lines. It also identifies the Universal Transverse Mercator (UTM) grid zone number.
- **Projection Note.** The projection system is the map's framework. Military maps use a conformal framework: Small areas of the surface of the earth retain their true shapes on the projection; measured angles closely approximate true values; and the scale factor is the same in all directions from a single point. The projection note appears in the center of the lower margin.
- **Vertical Datum.** Located in the center of the lower margin, the vertical datum or vertical-control datum is any level surface (for example, mean sea level) used to determine elevations. In the United States, Canada, and Europe, the vertical datum refers to mean sea level. In parts of Asia and Africa, however, the vertical-control



datum may vary locally and is based on an assumed elevation that has no connection to sea level.

- **Horizontal Datum Note.** This note appears in the center of the lower margin. The horizontal datum or horizontal-control datum is a geodetic reference point of which five quantities are known: latitude, longitude, azimuth of a line from this point, and two constants, which are the parameters of reference ellipsoid. These are the basis for horizontal-control surveys. The horizontal-control datum may extend over a continent or be limited to a small area.
- **Control Note.** You can find this note in the center of the lower margin. It shows the special agencies that control the technical aspects of all the information on the map.
- **Preparation Note.** This note is located in the center of the lower margin. It tells which agency prepared the map.
- **Printing Note.** This note is also found in the center of the lower margin. It indicates which agency printed the map and the printing date. Do not use the printing note to determine when the map information was obtained.
- **Grid Reference Box.** You can usually find this box in the center of the lower margin. It contains instructions for composing a grid reference.
- **Unit Imprint and Symbol.** The unit imprint and symbol is on the left side of the lower margin. It identifies the agency that prepared and printed the map. Use this information to evaluate the map's reliability.
- **Legend.** The legend is located in the lower left margin. It illustrates the topographic symbols that depict the more prominent features on the map. These symbols differ from map to map. Always refer to the legend to avoid errors when reading a map (FM 3-25.26).

Do not use the printing note to determine when the map information was obtained. Use the information date, which shows how recently the map was charted.

## Topographic Symbols

### topographic symbols

symbols used to represent natural and man-made features on the earth's surface

Maps use **topographic symbols** to represent the natural and man-made features of the earth's surface. For example, you might find crossed pickaxes representing a mine; square black boxes for buildings; or a black box with a cross on top for a church. Along with symbols, maps use color as a tool to help identify certain things. Below are a few common ones:

- **Black**—Indicates cultural (man-made) features such as buildings and roads, surveyed spot elevations, and all labels
- **Red-Brown**—The colors red and brown are combined to identify cultural features, all relief features, non-surveyed spot elevations, and elevation—such as contour lines on red-light readable maps
- **Blue**—Identifies water features such as lakes, swamps, rivers, and drainage
- **Green**—Identifies vegetation with military significance, such as woods, orchards, and vineyards
- **Brown**—Identifies all relief features and elevations, such as contours on older maps and cultivated land on red-light readable maps
- **Red**—Classifies cultural features, such as populated areas, main roads, and boundaries, on older maps
- **Other**—Occasionally other colors may be used to show special information. As a rule, you'll find these in the marginal information.

## Military Symbols

In addition to the topographic symbols and colors, military personnel require some way to show the identity, size, location, or movement of Soldiers, military activities, and installations. The symbols that represent these military features are known as military symbols. Maps do not usually contain these symbols because the features and units that they represent constantly move or change. Military security is also a consideration. These symbols and colors differ on different maps. Always refer to the legend to avoid errors when reading a map.

*You will learn more about operational symbols later in the course. You can read FM 1-02, Operational Terms and Graphics, for further study.*

## Elevation and Relief

### Contour Lines

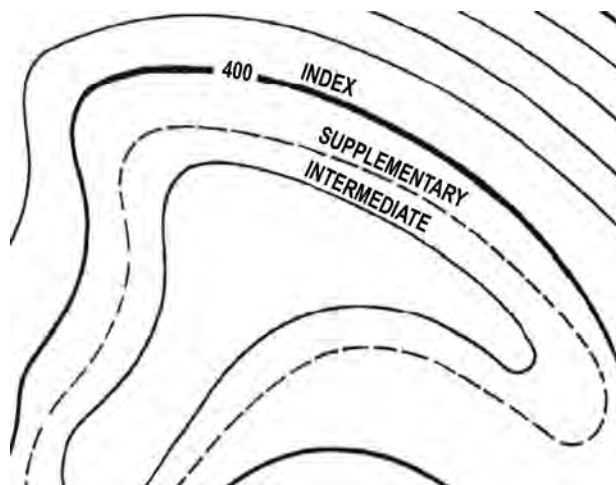
**Contour lines** make a map three dimensional by showing height and depth. They are the most common way to show relief and elevation on a standard topographic map. A contour line represents an imaginary line on the ground, above or below sea level. All points on the contour line are at the same elevation. Contour lines represent an elevation that is the vertical distance above or below sea level. A standard topographic map features three types of contour lines:

#### contour lines

*the most common method of showing relief and elevation on a standard topographic map*

- **Index**—Starting at zero elevation or mean sea level, every fifth contour line is a heavier line. These are index contour lines. Normally, each index contour line is numbered at some point to show the elevation of that line.
- **Intermediate**—The contour lines falling between the index contour lines are called intermediate contour lines. These lines are finer and do not give elevations. There are normally four intermediate contour lines between index contour lines.
- **Supplementary**—These contour lines resemble dashes. They show changes in elevation of at least one-half the contour interval. These lines are normally found where there is very little change in elevation, such as on fairly level terrain.

Contour lines show elevation and depressions. Before you can determine the elevation of any point on the map, you must know the contour interval for the map you are using. The contour interval measurement in the marginal information gives the vertical distance between adjacent contour lines.



**Figure 1.1** Terrain Contour Lines

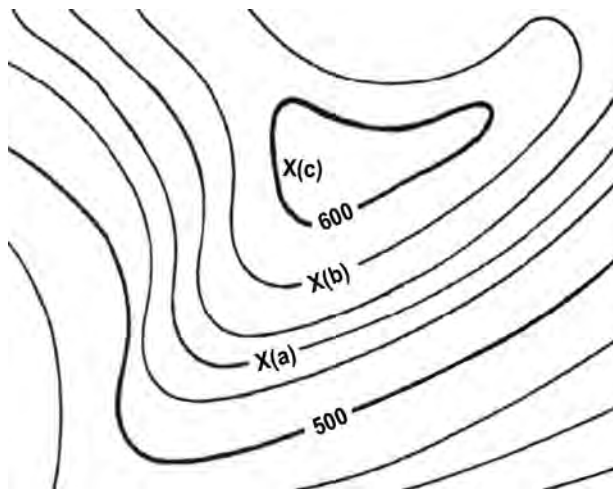
### Finding Elevation on a Map

1. Determine the contour interval and the unit of measure used, for example, feet, meters, or yards (Figure 1.2).

**ELEVATION IN METERS**  
**CONTOUR INTERVAL 20 METERS**

**Figure 1.2** Marginal Information Identifying Contour Units and Contour Intervals

2. Find the numbered index contour line nearest the point you are trying to determine the elevation of (Figure 1.3).



**Figure 1.3** Map Terrain Contour Lines

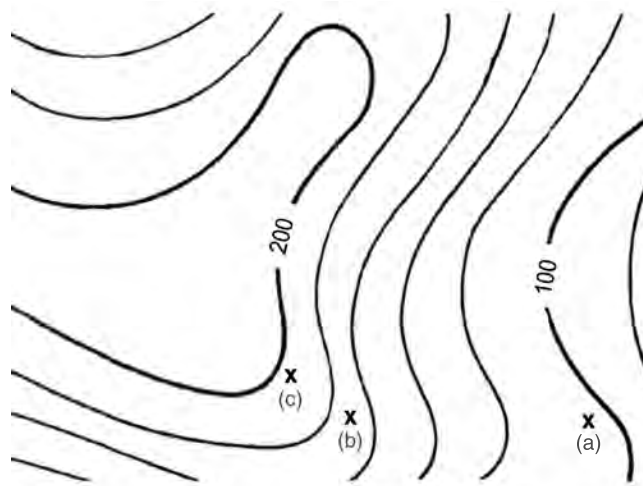
3. Determine if you are going from lower elevation to higher, or vice versa. In Figure 1.3, Point A is between the index contour lines. The lower index contour line is numbered 500, which means any point on that line is at an elevation of 500 meters above mean sea level. The upper index contour line is numbered 600, or 600 meters. Going from the lower to the upper index contour line shows an increase in elevation.
4. To determine the exact elevation of Point A (Figure 1.3), start at the index contour line numbered 500 and count the number of intermediate contour lines to Point A. Locate Point A on the second intermediate contour line above the 500-meter index contour line. The contour interval is 20 meters (Figure 1.2), thus each one of the intermediate contour lines crossed to get to Point A adds 20 meters to the 500-meter index contour line. The elevation of Point A is 540 meters—the elevation has increased.
5. To determine the elevation of Point B (Figure 1.3), go to the nearest index contour line. In this case, it is the upper index contour line numbered 600. Locate Point B on the intermediate contour line immediately below the 600-meter index contour line. (Below means downhill or a lower elevation.) Therefore, Point B is located at an elevation of 580 meters. Remember, if you are increasing elevation, add the contour interval to the nearest index contour line. If you are decreasing elevation, subtract the contour interval from the nearest index contour line.

6. To determine the elevation to a hilltop Point C (Figure 1.3), add one-half the contour interval to the elevation of the last contour line. In this example, the last contour line before the hilltop is an index contour line numbered 600. Add one-half the contour interval, 10 meters, to the index contour line. The elevation of the hilltop would be 610 meters.

### Finding Elevation with Greater Accuracy

There may be times when you need to determine the elevation of points to a greater degree of accuracy. To do this, you must determine how far between the two contour lines the point lies (Figure 1.4).

1. If the point is less than one-fourth the distance between contour lines, the elevation will be the same as the closest contour line. In Figure 1.4, the elevation of Point A will be 100 meters.



**Figure 1.4** Map Terrain Contour Lines

2. To estimate the elevation of a point between one-fourth and three-fourths of the distance between contour lines, add one-half the contour interval to the last contour line. Point B is one-half the distance between contour lines. The contour line immediately below Point B is at an elevation of 160 meters. The contour interval is 20 meters; thus, one-half the contour interval is 10 meters. In this case, add 10 meters to the last contour line of 160 meters. The elevation of Point B would be about 170 meters.
3. A point located more than three-fourths of the distance between contour lines is considered to be at the same elevation as the next contour line. Point C is located three-fourths of the distance between contour lines. In Figure 1.4, Point C would be considered to be at an elevation of 200 meters.

### Estimating the Depth of Depressions

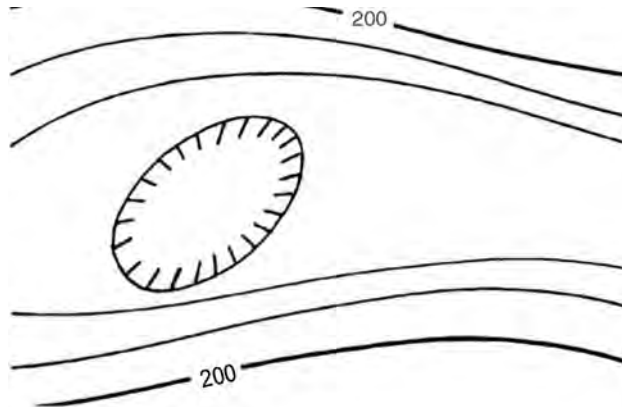
To estimate the elevation to the bottom of a depression, subtract one-half the contour interval from the value of the lowest contour line before the depression. In Figure 1.5, the lowest contour line before the depression is 240 meters in elevation. Thus, the elevation at the edge of the depression is 240 meters. To determine the elevation at the bottom of the depression, subtract one-half the contour interval. The contour interval for this example is 20 meters. Subtract 10 meters from the lowest contour line immediately before the depression. The

*Remember, if you are increasing elevation, add the contour interval to the nearest index contour line. If you are decreasing elevation, subtract the contour interval from the nearest index contour line.*



result is that the elevation at the bottom of the depression is 230 meters. The tick marks on the contour line forming a depression always point to lower elevations.

The tick marks on the contour line forming a depression always point to lower elevations.



**Figure 1.5** Depressions

## Bench Marks and Spot Elevations

In addition to the contour lines, bench marks and spot elevations are used to indicate points of known elevations on the map.

**Bench Marks.** The more accurate of the two, bench marks are symbolized by a black X, such as X BM 214. The 214 indicates that the center of the X is at an elevation of 214 units of measure (feet, meters, or yards) above mean sea level. To determine the units of measure, refer to the contour interval in the marginal information.

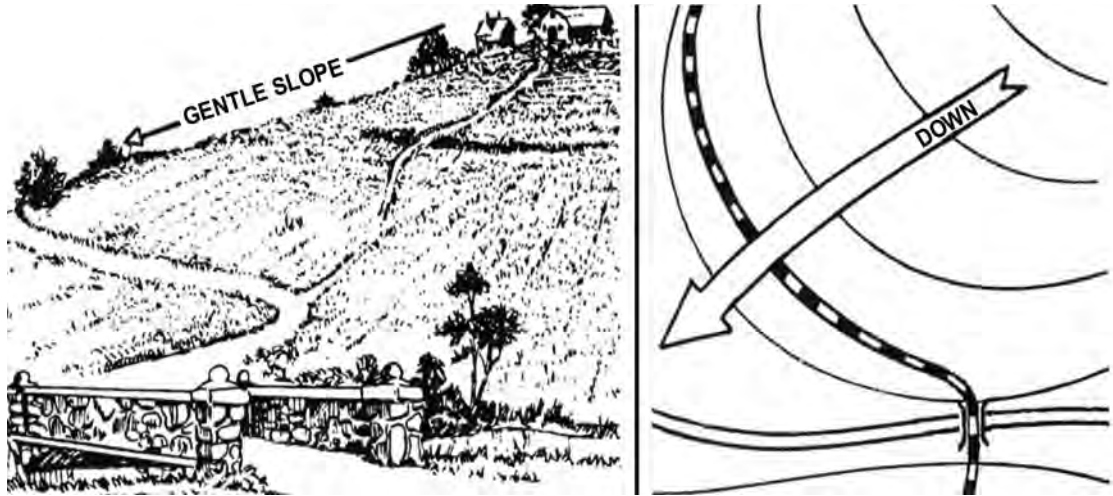
**Spot Elevations.** Spot elevations are shown by a brown X and are usually located at road junctions and on hilltops and other prominent terrain features. If the elevation is shown in black numerals, it has been checked for accuracy; if it is in brown, it has not been checked.

New maps are being printed using a dot instead of brown Xs.

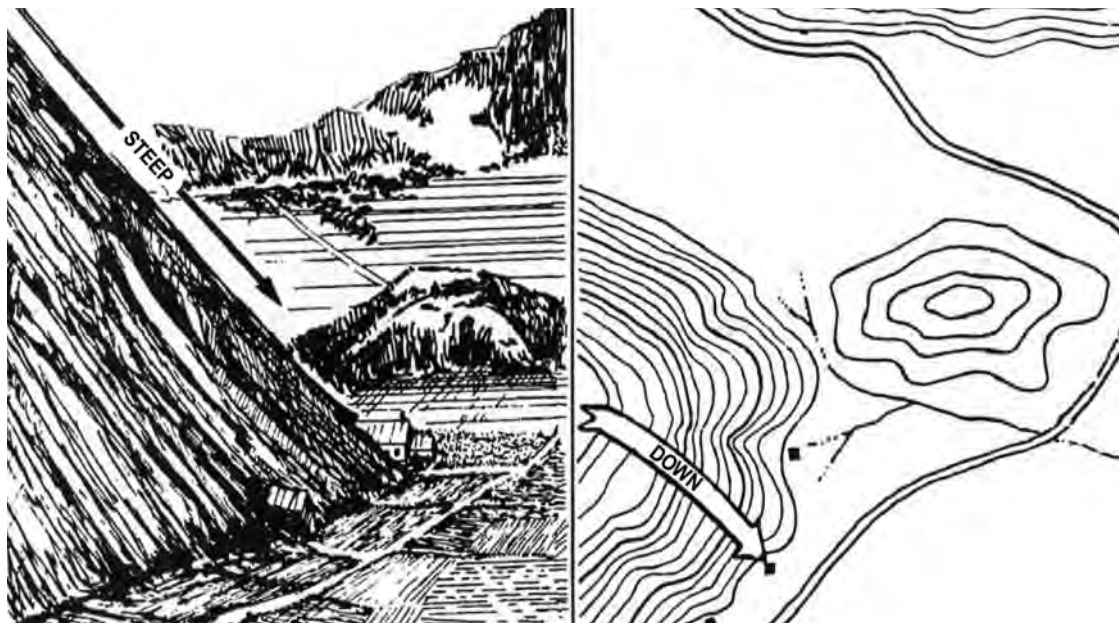
## Types of Slopes

The rate of rise or fall of a terrain feature is known as its slope. Depending on the military mission, Soldiers may need to determine not only the height of a hill, but the degree of the hill's slope as well. The slope of the ground or terrain feature affects the speed at which equipment or personnel can move. You can determine this slope from the map by studying the contour lines—the closer the contour lines, the steeper the slope; the farther apart the contour lines, the gentler the slope. Four types of slopes that concern the military are *gentle*, *steep*, *concave*, and *convex*.

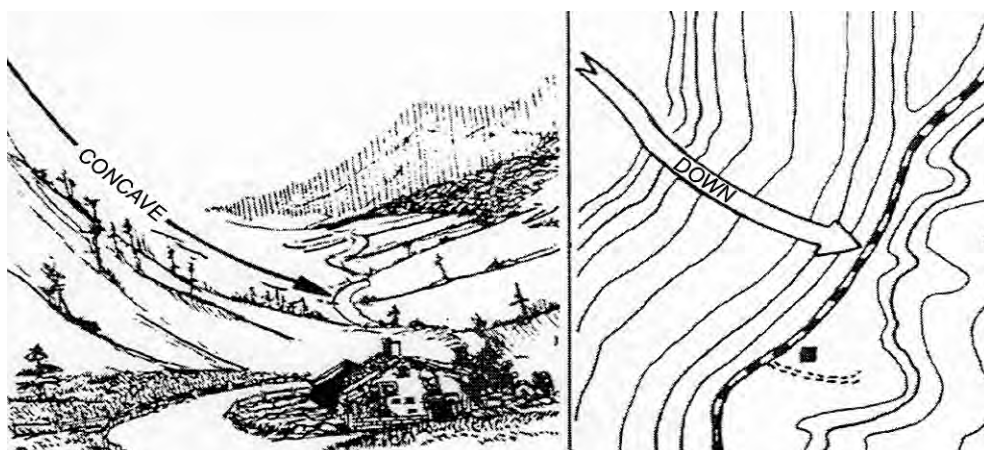
- **Gentle.** Contour lines showing a uniform, gentle slope will be evenly spaced and wide apart (Figure 1.6). Considering relief only, a uniform, gentle slope allows the defender to use grazing fire. The attacking force has to climb a slight incline.
- **Steep.** Contour lines showing a uniform, steep slope on a map will be evenly spaced, but close together. Remember, the closer the contour lines, the steeper the slope (Figure 1.7). Considering relief only, a uniform, steep slope allows the defender to use grazing fire, and the attacking force has to negotiate a steep incline.
- **Concave.** Contour lines showing a concave slope on a map will be closely spaced at the top of the terrain feature and widely spaced at the bottom (Figure 1.8). Considering relief only, the defender at the top of the slope can observe the entire slope and the terrain at the bottom, but cannot use grazing fire. The attacker would have no cover from the defender's observation of fire, and the climb would become more difficult farther up the slope.



**Figure 1.6** Uniform, Gentle Slope

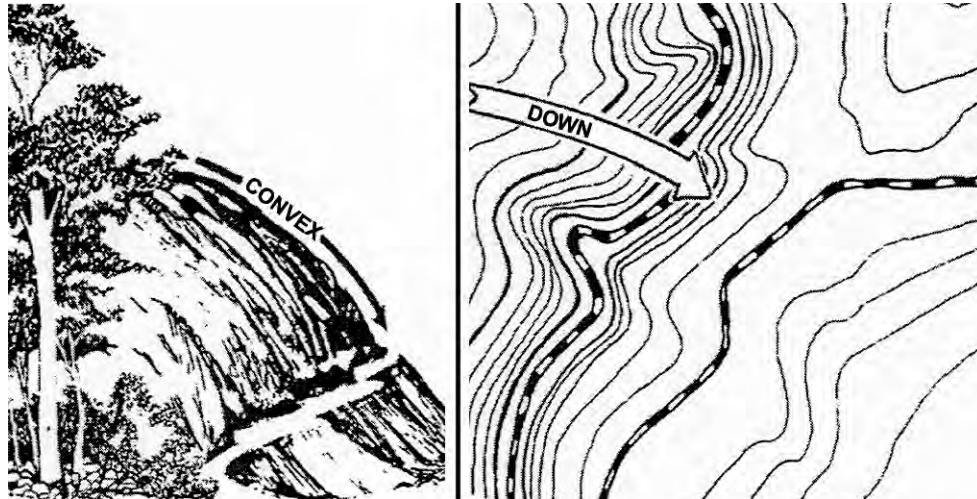


**Figure 1.7** Uniform, Steep Slope



**Figure 1.8** Concave Slope

- **Convex.** Contour lines showing a convex slope on a map will be widely spaced at the top and closely spaced at the bottom (Figure 1.9). Considering relief only, the defender at the top of the convex slope can obtain a small distance of grazing fire, but cannot observe most of the slope or the terrain at the bottom. The attacker will have concealment on most of the slope and an easier climb near the top.

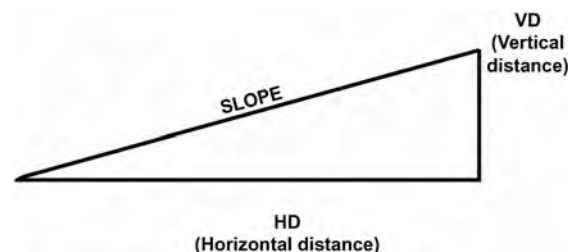


**Figure 1.9** Convex Slope

## Slope

As noted above, the slope of the ground and the limitations of the equipment affect the speed at which personnel and equipment can move up or down a hill. Because of this, you need a more exact way of describing a slope.

You can express slope in several ways, but all depend upon the comparison of vertical distance (VD) to horizontal distance (HD) (Figure 1.10). Before you can determine the percentage of a slope, you must know the VD of the slope. You determine the VD by subtracting the lowest point of the slope from the highest point. Use the contour lines to determine the highest and lowest point of the slope (Figure 1.11).

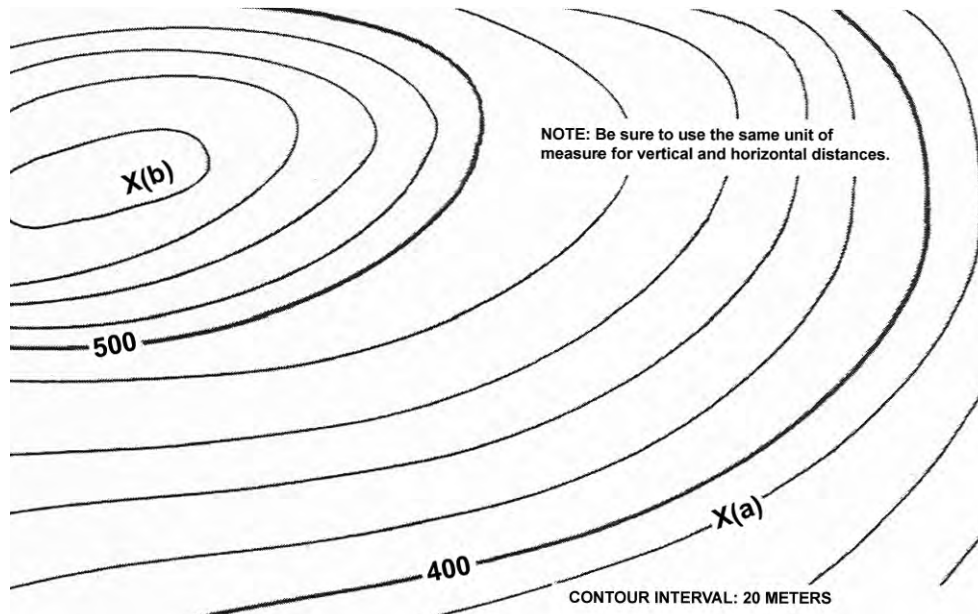


**Figure 1.10** Slope Diagram

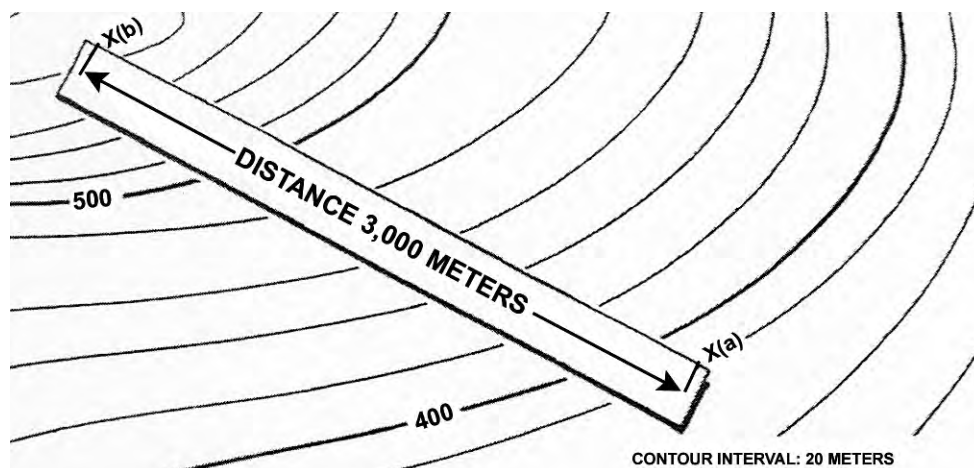
## Percentage of Slope

To determine the percentage of the slope between Points A and B in Figure 1.11, determine the elevation of Point B (590 meters). Then determine the elevation of Point A (380 meters). Determine the vertical distance between the two points by subtracting the elevation of Point A from the elevation of Point B. The difference (210 meters) is the VD between Points A and B. Then measure the HD between the two points on the map in Figure 1.12. After





**Figure 1.11** Contour Lines Around a Slope



**Figure 1.12** Measuring Horizontal Distance

you have determined the horizontal distance, compute the percentage of the slope by using the formula shown in Figure 1.13.

You can also express the slope angle in degrees. To do this, determine the VD and HD of the slope. Multiply the VD by 57.3 and then divide the total by the HD (Figure 1.14). This method determines the approximate degree of slope and is reasonably accurate for slope angles less than 20 degrees.

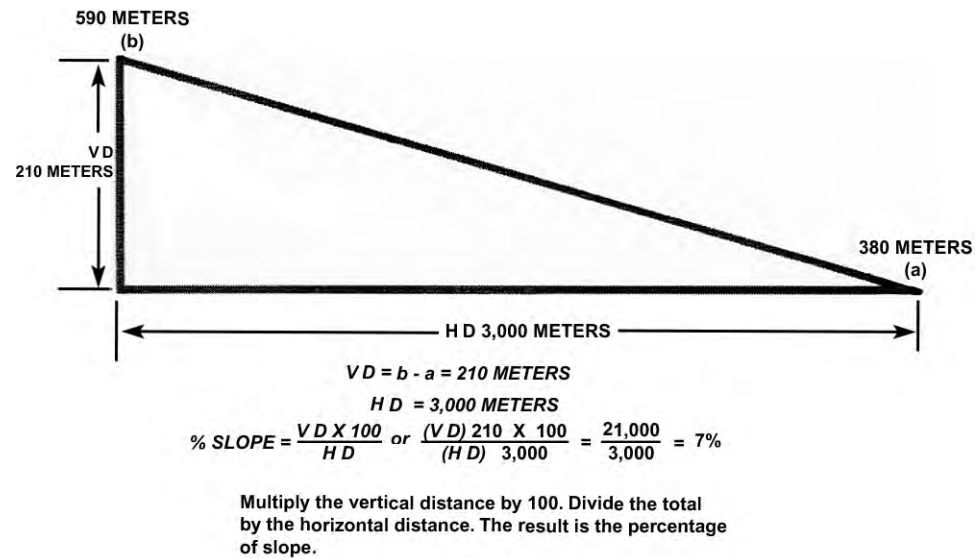
You can also express the slope angle as a gradient. The relationship of horizontal and vertical distance is expressed as a fraction with a numerator of one (Figure 1.15).

## Terrain Features

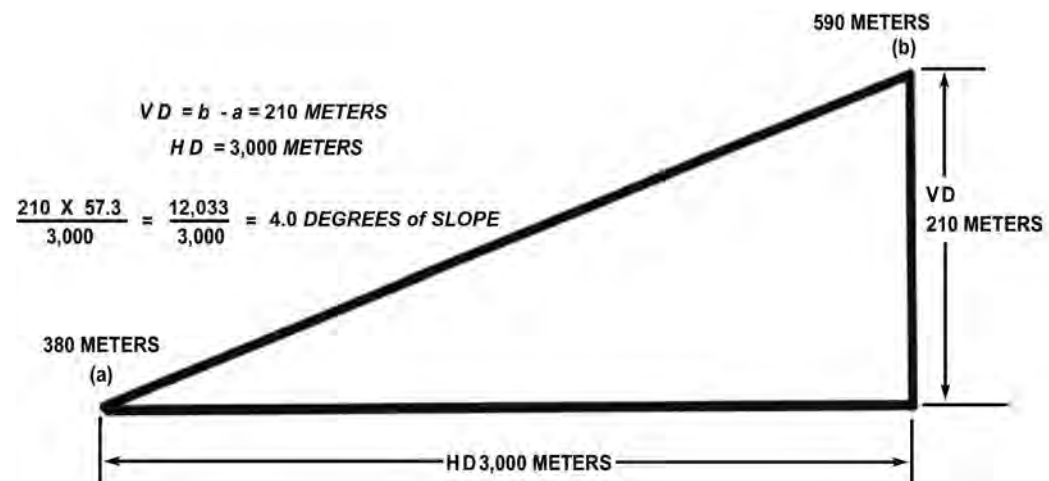
These three styles of contour lines allow you to see the five major, three minor, and two supplemental **terrain features** on a military map.

### terrain features

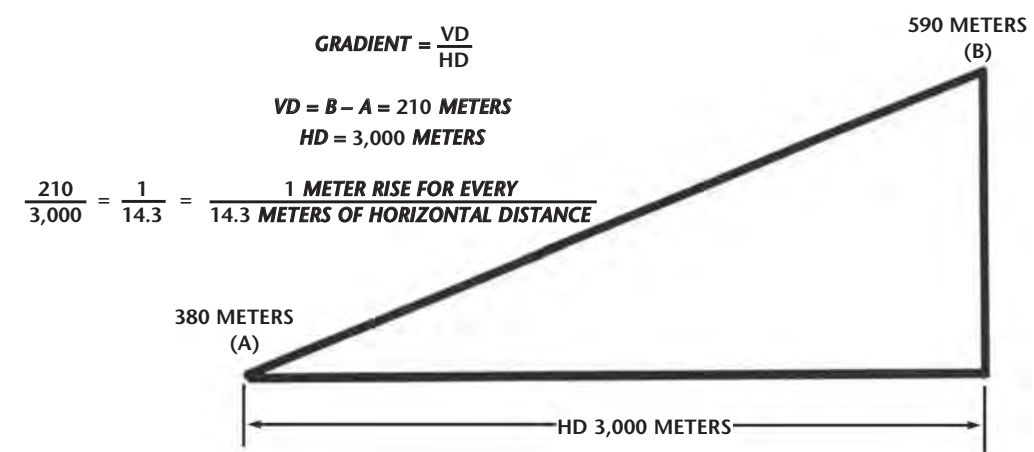
*characteristics of the land, such as hills, ridges, valleys, saddles, depressions, and so forth*



**Figure 1.13** Percentage of Slope in Meters



**Figure 1.14** Degree of Slope

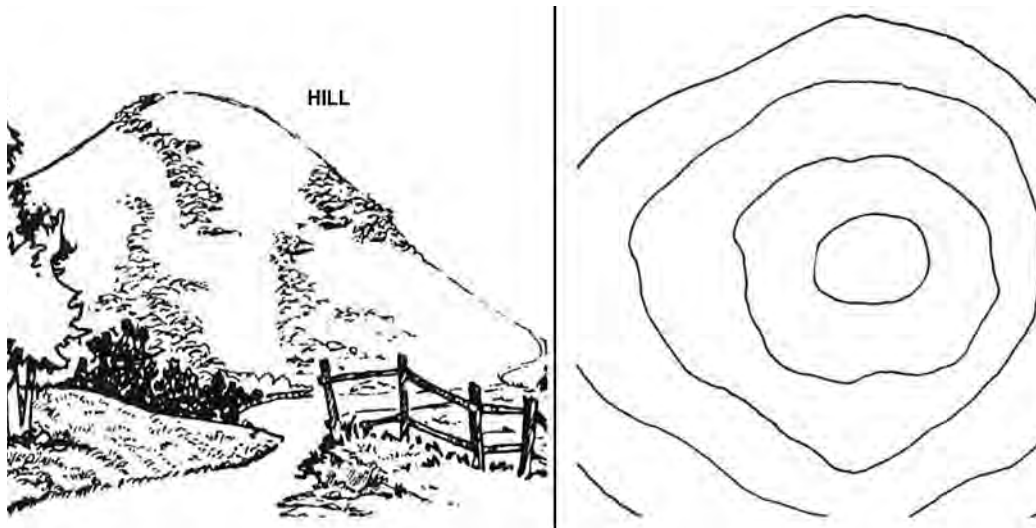


**Figure 1.15** Gradient



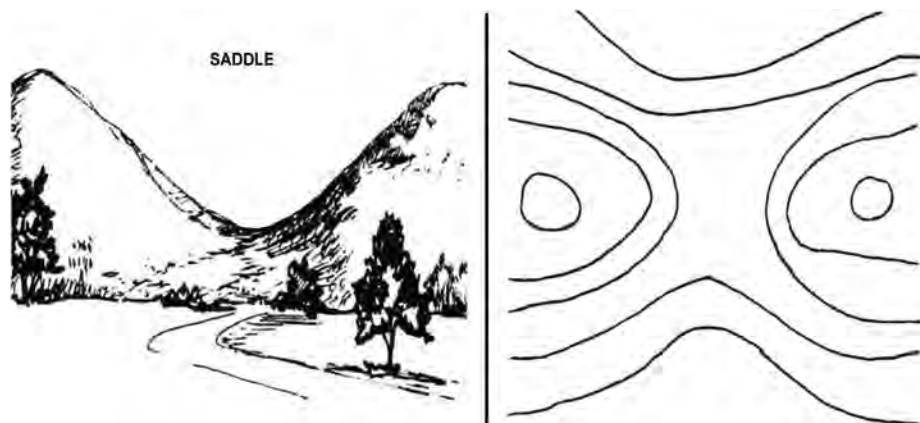
### Major Terrain Features

- **Hill**—A hill is an area of high ground. From a hilltop, the ground slopes down in all directions. A map shows a hill by contour lines forming concentric circles. The inside of the smallest closed circle is the hilltop (Figure 1.16).



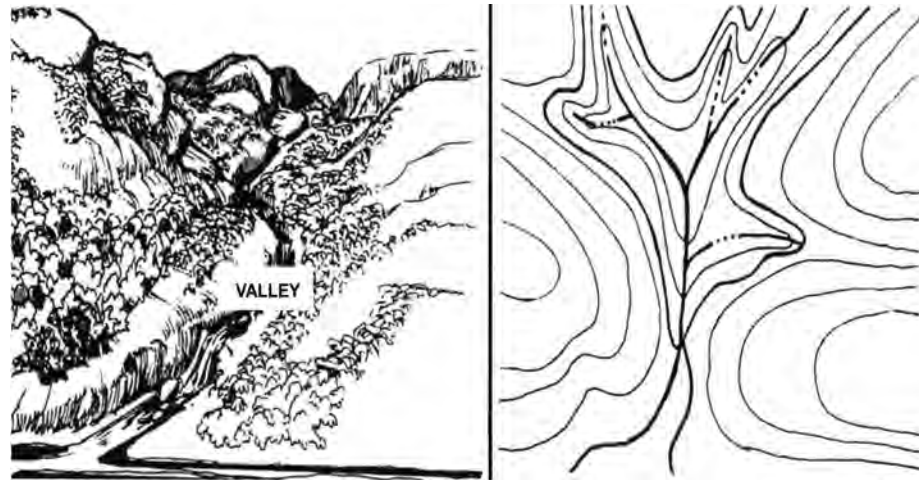
**Figure 1.16** Major Terrain Feature—Hill

- **Saddle**—A saddle is a dip or low point between two areas of higher ground. A saddle is not necessarily the lower ground between two hilltops—it may be simply a dip or break along a level ridge crest. If you are in a saddle, you see high ground in two opposite directions and lower ground in the other two directions. Contour lines for a saddle normally resemble an hourglass.



**Figure 1.17** Major Terrain Feature—Saddle

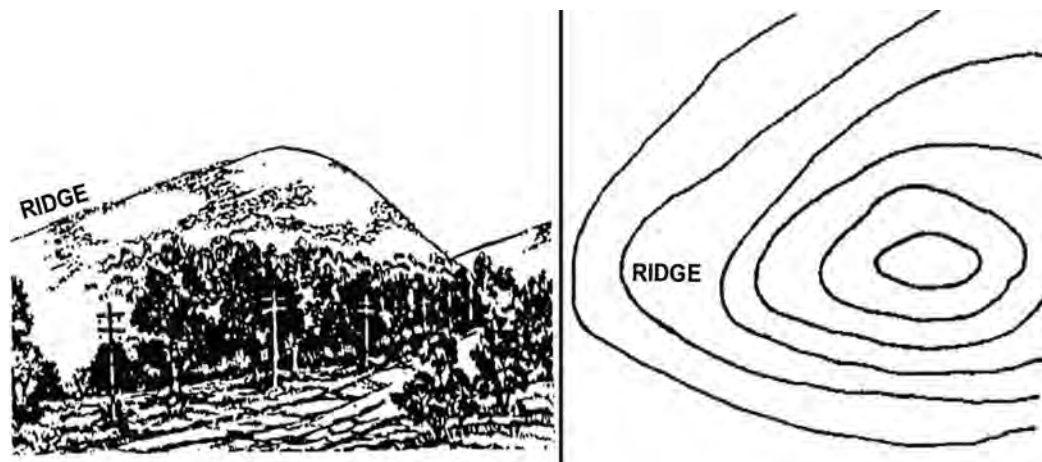
- **Valley**—A valley is a stretched-out groove in the land, usually formed by streams or rivers. A valley begins with high ground on three sides, and usually has a course of running water through it. If you are standing in a valley, three directions offer high ground, while the fourth direction offers low ground. Depending on the valley size and where you are standing, you may not see high ground in the third direction,



**Figure 1.18** Major Terrain Feature—Valley

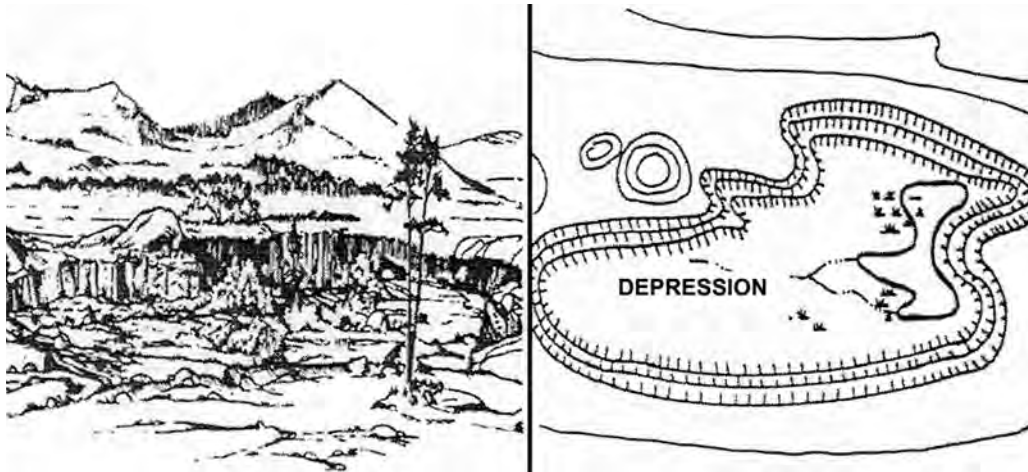
but water flows from higher to lower ground. Contour lines forming a valley are either U-shaped or V-shaped. To determine the direction the water is flowing, look at the contour lines. The closed end of the contour line (U or V) always points upstream or toward high ground (Figure 1.18).

- **Ridge**—A ridge is a sloping line of high ground. If you are standing on the centerline of a ridge, you will normally have low ground in three directions and high ground in one direction with varying degrees of slope. If you cross a ridge at right angles, you will climb steeply to the crest and then descend steeply to the base. When you move along the path of the ridge, depending on the location, you may find either an almost unnoticeable slope or a very obvious incline. Contour lines forming a ridge tend to be U-shaped or V-shaped. The closed end of the contour line points away from high ground (Figure 1.19).



**Figure 1.19** Major Terrain Feature—Ridge

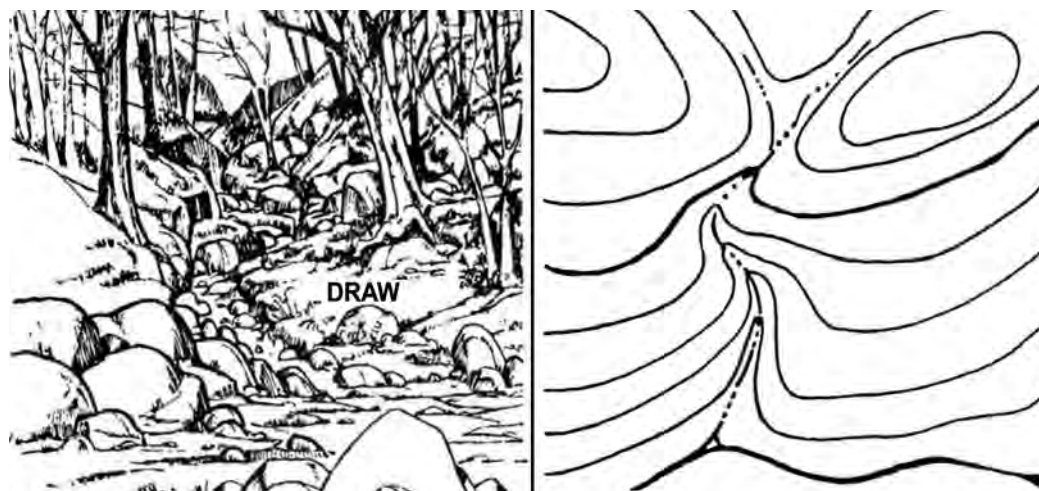
- **Depression**—A depression is a low point in the ground or a sinkhole. It could be an area of low ground surrounded by higher ground in all directions, or simply a hole in the ground. A map usually shows only depressions that are equal to or greater than the contour interval. Depressions are represented by closed contour lines that have tick marks pointing toward the low ground (Figure 1.20).



**Figure 1.20** Major Terrain Feature—Depression

### Minor Terrain Features

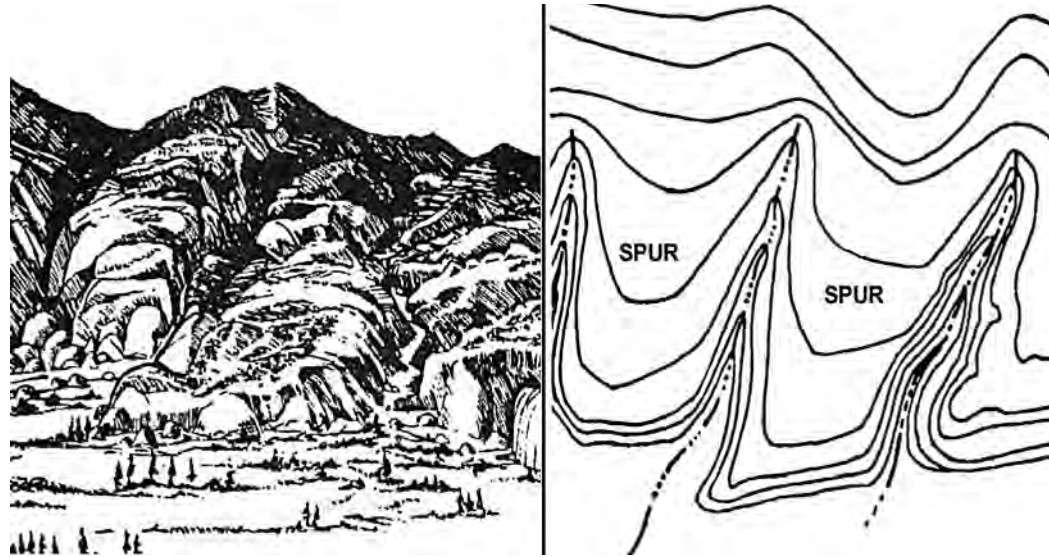
- **Draw**—A draw is a less developed stream course than a valley. A draw offers no level ground and, therefore little or no maneuvering room within its confines. If you are standing in a draw, the ground slopes upward in three directions and downward in the other direction. The contour lines depicting a draw are U-shaped or V-shaped, pointing toward high ground (Figure 1.21).



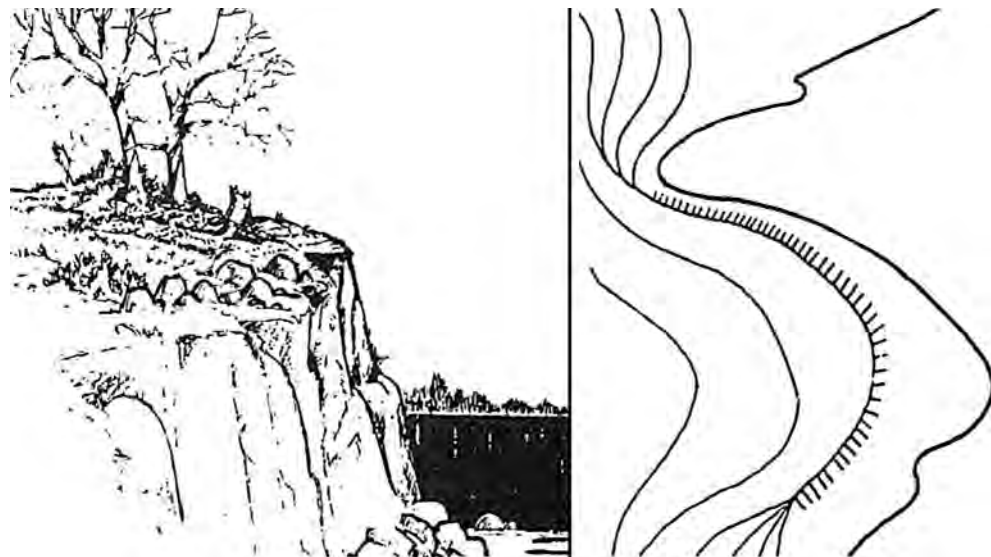
**Figure 1.21** Minor Terrain Feature—Draw

- **Spur**—A spur is a short, continuous sloping line of higher ground, normally jutting out from the side of a ridge. A spur is often formed by two rough parallel streams, which cut draws down the side of a ridge. The ground slopes down in three directions and up in one direction. Contour lines on a map depict a spur with the U or V pointing away from high ground (Figure 1.22).
- **Cliff**—A cliff is a vertical or near-vertical feature. It is an abrupt change of the land's elevation. When a slope is so steep that the contour lines converge into one “carrying” contour of contours, this last contour line has tick marks pointing toward low ground (Figure 1.23). Contour lines very close together or touching each other also indicate cliffs (Figure 1.24).

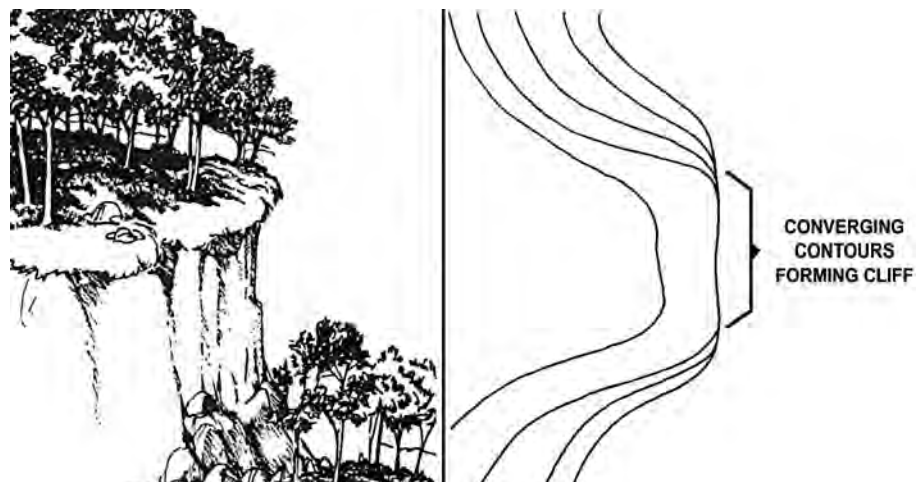




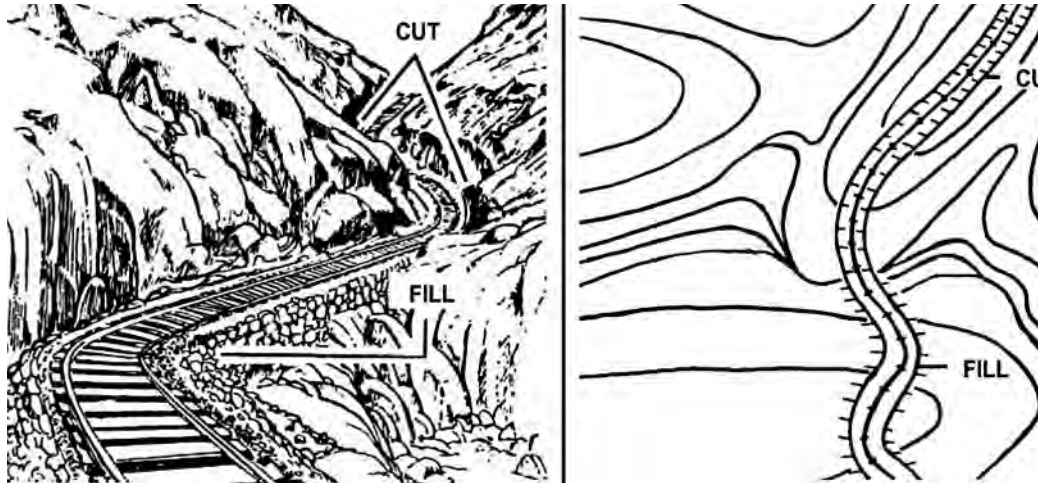
**Figure 1.22** Minor Terrain Feature—Spur



**Figure 1.23** Minor Terrain Feature—Cliff, Depicted with Tick Marks



**Figure 1.24** Minor Terrain Feature—Cliff, Depicted by Touching Contour Lines



**Figure 1.25** Supplemental Terrain Features—Cut and Fill

### Supplemental Terrain Features

- **Cut**—A cut is a man-made feature that results from cutting through raised ground, usually to form a level bed for a road or railroad track. Cuts are shown on a map when they are at least 10 feet high. They are drawn with a contour line along the cut line. This contour line extends the length of the cut and has tick marks from the cut line to the roadbed, if the map scale permits this level of detail (Figure 1.25).
- **Fill**—A fill is a man-made feature that results from filling a low area, usually to form a level bed for a road or railroad track. Fills are shown on a map when they are at least 10 feet high. They are drawn with a contour line along the fill line. This contour line extends the length of the filled area and has tick marks that point toward lower ground. If the map scale permits, the length of the fill's tick marks are drawn to scale and extend from the base line of the fill symbol (Figure 1.25) (FM 3-25.26).

## Map Coordinate Systems

When it was first created, the Global Positioning Systems (GPS) was used mainly by rescuers to locate ships missing at sea. GPS units were large and cumbersome. Today, that same technology is now in our homes, cars, and even cell phones. The military cannot operate effectively without it, from smart bombs to the individual Soldier in the field. A Soldier with a GPS can navigate to within three meters, if not closer, of a specific location. This technology has revolutionized navigation. But what do you do if your GPS unit doesn't work? The batteries could be dead; the face plate might break; or sand and dirt might get into the works. That's why you need to know how to read grid coordinates and convey them to others.

*What do you do if the GPS unit doesn't work?*

### Geographic Coordinates

One of the oldest methods of determining location is the geographic coordinate system. By drawing a set of east–west rings around the globe parallel to the equator, and a set of north–south rings crossing the equator at right angles and converging at the poles, a network of reference lines is formed from which you can locate any point on the earth's surface.



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If Christopher Columbus had had the right data when he was calculating the distance he needed to travel to reach “the Indies” he probably would have stayed home. Academics in Columbus’s day believed the earth was a sphere about 24,000 miles in circumference. Columbus calculated the earth’s circumference at about 18,000 miles. Others have demonstrated that Columbus made additional mistakes; for example, underestimating the length of a degree (45 versus 57.3 miles). His reliance on inaccurate information from Marco Polo’s *Description of the World* and Cardinal D. Ailly’s *Imago Mundi*, and on a statement in the Apocryphal Second Book of Esdras—which stated that the Earth consisted of six parts land and one part sea, instead of the real 3:1 ratio—led to numerous miscalculations. To make matters worse, he made all his calculations in Italian miles, unaware they were shorter than the Arabic miles many contemporary maps used (DeMar).

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#### latitude

the distance of a point north or south of the equator

#### longitude

the distance of a point east or west of the Prime Meridian, which runs through Greenwich, England

Latitude and longitude are represented by units of angular measure expressed in degrees, minutes, and seconds. A circle is divided into 360 degrees; each degree into 60 minutes; and each minute into 60 seconds.

#### Latitude

The distance of a point north or south from the equator is its *latitude*. The rings around the earth parallel to the equator are called parallels of latitude, or simply *parallels*. Lines of latitude (parallels) run east–west, but you measure north–south distances between them (Figure 1.26).

#### Longitude

A second set of rings around the globe at right angles to lines of latitude and passing through the poles is known as meridians of *longitude*, or simply *meridians*. One meridian is designated as the prime meridian. The prime meridian runs through Greenwich, England and is known as the Greenwich Meridian. The distance east or west from the prime meridian to a point is its longitude. Lines of longitude (meridians) run north–south but you measure east–west distances between them (Figure 1.27).

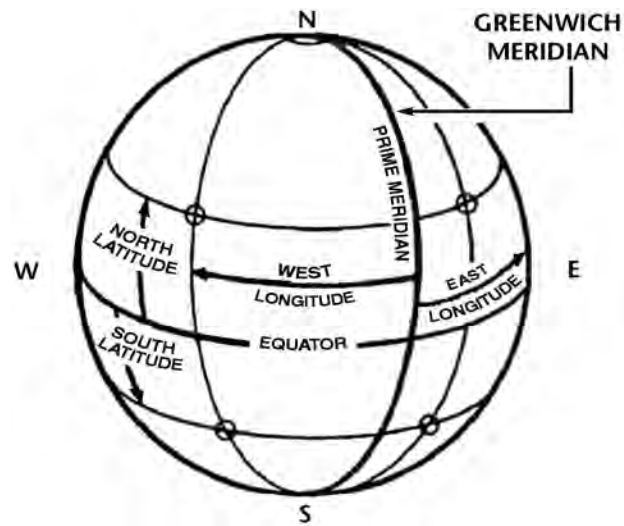
#### Angular Measure

Latitude and longitude are represented by units of angular measure expressed in degrees, minutes, and seconds (Figure 1.28). A circle is divided into 360 degrees; each degree into 60 minutes; and each minute into 60 seconds. The symbol for degree is °, for minute ', and for second ". Starting with 0° at the equator, the parallels of latitude are numbered to 90° north and south. The extremities are the North Pole at 90° north latitude and the South Pole at 90° south latitude. Latitude can have the same numerical value north or south of the equator, so you must always give the direction N or S. Starting with 0° at the prime meridian, longitude is measured both east and west around the world. Lines east of the prime meridian are numbered to 180° and identified as east longitude; lines west of the prime meridian are numbered to 180° and identified as west longitude. You must always give the direction E or W. You may refer to the line directly opposite the prime meridian, 180°, as either east or west longitude.

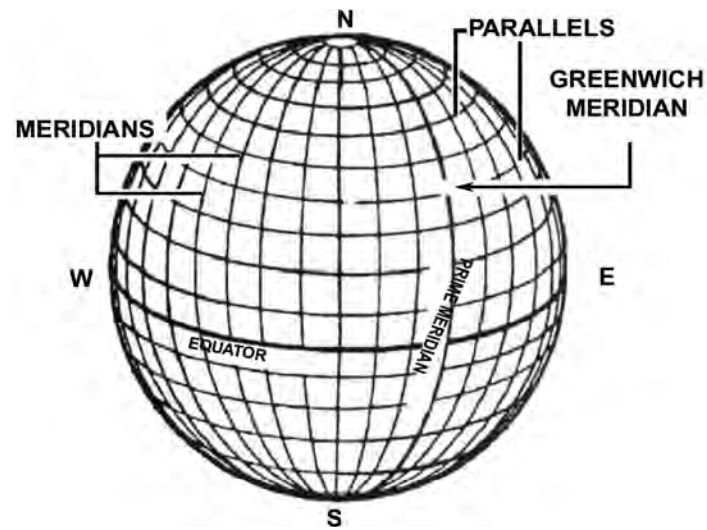
#### Coordinate Pair

You can express the location of any point on earth by a coordinate pair in latitude and longitude. The point is located at the intersection of the corresponding parallel and meridian. To navigate with some maps, you must understand coordinate locations expressed in latitude and longitude.

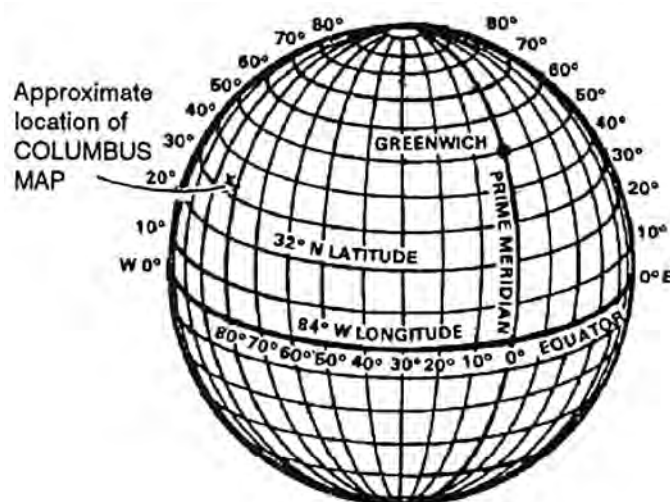
Geographic coordinates appear on all standard military maps. On some, they may be the only method of locating and referencing a specific point. The four lines that enclose



**Figure 1.26** Lines of Latitude



**Figure 1.27** Lines of Longitude



**Figure 1.28** Angular Measures on the Earth

the body of the map (neat lines) are latitude and longitude lines. Their values are given in degrees and minutes at each of the four corners. In addition to the latitude and longitude at the four corners, at regularly spaced intervals along the sides of the map, you will see small tick marks extending into the body of the map. Each of these tick marks is identified by its latitude or longitude value. To locate any position on the map using a coordinate pair, find the tick marks representing the given latitude and longitude, then follow the intersection of the corresponding parallel and meridian.

It can be hard to master the use of geographic coordinates to find positions, and at times this may not provide you the detail needed to perform your mission. Because of this, military grids are another way to express coordinates—one that is more exact and easier to use.

## Military Grids

The problem with geographic coordinates is that most lines of latitude and longitude are curved lines. The quadrangles formed by the intersection of these curved parallels and meridians have different sizes and shapes, which complicates locating the points and measuring the directions. The military grid system overcomes these shortfalls by superimposing a rectangular grid over the map. This grid (a series of straight lines intersecting at right angles) furnishes the map reader with a system of squares similar to the block system of most city streets. The dimensions and orientation of different types of grids vary, but three properties are common to all military grid systems:

1. They use true rectangles.
2. They are superimposed on the geographic projection.
3. They permit linear and angular measurements.

There are three common forms of grid reference systems: the Universal Transverse Mercator, the Universal Polar Stereographic Grid, and the United States Army Military Grid Reference System.

### Universal Transverse Mercator Grid

The UTM grid was designed to cover the world between latitude 84°N and latitude 80°S. As its name implies, it is imposed on the transverse Mercator projection of the world. UTM subdivides this area into 60 *grid zones* 6 degrees wide. Each grid zone has its own origin at the intersection of its central meridian and the equator. The grid is identical in all 60 grid zones. Base values (in meters) are assigned to the central meridian and the equator, and the grid lines are drawn at regular intervals parallel to these two base lines. Since each grid line has a value that indicates its distance from the origin, the problem of locating any point becomes progressively easier. You always measure distances RIGHT and UP (east and north as you face the map). The assigned values are called “false easting” and “false northing.”

### Universal Polar Stereographic Grid

The UPS grid is used to represent the polar regions. A separate grid zone is applied to each of the two polar areas:

*All flat maps are two-dimensional projections of a three-dimensional sphere. All projection processes introduce some level of distortion to the final representation, making it difficult to take accurate measurements. Different methods of projection distort different areas of the map to facilitate accurate measurement within confined areas of interest. In the UTM system, distortion becomes more pronounced closer to the poles.*

## Critical Thinking

Describe how the use of traditional features on military maps serves as an important tool in combat communications.

- **North Polar Area.** The North Pole serves as origin of the UPS grid applied to the north polar area. The “north–south” base line is the line formed by the 0° and 180° meridians; the “east–west” base line is formed by the two 90° meridians.
- **South Polar Area.** The South Pole is the origin of the UPS grid in the south polar area. The base lines are similar to those of the north polar area.

### United States Army Military Grid Reference System

This grid reference system is meant for use with both the UTM and UPS grids. The coordinate value of points in these grids could contain as many as 15 digits if numerals alone were used. So the US Army military grid reference system shortens written coordinates by substituting single letters for several numbers. Using the UTM and the UPS grids, a point's location (identified by numbers alone) can be in many different places on the earth's surface. When you use the US Army military grid reference system, that cannot happen.

**Grid Zone Designation.** The US Army military grid reference system applies an alphanumeric map-labeling scheme to UTM and UPS grid zones to generate unique coordinate positions, eliminating any chance of ambiguity. The US Army military grid reference system begins by subdividing the UTM and UPS grid zones into smaller areas. It then assigns a unique alphanumeric *grid zone designation* to each (Figure 1.29).

- **Grid Zone Designation for UTM Grid.** The first major breakdown is the division of each zone into areas 6° wide by 8° high and 6° wide by 12° high. Remember, for the transverse Mercator projection, the earth's surface between 80°S and 84°N is divided into 60 N–S zones, each 6° wide. These zones are numbered from west to east, 1 through 60, starting at the 180° meridian. This surface is divided into 20 east–west rows: 19 are 8° high, and one row at the extreme north is 12° high. These rows are then lettered, from south to north, C through X (I and O were omitted). You identify any 6° by 8° zone or 6° by 12° zone by giving the number and letter of the grid zone and row in which it lies. You read these RIGHT and UP, so the number is always written before the letter. This combination of zone number and row letter constitutes the grid zone designation.
- **Grid Zone Designation for UPS Grid.** The remaining letters of the alphabet, A, B, Y, and Z, are used for the UPS grids. Each polar area is divided into two zones separated by the 0–180° meridian. In the south polar area, the letter A designates the grid zone for the area west of the 0–180° meridian, while B designates the area to the east. In the north polar area, Y designates the grid zone designation for the western area and Z the eastern area.

**100,000-Meter Grid Square.** Each grid zone designation area is further subdivided into 100,000-meter grid squares. A two-letter alphabetical identifier that is unique in the grid zone labels each 100,000-meter square. The first letter is the column designation; the second letter is the row designation (Figure 1.30).

**Grid Coordinates.** We have now divided the earth's surface into 6° by 8° quadrangles, and covered these with 100,000-meter squares. The military grid reference for a point consists of the numbers and letters that indicate in which areas the point lies, plus the coordinates that locate the point to the desired position within the 100,000-meter square. The next step is to tie in the coordinates of the point with the larger areas. To do this, you must understand the following:

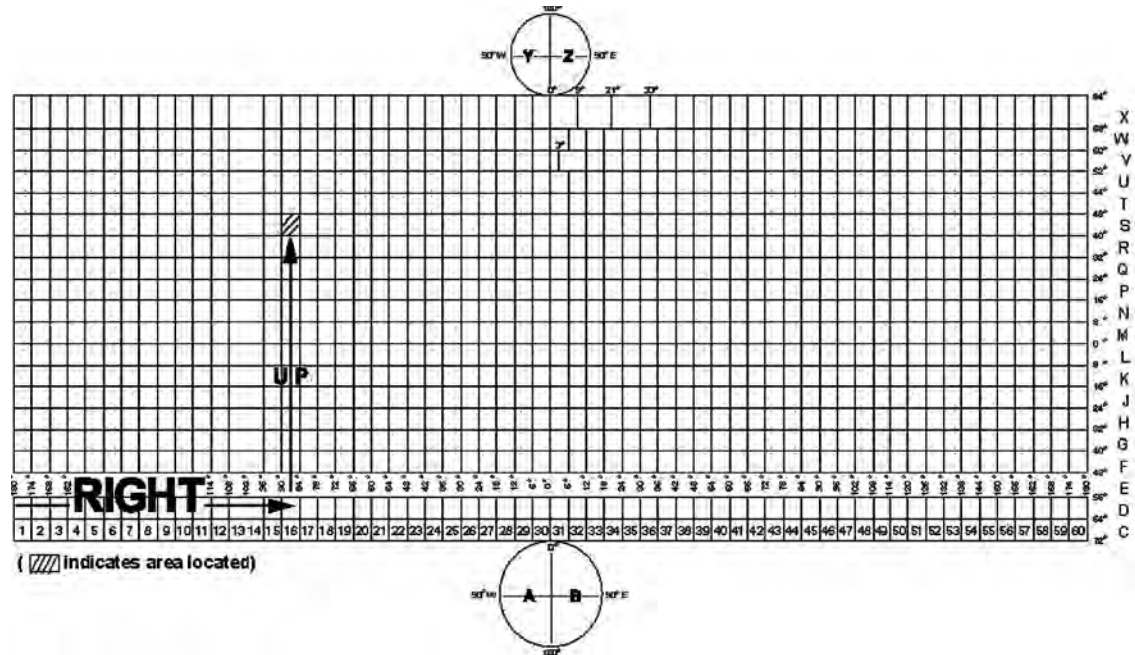
- **Grid Lines.** The regularly spaced lines that make the UTM and the UPS grid on any large-scale maps are divisions of the 100,000-meter square. The lines are spaced at 10,000- or 1,000-meter intervals (Figure 1.31). Each of these lines is labeled at

*The US Army military grid reference system applies an alphanumeric map-labeling scheme to UTM and UPS grid zones to generate unique coordinate positions, eliminating any chance of ambiguity.*

### grid coordinates

*letter and number designations that allow you to locate a point on a map*





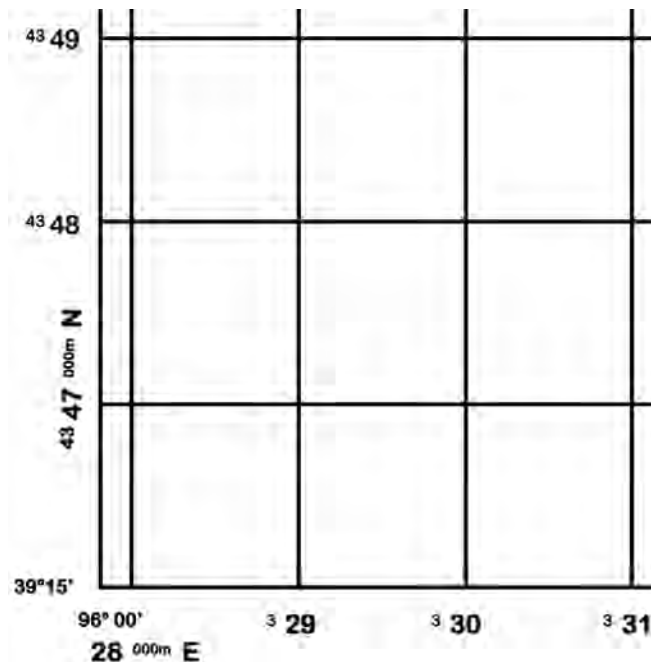
**Figure 1.29** Grid Zone Designation for UTM and UPS Coordinate Grids

**PLATE 12**

96°	580,000m						90°	500,000m						84°
QV	TQ	UQ	VQ	WQ	XQ	YQ	BV	CV	DV	EV	FV	GV	KQ	
QU	TP	UP	VP	WP	XP	YP	BU	CU	DU	EU	FU	GU	KR	
QT	TN	UN	VN	WN	XN	YN	BT	CT	DT	ET	FT	GT	KN	
QS	TM	UM	VM	WM	XM	YM	BS	CS	DS	ES	FS	GS	KM	
QR	TL	UL	VL	WL	XL	YL	BR	CR	DR	ER	FR	GR	K	
QQ	TK	UK	VK	WK	XK	YK	BQ	CQ	DQ	EQ	FQ	GQ	K	
QP	TJ	UJ	VJ	WJ	XJ	YJ	BP	CP	DP	EP	FP	GP	K	
QN	TH	UH	VH	WH	XH	YH	BN	CN	DN	EN	FN	GN	K	
QM	TG	UG	VG	WG	XG	YG	BM	CM	DM	EM	FM	GM	K	
QL	TF	UF	VF	WF	XF	YF	BL	CL	DL	EL	FL	GL	K	

**Figure 1.30** Grid Zone Designation Subdivided Into 100,000-Meter Grid Squares





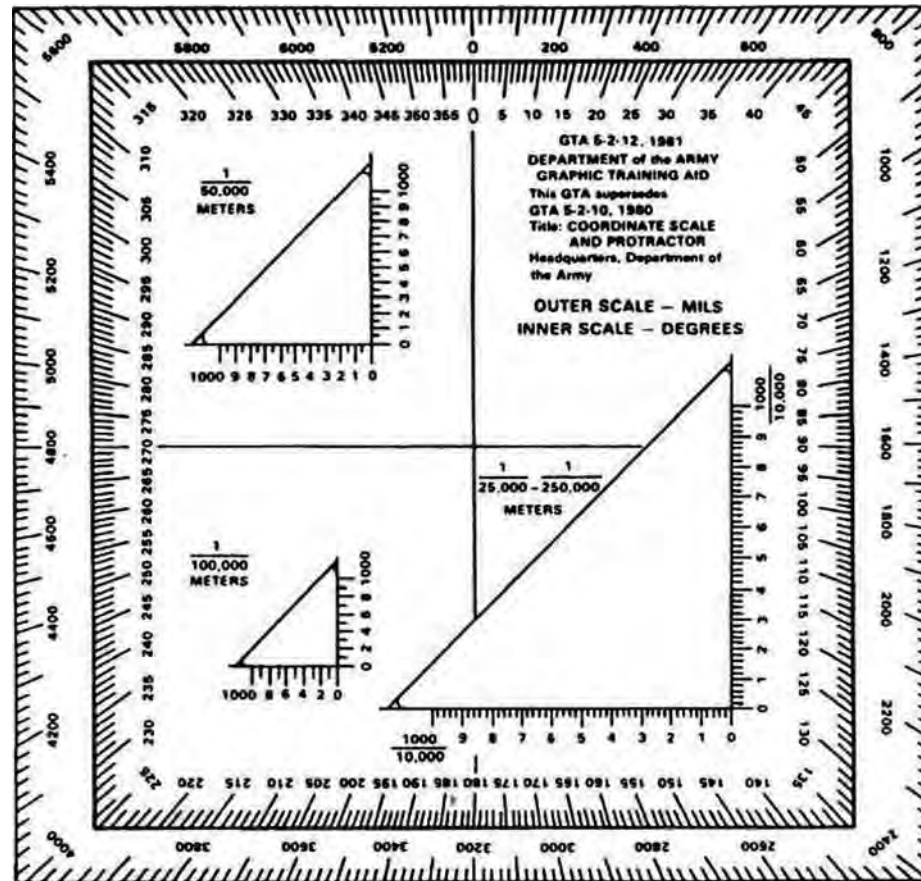
**Figure 1.31** Grid Lines

both ends of the map with its false easting or false northing value, showing its relation to the origin of the zone. Two digits of the values are printed in large type. These same two digits appear at intervals along the grid lines on the face of the map. These are the *principal digits*, and represent the 10,000 and 1,000 digits of the grid value. They are very important to the map reader because they are the numbers you will use most often for referencing points. The smaller digits complete the UTM grid designation.

- **Grid Squares.** The north–south and east–west grid lines intersect at 90°, forming grid squares. On large-scale maps, one of these grid squares is normally 1,000 meters (1 kilometer).

**Grid Coordinate Scales.** Your primary tool for plotting grid coordinates is the grid coordinate scale. The grid coordinate scale divides the grid square more accurately than you can do by estimating, and the results are more consistent. When used correctly, it presents fewer chances for error.

- You can use the 1:25,000/1:250,000 scale (lower right in Figure 1.32) in two different scale maps, 1:25,000 or 1:250,000. The 1:25,000 scale subdivides the 1,000-meter grid block into 10 major subdivisions, each equal to 100 meters. Each 100-meter block has five graduations, each equal to 20 meters. You can accurately read points falling between the two graduations by estimating. These values are the fourth and eighth digits of the coordinates. Likewise, the 1:250,000 scale is subdivided into 10 major subdivisions of 1,000 meters each. Each 1,000-meter block has five graduations of 200 meters each. You can approximately read points falling between two graduations by estimating.
- The 1:50,000 scale (upper left in Figure 1.32) subdivides the 1,000-meter block into 10 major subdivisions, each equal to 100 meters. Each 100-meter block is then divided in half. You must estimate points falling between the graduations to the nearest 10 meters for the fourth and eighth digits of the coordinates.
- The 1:100,000 scale (lower left in Figure 1.32) subdivides the 1,000-meter grid block into five major subdivisions of 200 meters each. Each 200-meter block is then divided in half at 100-meter intervals.



**Figure 1.32** Grid Coordinate Scale

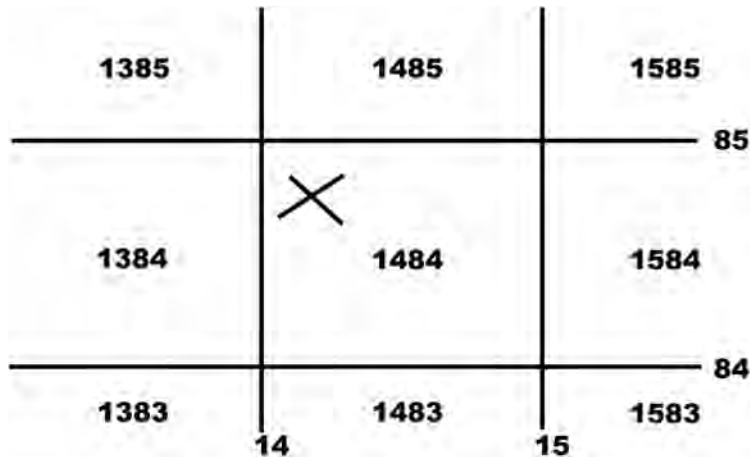
### Locating a Point Using Grid Coordinates

Based on the military principle for reading maps (RIGHT and UP), you can determine locations on the map using grid coordinates. The number of digits represents the degree of precision to which a point has been located and measured on a map. The more digits you use, the more precise the measurement.

*You must remember only one rule when reading or reporting grid coordinates: Always read to the RIGHT and then UP.*

**Locating a Point Without a Coordinate Scale.** You can determine grids without a coordinate scale by referring to the north–south grid lines numbered at the bottom margin of any map. Then read RIGHT to the north–south grid line before the desired point (this first set of two digits is the RIGHT reading). Then by referring to the east–west grid lines numbered at either side of the map, move UP to the east–west grid line before the desired point (these two digits are the UP reading). Locate the point to the nearest 100 meters by estimation. Mentally divide the grid square in tenths, then estimate the distance from the grid line to the point in the same order (RIGHT and UP). Give the complete coordinate RIGHT, then the complete coordinate UP. Point X is about two-tenths or 200 meters to the RIGHT of 14 and is about seven-tenths or 700 meters UP from 84. You would read the coordinates to the nearest 100 meters, or “142847” (see Figure 1.33).

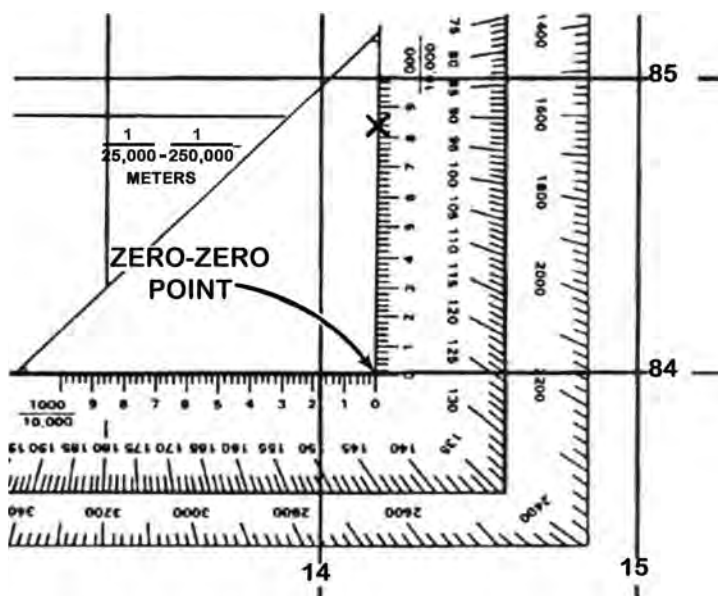
**Locating a Point With a Coordinate Scale (1:25,000).** To use the coordinate scale for determining grid coordinates, ensure that the appropriate scale appears on the corresponding map and that the scale is right side up. To ensure the scale is correctly aligned, place it with the zero–zero point at the lower left corner of the grid square. Keeping the horizontal line of the scale directly on top of the east–west grid line, slide it to the right until the vertical line of the scale touches the point for the coordinates you want (Figure 1.34). When you read coordinates, look at the two sides of the coordinate scale to ensure



**Figure 1.33** Locating a Grid Coordinate Without a Grid Scale

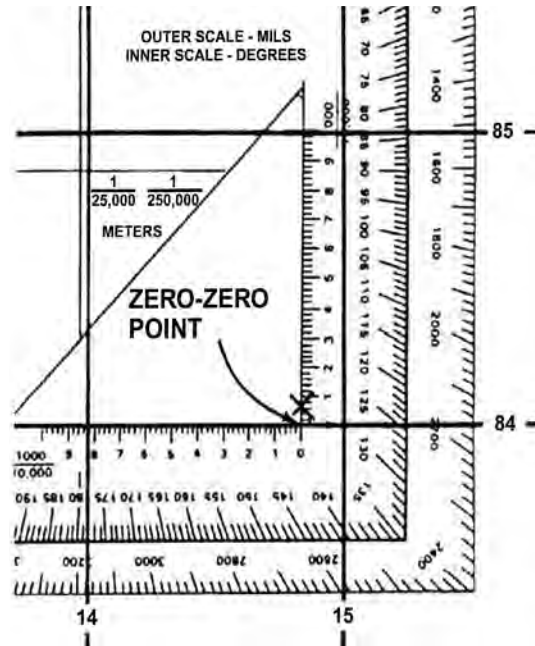
that the horizontal line of the scale is aligned with the east–west grid line, and the vertical line of the scale is parallel with the north–south grid line. Use the scale when you need precision of more than 100 meters. To locate the point to the nearest 10 meters, measure the hundredths of a grid square RIGHT and UP from the grid lines to the point. Point X is about 17 hundredths or 170 meters RIGHT and 84 hundredths or 840 meters UP. The coordinates to the nearest 10 meters are 14178484.

**1:50,000 Coordinating Scale.** The 1:50,000 coordinate scale has two sides: vertical and horizontal. These sides are each 1,000 meters in length. The point at which the sides meet is the zero-zero point. A long tick mark and a number divide each side into 10 equal 100-meter segments. A short tick mark divides each 100-meter segment into 50-meter segments (Figure 1.36). Mentally divide each 50-meter segment into tenths. For example, a point that lies after a whole number but before a short tick mark is identified as 10, 20, 30, or 40 meters. Any point that lies after the short tick mark but before the whole number is identified as 60, 70, 80, or 90 meters.



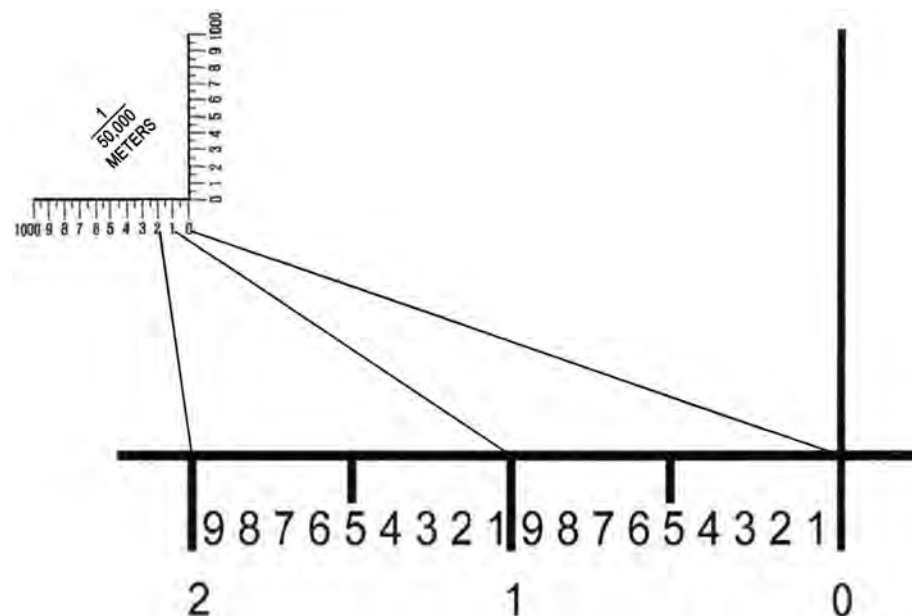
**Figure 1.34** Locating a Grid Coordinate Using a Grid Scale (1:25,000)

Always be careful when using the coordinate scale while you are looking for a point between the zero-zero point and the number 1. Always prefix a zero if the hundredths reading is less than 10.



**Figure 1.35** Locating a Grid Coordinate Using a Grid Scale Near the Zero-Zero Point

**Recording and Reporting Grid Coordinates.** Coordinates are written as one continuous number without spaces, parentheses, dashes, or decimal points. They must always contain an even number of digits. Therefore, the person who will use the written coordinates must know where to make the split between the RIGHT and UP readings. It is a military requirement that the 100,000-meter square identification letters be included in any point designation. Normally, you determine grid coordinates to the nearest 100 meters (six digits) for reporting locations. With practice, you can do this without using plotting scales. You determine the location of targets and other point locations for fire support to the nearest 10 meters (eight digits).



**Figure 1.36** Locating a Grid Coordinate Using a Grid Scale (1:50,000)

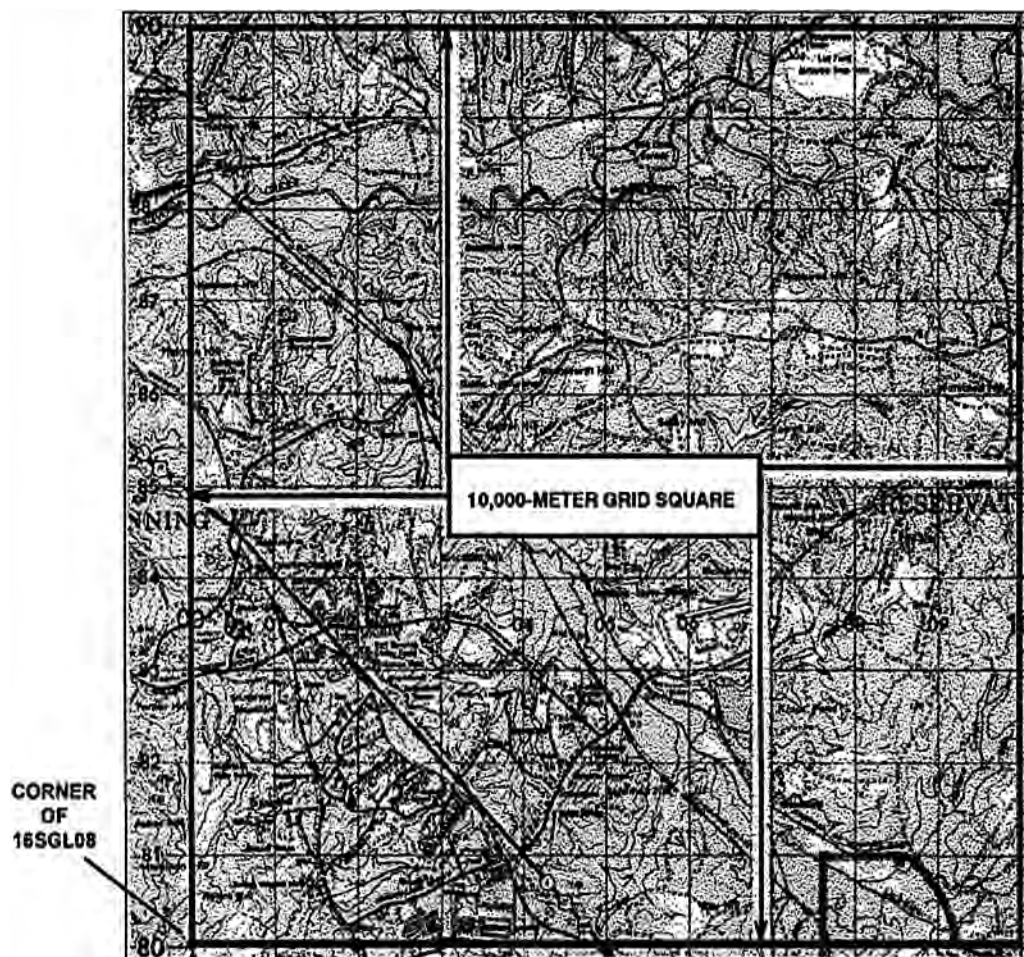


### Locating a Point Using the US Army Military Grid Reference System

You must remember only one rule when reading or reporting grid coordinates: Always read to the RIGHT and then UP. The first half of the reported set of coordinate digits represents the left-to-right (easting) grid label. The second half represents the label as read from the bottom to top (northing). The grid coordinates may represent the location to the nearest 10-, 100-, or 1,000-meter increment.

- **Grid Zone.** (NUMBER/NUMBER) The number 16 locates a point within Zone 16, which is an area 6° wide and extends between 80°S latitude and 84°N latitude (Figure 1.29)
- **Grid Zone Designation.** (NUMBER/LETTER) The number and letter combination, 16S, further locates a point within grid zone 16S, which is a quadrangle 6° wide by 8° high. Grid zone 16 contains 19 of these quads. Quad X, located between 72°N and 84°N latitude, is 12° high.
- **100,000-Meter Square Identification.** (LETTER/LETTER) The addition of two more letters locates a point within the 100,000-meter grid square. Thus 16SGL (Figure 1.30) locates the point within the 100,000-meter square GL in grid zone 16S.
- **10,000-Meter Square.** (NUMBER/NUMBER) The breakdown of the US Army military grid reference system continues as each side of the 100,000-meter square is divided into 10 equal parts. This division produces lines that are 10,000 meters apart. Thus the coordinates 16SGL08 would locate the point shown in Figure 1.37. The 10,000-meter grid lines appear as index (heavier) grid lines on maps at 1:100,000 and larger.

*Take special care when recording and reporting coordinates. Transposing numbers or making errors could harm military operations.*



**Figure 1.37** Coordinate (16SGL08) Localization to 10,000 Meter Square



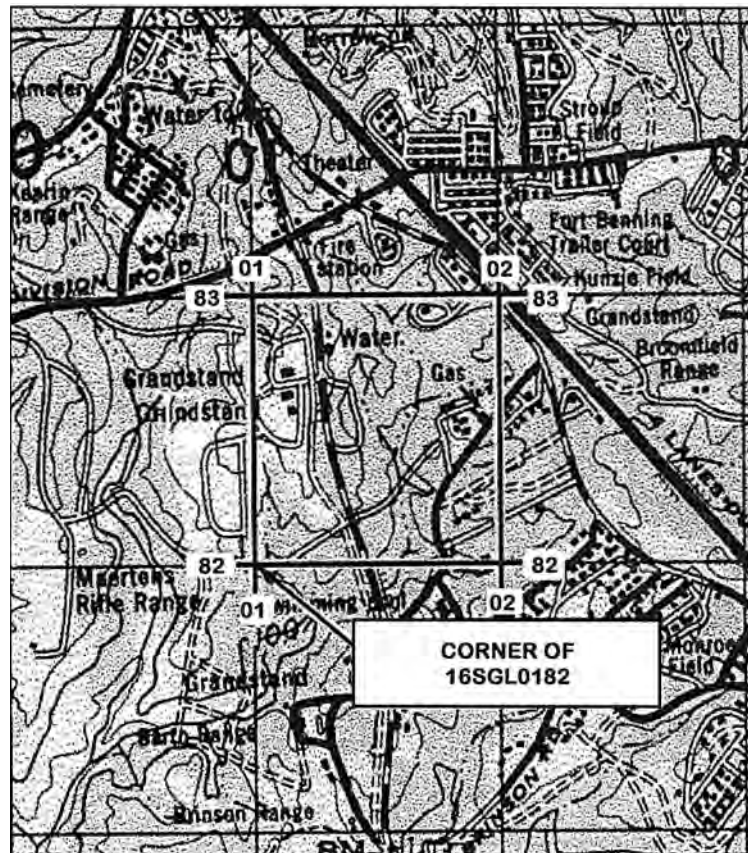
- **1,000-Meter Square.** To obtain 1,000-meter squares, each side of the 10,000-meter square is divided into 10 equal parts. This division appears on large-scale maps as the actual grid lines; they are 1,000 meters apart. On the Columbus, Ga., map, using coordinates 16SGL0182, the easting 01 and the northing 82 give the location of the southwest corner of grid square 0182 or to the nearest 1,000 meters of a point on the map (Figure 1.38).
- **100-Meter Identification.** To locate to the nearest 100 meters, you can use the grid coordinate scale to divide the 1,000-meter grid squares into 10 equal parts (Figure 1.39).
- **10-Meter Identification.** The grid coordinate scale has divisions every 50 meters on the 1:50,000 scale and every 20 meters on the 1:25,000 scale. You can use these to estimate to the nearest 10 meters and give the location of a point on the earth's surface to the nearest 10 meters.
- **Precision.** The precision of a point's location is shown by the number of digits in the coordinates; the more digits, the more precise the location (Figure 1.40).  
**Example:** 16SGL01948253 (gas tank) (Figure 1.39, insert).

### Other Grid Systems

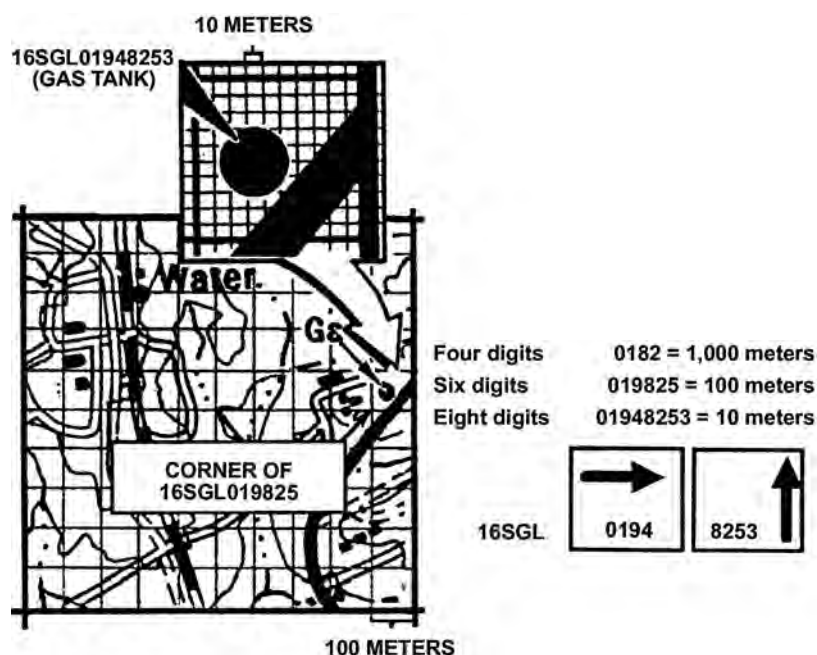
Not everyone uses the military grid reference system. You and your Soldiers must be prepared to interpret and use other grid systems, depending on the area of operations or the personnel with whom you are operating.

#### British Grids

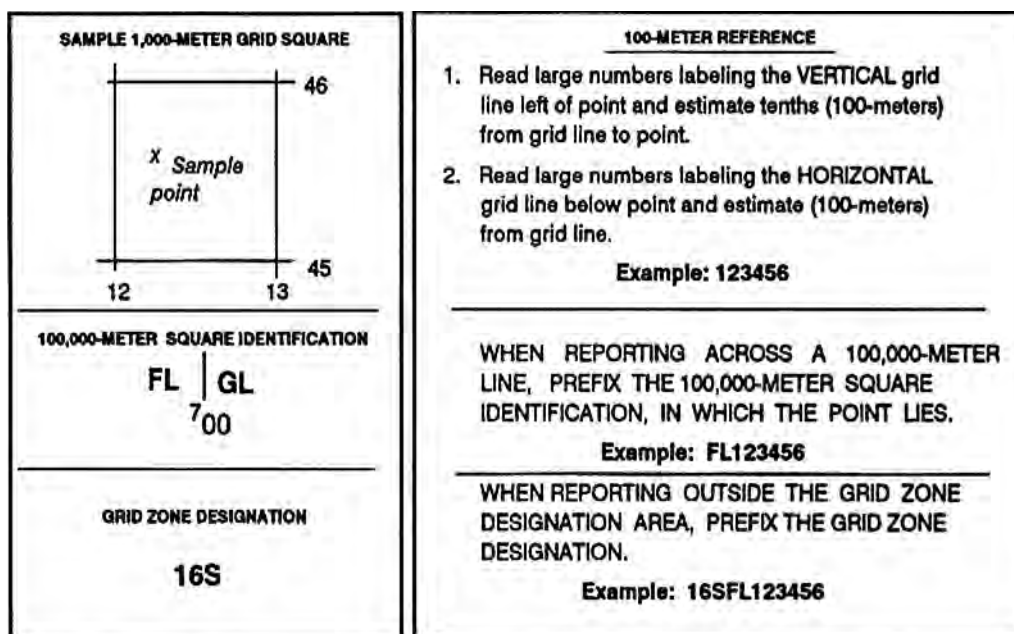
In a few areas of the world, you will find British grids on military maps. The British grid systems are being phased out, however. Eventually all military mapping will convert to the UTM grid.



**Figure 1.38** Coordinate (16SGL0182) Localization to 1,000 Meter Square



**Figure 1.39** Coordinate Localization Within 10 Meters Using Grid Coordinate Scale



**Figure 1.40** Coordinate Precision

## Critical Thinking

Explain how the Military Grid Reference System relates to GPS technology.

### World Geographic Reference System (GEOREF)

This worldwide position reference system is used primarily by the US Air Force. You can use it with any map or chart that shows latitude and longitude. Instructions for using GEOREF data are printed in blue and are found in the margin of aeronautical charts (Figure 1.41). This system is based upon a division of the earth's surface into quadrangles of latitude and longitude; each has a systematic identification code. The system expresses latitude and longitude in a form suitable for rapid reporting and plotting. Figure 1.41 illustrates a sample grid reference box using GEOREF.

#### Example

The map scale is  
1:50,000

$RF = 1/50,000$

The map distance from  
point A to point B is  
5 units

$5 \times 50,000 = 250,000$   
units of ground distance

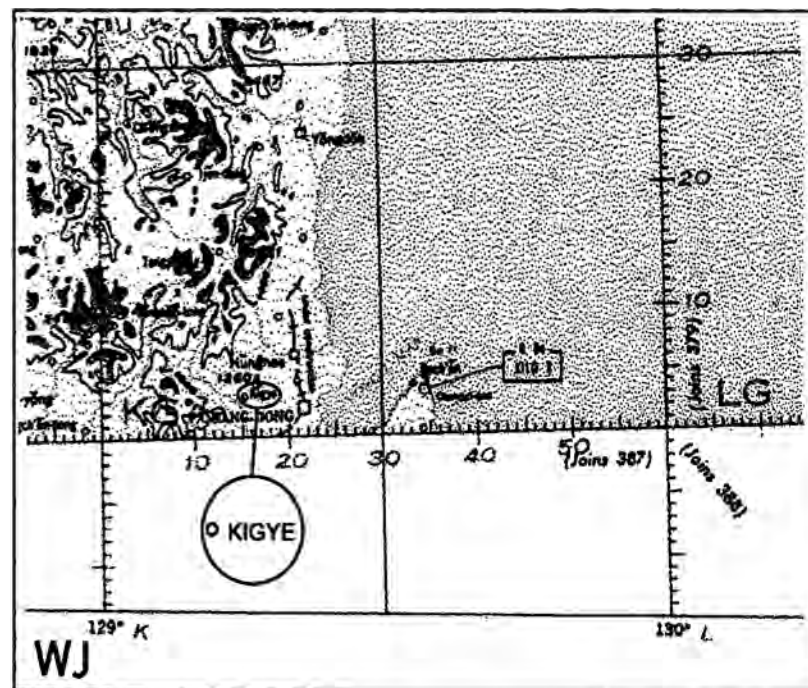
### Measuring Distances on a Map

From marginal information to symbols, from legend to grid coordinates, and from contour lines to colors, you can see how important it is to understand the “instructions” when using a map. But you must know another bit of important information if you are going to be proficient at navigation—how to measure distances on a map.

A map is a scaled representation of part of the earth's surface. The scale of the map permits you to convert distance on the map to distance on the ground or vice versa. You must be able to determine distance on a map, as well as on the earth's surface, to plan and execute military missions.

### Representative Fraction

The numerical scale of a map indicates the relationship between distance measured on a map and the distance on the ground. This scale is usually written as a fraction called the



#### TO REFERENCE BY GEOREF (SHOWN IN BLUE) TO MINUTES

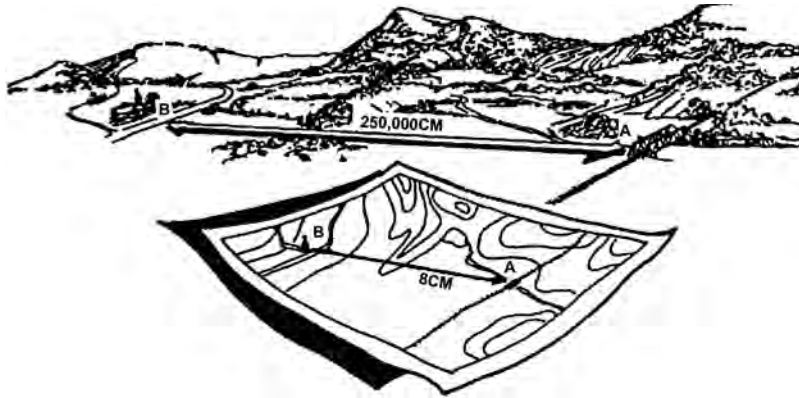
Select nearest intersection south and west of point.

Sample Point: KIGYE

1. WJ identifies basic 15° quadrangle.
2. KG identifies 1° quadrangle.
3. 15 identifies Georef minute of longitude.
4. 03 identifies Georef minute of latitude.
5. Sample reference: WJKG 1503.

**Figure 1.41** World Geographic Reference System (GEOREF)





**Figure 1.42** Converting Map Distance to Ground Distance

representative fraction (RF). The RF is always written with the map distance as the numeral 1 and is independent of any unit of measure. (It could be yards, meters, inches, and so forth.) An RF of  $1/50,000$  or  $1:50,000$  means that one unit of measure on the map is equal to 50,000 units of the same measure on the ground.

You determine the ground distance between two points by measuring between the same two points on the map and then multiplying the map measurement by the denominator of the RF or scale (Figure 1.42).

Since the distance on most maps is marked in meters and the RF in most cases is expressed in meters, let's briefly review the **metric system**. In the metric system, the standard unit of measurement is the meter.

- 1 meter contains 100 centimeters (cm)
- 100 meters is a regular football field plus 10 meters
- 1,000 meters is 1 kilometer (km)
- 10 kilometers is 10,000 meters.

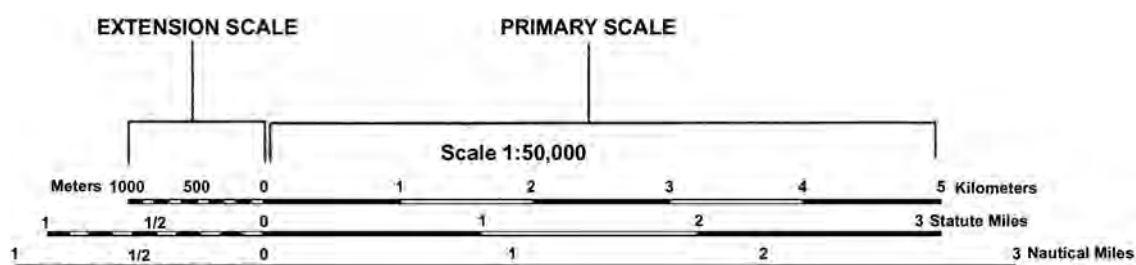
#### metric system

*a decimal system of measurement designed in France in 1791 and used in most of the world—the basic unit is a meter*

### Graphic (Bar) Scales

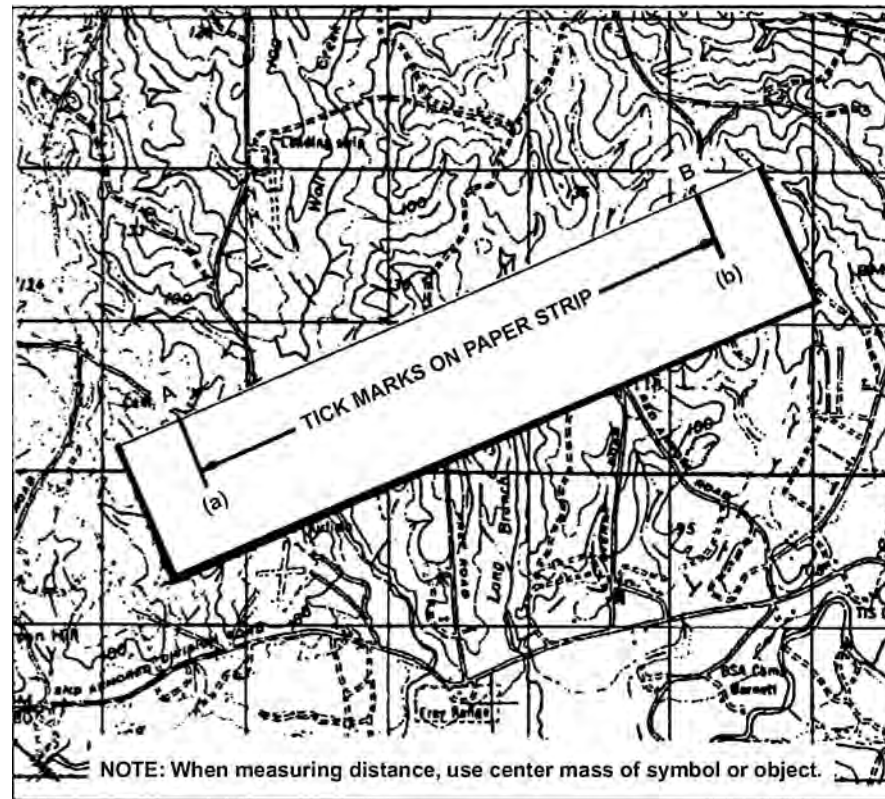
A graphic scale is a ruler printed on the map and is used to convert distances on the map to actual ground distances. The graphic scale is divided into two parts. To the right of the zero, the scale is marked in full units of measure; this is the *primary scale*. To the left of the zero, the scale is divided into tenths; this is called the *extension scale*. Most maps have three or more graphic scales, each using a different unit of measure (Figure 1.43). When you use the graphic scale, be sure to use the correct scale for the unit of measure you want.

To determine straight-line distance between two points on a map, lay a straight-edged piece of paper on the map so that the edge of the paper touches both points and extends past them. Make a tick mark on the edge of the paper at each point (Figure 1.44).



**Figure 1.43** Graphic (Bar) Scale

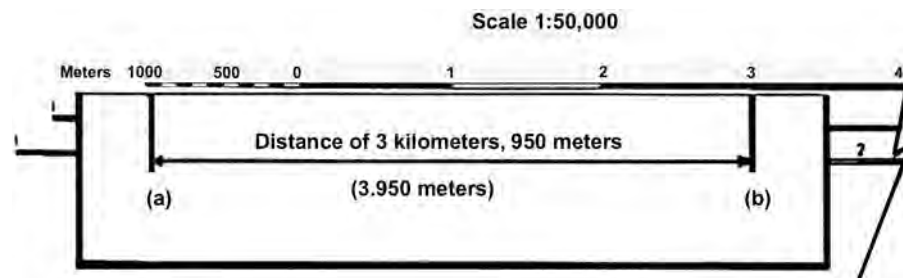




**Figure 1.44** Measuring Map Distances Using the Graphic (Bar) Scale

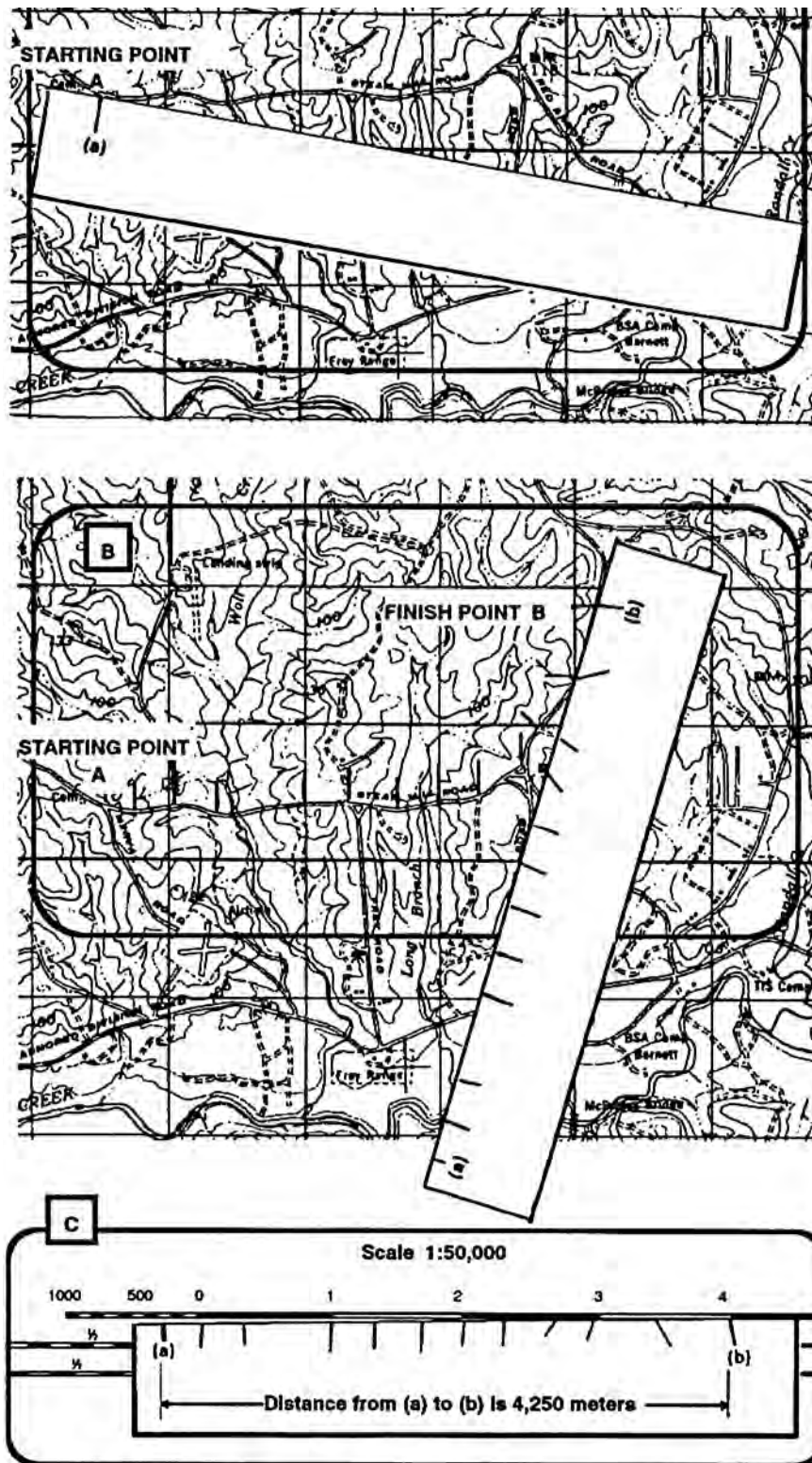
To convert the map distance to ground distance, move the paper down to the graphic bar scale, and align the right tick mark with a printed number in the primary scale so that the left tick mark is in the extension scale (Figure 1.45).

To measure distance along a road, stream, or other curved line, use the straight edge of a piece of paper. In order to avoid confusion over the point to measure from and the ending point, get the eight-digit coordinate for both points. Place a tick mark on the paper and map at the beginning point from which you will measure the curved line. Align the edge of the paper along a straight portion and make a tick mark on both map and paper when the edge of the paper leaves the straight portion of the line being measured (Figure 1.46, upper). Keeping both tick marks together (on paper and map), place the point of the pencil close to the edge of the paper on the tick mark to hold it in place and pivot the paper until another straight portion of the curved line is aligned with the edge of the paper. Continue in this manner until you complete the measurement (Figure 1.46, lower). When you have completed measuring the distance, move the paper to the graphic scale to determine the ground distance.



**Figure 1.45** Converting Map Distance to Ground Distance Using the Graphic (Bar) Scale

When you measure distance on a map you do not take into consideration the rise and fall of the land. All distances you measure using the map and graphic scales are flat distances. Therefore, the distance measured on a map will increase when you travel it on the ground. You must take this into consideration when navigating across rough country (FM 3-25.26).



**Figure 1.46** Measuring Distances Around a Curve



# CONCLUSION

With the military advancing technologically almost daily, it's very easy to forget how to do things the old-fashioned way. When the military started to use GPS systems, some wanted to do away with teaching navigation by map and compass. They believed it was not needed anymore. Fortunately, they lost the argument. As long as the military must travel over land, Soldiers will need to know how to use a map and compass. To be proficient in navigation you need a thorough knowledge of the map, the coordinate and grid reference systems, and how to measure distance.

## Learning Assessment

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1. Find and identify five common symbols on your map.
2. Give examples of how different colors are used on the map.
3. Identify the symbols used on a military map and how they represent certain objects and physical surroundings.
4. Identify the information you can find in a map's legend.
5. Determine the elevation and slope of selected points on a map.
6. Identify the major, minor, and supplemental terrain features on a map.
7. Give military grid coordinates for points on the map.
8. Measure distances between selected locations on a map.

## Key Words

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**marginal information**

**topographic symbols**

**contour lines**

**terrain features**

**latitude**

**longitude**

**grid coordinates**

**metric system**

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